Supergen Bioenergy
SUSTAINABLE BIOENERGY SYSTEMS FOR OUR LOW-CARBON FUTURE

Supergen Bioenergy Hub Response to the Scottish Government Draft Bioenergy Policy Statement Consultation

The material in this document is based on the Supergen Bioenergy Hub response to Scottish Government's 2024 Draft Bioenergy Policy Statement consultation. All enquiries related to this document should be sent to: supergen-policy@aston.ac.uk

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Question 1. Do you agree with the overarching principles for use of bioenergy, as set out in this document?

We mostly agree with the principles laid out in the policy statement and welcome the breadth of coverage that is attempted. However, we felt that perhaps the principles were not clear and concise enough to provide adequate guidance to potential developers, users, and decision-makers in Scotland.

We found it helpful to summarise the principles discussed in the strategy as:

1. Biomass and bioenergy use must be sustainable, with sustainability including consideration of greenhouse gas (GHG) emissions as well as wider environmental, economic, and social impacts.
2. Biomass use should be prioritised to support the transition to net zero, by focusing on hard to decarbonise sectors and negative emissions.
3. The bioenergy sector should prioritise the use of available waste feedstocks and ensure that feedstocks have no other value within society before they are used for energy.

We agree with the first two principles relating to sustainability and prioritising biomass use [1, 2]. However, the third point on waste feedstocks perhaps warrants more careful interrogation.

Using waste material as a primary resource for bioenergy has many attractions, including low feedstock cost and avoided environmental impacts of waste disposal. At present, the GHG impact of utilising waste is considered in different ways in different pieces of legislation/regulation. Sometimes wastes may be considered to have zero carbon emissions at the point of acquisition; some wastes may be considered to have an embodied GHG impact related to how they were produced; and sometimes GHG credits may be given for utilisation of waste because it avoids emissions that would have otherwise occurred in waste disposal. In the last case, the potential for avoided emissions is highly sensitive to the alternative waste disposal mechanism and energy use is not always lower emission than alternative approaches to waste disposal [3]. So, care needs to be taken when assessing the GHG impact of waste utilisation and it should never be assumed that using waste will automatically be a lower carbon route than systems using alternative feedstocks such as energy crops.

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Regarding negative emissions from systems using waste feedstocks, it is important to distinguish between avoided and sequestered emissions. For any BECCS system, calculation of the GHG emissions across the entire lifecycle is necessary to demonstrate that net transfer of carbon dioxide from the atmosphere is actually achieved [4, 5]. Some methods for GHG accounting and lifecycle analysis attribute negative emissions to systems based on avoided emissions at end of life [3]. Using this approach, the overall lifecycle emissions value may be calculated as negative where there is a reduction in carbon emissions that would have otherwise occurred but where there is no net removal of carbon from the atmosphere over the entire lifecycle. This means that particular care must be taken to ensure that the GHG impacts of waste based BECCS systems are properly calculated to achieve carbon removal (if that is the desired objective). Both forestry and energy crop systems actively remove carbon dioxide from the atmosphere and by encouraging new plantations through targeted policy measures additional carbon removal that would not have occurred otherwise can be achieved. Wastes and residues rely on naturally occurring sequestration of carbon from the atmosphere. As a result, there is potential for deeper and more significant carbon removals with some non-waste feedstocks. It may be appropriate to differentially incentivise negative emissions that deliver additional carbon removals that would not otherwise have occurred.

There is also a need to be wary of the wider consequences of focusing on waste feedstocks. Some waste feedstocks are already used for non-energy applications such as animal bedding or feed. This may reduce the amount of feedstock that is available for energy, or the use in energy could divert waste away from these applications, and the consequences of this should be considered. Additional demand for wastes may ultimately result in the waste not really being a waste anymore. Desirable waste feedstocks that attract higher premiums or policy priorities may begin to be traded at a cost. There is also a risk that if some applications reward the use of waste feedstocks more than others, waste will be “channelled” into use in a certain sector (e.g. for aviation fuels via the SAF mandate), whether or not that application gives the highest GHG savings [2].

