Department for
Business, Energy
& Industrial Strategy

Biomass Policy Statement

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About this document

Executive Summary

The Government is developing an ambitious plan to accelerate the decarbonisation of the economy across all sectors. The Net Zero Strategy has set out the actions we will take to deliver on the UK's carbon budgets and 2030 Nationally Determined Contribution (NDC) and sets out our vision for a decarbonised economy in 2050. Central to achieving net zero by 2050 will be a transition to wide-scale deployment of low carbon technologies across all sectors of the economy, as well as a transition to low carbon ways of living and operating by individuals and businesses.

The Net Zero Strategy set out that achieving net zero involves a move away from fossil fuels and growth in low carbon fuels, such as hydrogen, improving energy and resource efficiency, reducing demand for energy and carbon-intensive resources, delivering greenhouse gas removals (GGRs) at scale, and changing the way we use our land to support carbon sequestration and clean energy production among other things. Biomass has a role to play in all of these areas and is a vital resource for the key green technologies and energy carriers highlighted as necessary for net zero: low carbon electricity, hydrogen, carbon capture, and bioenergy.

In this policy statement Government provides a strategic view on the role of biomass across the economy in the medium- to long-term. We set out key principles we have established for the biomass priority use framework for the short- (2020s), medium- (by 2035) and long-term (by 2050) to deliver towards net zero. Key principles across these timelines include:

- compliance with sustainability criteria and waste hierarchy principles;
- contribution to carbon budgets and net zero considering feedstock availability, life-
- cycle greenhouse gas emissions, and cost-benefits; and
- biomass to be used with carbon capture utilisation or storage where feasible, otherwise used only in hard-to-decarbonise sectors with limited or no low carbon alternatives.

We expect biomass use to be prioritised according to these principles, in areas, such as sustainable aviation fuel and hydrogen production helping to decarbonise greenhouse gas (GHG) intensive sectors such as aviation and industry, and as a fossil fuel replacement to make valuable products from materials further down the waste hierarchy and provide a circular economy benefit. Over time, as the technology develops, we expect biomass use to also be focused in applications that can deliver negative emissions through Bioenergy with Carbon Capture and Storage (BECCS), while also supporting energy security.

This document sets out key policy aims for biomass use across the economy, such as in electricity, heat, transport and industry sectors. It also discusses the role of BECCS in delivering negative emissions in the power, industry, renewable fuel and hydrogen industries, which, if adopted early, could provide an opportunity to help meet our NDC in 2030, and

Carbon Budgets 5 and 6. In this document we outline our intention to develop a business model to support BECCS in the power sector and develop a BECCS policy that only rewards genuine negative emissions – meaning that BECCS applications must only use sustainable biomass that removes more GHG emissions from the atmosphere than it creates.

Finally, as part of this statement, we present a summary of research and innovation (R&I) gaps that need to be addressed to enable biomass, bioenergy technologies, and the wider bioeconomy to deliver net zero. Key R&I gaps identified and being addressed via government and research council projects include, among others, ensuring flexibility in sourcing and using biomass to achieve the greatest possible GHG abatement in a cost and performance competitive way and a technology agnostic approach to biomass; and technological developments to allow deployment of BECCS in a variety of ways, including alongside anaerobic digestion and fermentation, and without the need for CO_2 transport and storage networks. In addition, air quality impacts of biomass use, especially in emerging areas, need to be better understood and mitigation measures developed to ensure we do not compromise our ability to meet statutory air quality ceilings.

We intend to publish a Biomass Strategy in 2022 that will set out in detail the Government's view on how biomass can best contribute towards net zero across the economy. It will outline the policies needed to deploy biomass in the priority areas for net zero, alongside the frameworks to support these policies, such as sustainable supply of resources, air quality requirements, and GHG accounting mechanisms.

Biomass production and use spans many sectors of the economy; therefore, its use features in other Government Strategies that have been published, or are due to be published, setting out sectoral plans for decarbonisation and meeting net zero. Recently published strategies and UK Government plans, such as the Industrial Decarbonisation Strategy, the UK Hydrogen Strategy, the Heat and Buildings Strategy, the Transport Decarbonisation Plan, and the England Tree Action Plan, outlined how individual sectors are expected to contribute to climate mitigation and adaptation, with all touching on either the production or use of biomass. The devolved administrations have also published several strategies and plans where production and use of biomass in individual sectors is reflected (e.g., Scottish Government Heat in Buildings Strategy).

Earlier this year we launched a call for evidence to seek the public's view on the role of biomass in achieving net zero, and some initial views are reflected here. We will use the information gathered in the call for evidence to inform the development of the Biomass Strategy. Over the coming months we will continue to engage with stakeholders and the public to develop a comprehensive and detailed strategy with clear actions for the coming decade.

Scope

In the Biomass Strategy we will consider how biomass can best support decarbonisation across the economy, help create new jobs, tackle climate change, and improve air quality and the environment, supporting the green industrial revolution the Prime Minister set out in his Ten

Point Plan[1]. We will explore how biomass can deliver GHG reductions and/or GHG removals in the power, heat and buildings, industry, transport, agriculture and land use, land use change and forestry (LULUCF), and bioeconomy sectors. This policy statement is the first step in considering these aims and objectives.

Feedstocks considered include domestic and imported biomass feedstocks such as conventional food and feed crops, perennial energy crops (Miscanthus and short rotation coppice (SRC)), short rotation forestry (SRF) and wastes, products, agricultural residues, forest residues, residues from processing, and marine-based feedstocks alongside other potential novel feedstocks.

Uses of biomass in scope of this statement include electricity generation, heat generation, low carbon fuel production (including hydrogen), materials, chemicals and bioproducts production, and the deployment of BECCS. The strategy will set out a detailed priority use framework for biomass that will outline the best use of sustainable biomass across the economy to achieve net zero, based on available evidence, taking into account key environmental, social and economic metrics.

We are also considering how UK technology, research and innovation can support the changes to the way we source, process, and use biomass to ensure we benefit from the opportunities these bring to the UK.

Individual sectors have specific plans to enhance resilience to climate risks as set out in the UK Climate Change Risk Assessment (CCRA). The UK's National Adaptation Programme sets out the actions that government and others will take to adapt to the challenges of climate change. Climate adaptation is outside the scope of this policy statement and the Biomass Strategy.

Geographic extent

The Biomass Strategy will take a cross-cutting approach to delivering a comprehensive view on biomass for net zero and will therefore touch on policies reserved and devolved. This paper sets out a high-level summary of the UK Government's position on the role of biomass for net zero and sets out specific information about policies in England. All parts of the UK have a significant role to play in delivering net zero, and the devolved administrations have a range of plans and policies in place to reach their own statutory targets and