If industry is to build new facilities to convert waste for priority applications, they will also need to be certain that sufficient waste resource will be available for a long time into the future, despite any initiatives that may be deployed to reduce waste production. This is because new facilities, which will often be required if new applications are prioritised, demand significant capital investment and investors and lenders will want to see evidence that there is a secure and reliable feedstock supply for the whole plant or finance loan lifetime so that this investment cost can be offset by the income received during subsequent years.

Question 2. Do you agree with the priority uses of bioenergy, as set out in this document?

The best use of biomass depends on the main objective for using it. Given that the main driver for deployment of biomass and bioenergy systems in Scotland is the reduction of GHG emissions and the transition to net zero, biomass use should be prioritised in applications that deliver the greatest GHG emission reductions compared to the counterfactual and offer opportunities for negative emissions, and sectors that are hard to decarbonise in other ways [2, 6]. This aligns with the general approach outlined in the policy statement, which in the future prioritises Bioenergy with Carbon Capture and Storage (BECCS) systems and to a

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certain extent use in hard to decarbonise sectors, and which changes over time as the wider system develops and new technologies are deployed.

Those developing future policy frameworks should also be mindful of the need to prioritise applications that deliver the greatest GHG emission savings, as this will vary according to the end use, but also the specifics of the technology, feedstocks, and system operation (e.g., see the point made in our response to Question 1 about the channelling of waste feedstocks into applications which don't deliver the greatest GHG reductions).

Beyond these high-level priorities, we felt that the detailed picture of how things would evolve over time was less clear. Some of the complexity stems from the fact that certain aspects are devolved, and others not, and that many different sectors have a stake in this discussion. However, there were some statements made which we found ambiguous or inconsistent. For example:

- The statement described CHP as high priority between now and 2035, and there is the intention for new CHP plants to be built in this period, but there is no mention of CHP amongst the long-term priorities (here we are referring to the information on page 10 of the statement). It is of course to be expected that priorities will change over time but given the minimum lifetime of a new plant it seems unlikely that Scottish government would want to incentivise new plants in the period up to 2035 if they were not to be used in the years following.
- The statement indicates that early uptake of CCS for AD is to be encouraged, but it is less clear where AD and biomethane fits in the longer term priorities.
- In reference to the period from now to 2035 the statement says, "wherever possible we expect locally available resources to be used to meet the demands of the area". As this sentiment is not repeated or discussed elsewhere, it is not clear if it still applies in the long term or how it relates to the prioritisation of waste or the policies that exclude certain feedstocks for some applications, or how this use of local resource might be encouraged.

Here, we will also comment on the policy statement's approach to two key applications of biomass in more detail:

Heat:

There are a significant proportion of rural dwellings in Scotland that are not currently on the gas grid and may be commonly heated by liquid and solid fuels. Rural dwellings are often "hard to heat" and there can be challenges associated with electrification and the grid infrastructure. Switching hard to heat, off-grid rural homes to biomass heating can reduce GHG emissions, and there are opportunities to use local biomass resources and drop-in fuels that can be used in existing devices. Adding in significant new electrical heating loads will demand grid development as well as device deployment, both of which come at a cost, and these will only be low carbon if there is an equivalent expansion in low carbon electricity generation. It is also worth noting that the recent experience of storms and the likelihood of more frequent extreme weather events with climate change has recently resulted in the electricity network being damaged for weeks on end during winter. Biomass heating is a more resilient form of heating for off-grid rural properties in many scenarios. The suggestion that biomass boilers should only be used for standby purposes is problematic because it seems unlikely that owners will invest in expensive devices or keep good quality fuel stores available for something they will rarely use and it seems likely that devices that are rarely used are more likely to be poorly maintained and thus give rise to higher levels of airborne emissions.

As the policy statement highlights, biomass can be used for heating in the form of solid biomass or liquid or gaseous biofuels. It is disappointing to see the lack of differentiation between the different forms of solid biomass (chip, pellet, logs). Using solid biomass for heat results in a higher level of emissions (particularly particulates) than gaseous and liquid biofuels, but different forms of solid biomass feedstock can also have vastly different airborne emission profiles and this should be recognised [7-11]. Emissions also vary with the nature, scale, and operation of the heating device, with larger scale devices supporting better control of particulates and NOx [12-14]. Affordability is also particularly important given the rate of fuel poverty in off grid homes, and solid biomass tends to be less expensive than liquid fuels.

It is also disappointing to see the grouping of heat demand sectors as “industry” and “other”. Again, there are a wide variety of different things included in “other” with varying degrees of suitability for biomass solutions. Commercial and public buildings, such as shopping centres, schools, leisure centres, government offices (particularly in semi-rural locations) could effectively deploy biomass heating to reduce carbon. In many cases these systems run near continuously, which can lead to reduced airborne emissions because of the high emissions associated with the start-up phase, and they are of a size which enables pollutant abatement measures not possible for smaller residential boilers [12, 13, 15, 16]. The value of such decarbonisation alongside energy security and fuel cost benefits should not be underestimated.

Non-energy applications:

There are a variety of non-energy applications for biomass, such as building materials (e.g., timber) and a variety of bio-based chemicals and materials. Modern society relies on carbon-based chemicals and materials: they are in our medicines, packaging, buildings, cars, electronics and clothes [17]. However, at the moment these carbon-based products are mostly derived from fossil feedstocks and this is a source of GHG emissions [18-21]. Because these chemicals are carbon-based, they cannot be decarbonised. That means to transition away from fossil feedstocks, the chemical industry needs sources of renewable carbon, such as biomass [20-23]. Bio-based chemicals and materials can deliver GHG emission reductions and potentially even carbon storage, and there is the potential for novel bio-based chemicals with useful properties (e.g., biodegradability or reduced toxicity), and the use of biomass will be explored in a soon to be published report from the Supergen Bioenergy Hub and the Biomass Biorefinery Network.

Chemicals are already an important output of Scottish industry and there could be opportunities for new bio-based chemicals manufacturing, so it is important that non-energy applications of biomass are considered alongside bioenergy systems when it comes to resource availability and prioritisation [24, 25].

Question 3. Do you agree with the intention to phase out unabated combustion of biomass?

We agree that in the future biomass should primarily be used in applications with negative emissions as opposed to those that are unabated, although there are some examples where unabated use may still make sense (e.g., heating for some off grid rural properties). Bioenergy with Carbon Capture and Storage (BECCS) is crucial to delivering global

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decarbonisation targets as it currently the only technology which delivers both a low-carbon energy source and a net-negative emission [4, 6, 26-28].

A variety of different biomass related technologies have the potential to deliver negative emissions through integration with CCS, for example production of electricity, hydrogen, and biomethane (as highlighted in the strategy) but also other fuels (e.g., SAF) and perhaps even chemicals [4, 29, 30]. Delivering the climate benefits of any of these BECCS systems requires assessment of the emissions across the entire supply chain to ensure that negative emissions are actually achieved for the given feedstock, technology, and operation.

Scotland has a distinctive geology and offshore skills sector which presents specific opportunities for large scale geological storage of carbon dioxide. It would make most climate sense to deploy that storage capacity to generate negative emissions by storing carbon dioxide that has been removed from atmosphere, rather than using it to support continued use of fossil fuels by reducing emissions by storing carbon dioxide that originates from fossil fuels.

In some cases integration of a particular bioenergy technology with CCS may be unfeasible, for example in bioenergy plants that are too small and/or located too far away from CCS infrastructure [31]. In some smaller plants, Carbon Capture and Utilisation (CCU) may be a favourable way of abating carbon dioxide emissions by converting carbon dioxide into usable products like fuels and chemicals [4].

When discussing the deployment of BECCS it is important to note that the scale of negative emissions needed to meet climate targets and limit global temperature increases depends on the extent of decarbonisation across society, and so negative emission technologies like BECCS should be deployed alongside measures to reduce emissions (e.g., through a transition away from fossil fuels) and not be relied on to support business as usual elsewhere in the economy [6, 27]. The requirement for BECCS also depends on the extent to which other GHG removal approaches, such as nature-based solutions like peatland restoration and woodland creation, can be harnessed in Scotland.

Question 4. From what date should any mandate to consider carbon capture technology be implemented for bioenergy plants?

Presently, the technology readiness of BECCS is low; and whilst both bioenergy and CCS technologies have been individually demonstrated on a large-scale, there is currently no case showing bioenergy combined with underground carbon dioxide storage on a commercial scale [4]. Given the variety of technologies that can be used in bioenergy plants it is difficult to specify a date at which carbon capture could be universally deployed. To support decision making demonstration and testing of BECCS technologies is important in the near term, and we agree with the sentiments laid out in the strategy that BECCS should be deployed as soon as possible.

What cannot be ignored, is that on top of the technical challenges that are yet to be addressed, there are a variety of financial, legislative, and social challenges associated with the deployment of BECCS systems at scale [4]. Clear policy frameworks need to be implemented to incentivise negative emissions through BECCS, and challenges with planning and permits for facilities based on new technologies such as CCS must be addressed. Infrastructure for the transport and storage of captured carbon dioxide must also be in place before BECCS is possible. This requires further technology development but also building of infrastructure and potentially repurposing of existing infrastructure from the oil industry. The development of technologies for using carbon dioxide and markets for biogenic carbon dioxide could be a driver for implementation of carbon capture, even where CCS is not feasible or infrastructure is not yet in place. Other barriers to BECCS include the negative social perception related to bioenergy regarding food security and land usage; and also, the economic hurdle of competing for investment with other, more affordable energy sources which are continually falling in price (e.g., wind)[4].

Question 7. The Climate Change Committee (CCC) advise that the UK will need 700,000 hectares of perennial energy crops by 2050 to meet their pathway to net zero. How much could Scotland contribute towards this figure and what evidence is available to support your view?

Our own analysis suggests that Scotland could grow more perennial energy crops than the figures of 219,100 ha of SRC and 51,800 ha of Miscanthus (across land class 4, 5 and 6.1) given by the ClimateXchange report referenced in the policy statement. Our analysis used a set of similar restrictions including slope, land cover categories, designations for environment, history and landscape, peat, and used data from the ELUM model, which is ground truthed [32]. We calculated that on Land capability 4 you could produce 6,410,830 tons per year of Miscanthus and SRC Willow assuming the best crop is planted in the best place, representing an average yield of 12.26 Tons per ha and occupying 522,993 ha. On land capability 5 this would be 5,933,627 tons per year with an average yield of 12.96 tons per hectare, occupying 457,961 ha.

This raises some questions about land exclusions, and about how we decide where biomass crops will be grown. Given that we would choose to target bioenergy crop production in places where it displaces high GHG agricultural activity or promotes net soil organic carbon sequestration, in some areas it may therefore be beneficial to forego food production if it contributes to net zero ambitions. Although the choices about exclusion criteria used in the policy statement’s modelling are sound, it must be recognised that they may impose significant costs on the system with the assumption that this cost is justified to deliver a better outcome for society. For example, previous work at UK scale indicates that exclusion zones such as national parks when applied to bioenergy crops can impose an additional cost on certain pathways that may cost billions of pounds or make certain pathways infeasible [33]. Such assumptions place a lower bound on the economic value on certain areas (i.e. national parks). There are two assumptions here that may not hold. Firstly, designated areas represent areas of the highest environmental quality and so should be excluded. This may not be the case. For example, numerous reports examining important areas within national parks such as SSSI’s (Sites of Special Scientific Interest) find that they are in a poorer condition that those outside the parks. This reflects the role of national parks as much in the preservation of cultural heritage. As such it asks the question of the extent to which bioenergy crops might be produced within these landscapes in a way that is sympathetic to them and will have public support. The second assumption is that bioenergy crops will always have a negative impact and so should be restricted to lower grade agricultural land. Again this implicit assumption does not hold with significant evidence of the benefits of some form of conversion to bioenergy crops [34, 35].

At the broad scale the economic benefits associated with other ecosystem services such as pollination or flood mitigation are unlikely to be large enough to significantly alter the most desirable deployment patters (which will be based on carbon and GHG emissions) but at local scales these could be important and it is unclear whether there is sufficient granularity in the spatial framework to be able to make such local decisions. For this reason, it might become increasingly important to think about local implementation. Where in specific farms

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etc might conversion of the land deliver environmental benefits in part of the farm? How might this be integrated into environmental schemes better?

Sustainable and strong domestic supply chains for biomass in Scotland are important, but the potential role of imported biomass should not be ignored [27, 36, 37]. Scotland has significant geological storage potential compared to other regions of the world, but there are other regions of the world with greater potential for biomass production (e.g., more land, higher yields). Imported feedstocks can also offer a lower cost than some domestic supply chains, something which cannot be ignored given the ongoing questions around the cost of the net zero transition [38]. The challenge is that international supply chains are harder to govern in terms of the sustainability risks, particularly where they are not transparent. Enforceable and rigorous sustainability criteria are therefore particularly important if imported biomass is to be utilised in Scotland, and so the opportunity for improved sustainability governance through the cross sectoral sustainability framework promised in the Biomass strategy must be a priority [1, 2, 27, 39].

Question 8. What would encourage you to use biomass from domestic perennial energy crops as a feedstock?

It is improtant to recognise that different biomass technologies can utilise different feedstocks, so not all will necessarily be suited to conversion of perennial energy crops. Currently, perennial energy crops that are grown in the UK are mostly used in combustion in boilers, but this will be impacted by the priorities laid out in the policy statement. Technological development may broaden the range of applications of energy crops at commercial scale.

Before they construct new bioenergy plants capable of using biomass from perennial energy crops industry will likely need to be sure that they will be able to access sufficient feedstock in the future, and so widespread use may not develop until planting begins to increase.

Perennial energy crops can tend to require fewer agricultural inputs than arable crops, and thus their production tends to have lower GHG emissions. Policy frameworks that demand minimum GHG savings from a bioenergy system (or impose limits on the maximum carbon emissions from a renewable energy system) would encourage the use of feedstocks with lower embodied emissions such as perennial crops, as long as frameworks did not explicitly exclude perennial energy crops (as is the case for the SAF mandate). Harmonised approaches to sustainability governance which encourage biomass systems that avoid negative impacts but also encourages systems that deliver sustainability benefits, could also encourage the use of some of these feedstocks.

Question 9. What are the opportunities or challenges to growing energy crops and what would encourage planting at a commercial scale in Scotland?

Planting perennial energy crops, such as Miscanthus, can provide ecosystem benefits such as soil health improvement, biodiversity support, water regulation, and flood defence, and requires fewer inputs such as fertilisers and pesticides compared to conventional crops [34, 35, 40-42]. These benefits are dependent on the specific crop, the planting location, and management practices, and potentially scale [34, 35, 43]. Energy crops can be cultivated on marginal land to avoid competition with food crops and to minimize biodiversity impacts [44]. Integrating energy crops into existing systems can also enhance farm resilience and diversify income.

Previous activities engaging with land managers and other stakeholders has indicated several barriers to energy crop deployment [45, 46]. Economic barriers area particular

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challenge. Currently, energy crops often cannot compete economically with other land uses. There are concerns about cash flow and the long-term investment needed and energy crops are often seen as economically risky, especially given that markets demand is still limited. Markets and crop production will have to co-develop, because it seems unlikely either will grow significantly in the absence of the other.

Social barriers include negative perceptions of energy crops among the public and farming community, and a lack of communication regarding their benefits, which limits uptake. There are also knowledge gaps and equipment and infrastructure needs (e.g., nurseries, and planting or harvesting equipment) that pose a challenge to the practical deployment of biomass crops at a commercial scale.

Lack of consistency between different government strategies or policies, and lack of long-term policy certainty about the biomass sector, are also a barrier to increased planting of biomass crops. This is a real challenge because biomass and bioenergy cuts across many sectors, and thus aspects are covered by different government departments, and some is devolved to Scottish Government and some not.

The introduction of novel biomass crops could also support future bioenergy demands. A Supergen Bioenergy Hub workshop examining these novel biomass crops suggested that some may have useful properties such as tolerance of future climate change and extreme weather and they can offer diverse integration opportunities into current farming and forestry practices [47]. However, there are uncertainties with novel biomass crops, including knowledge gaps on each species, predicting the impact of future climates on crop yields, and soil health and more research and independent scientific verification is needed to properly assess these novel biomass crops [47].

The above suggests a number of routes to increasing planting of perennial energy crops [45]:

- Greater clarity in terms of the future of biomass, synergy across different policies and government departments, and integration of biomass into land-use, energy, and net zero policies.
- Measures that support market development and demand.
- Further research to reduce barriers, for example reducing establishment cost and providing evidence on environmental impacts and ecosystem service delivery.
- Targeted interventions to overcome economic challenges and cash flow issues, such as subsidies, tax incentives, and grants.
- Support to overcome knowledge barriers and provide independent advice for land managers and farmers.

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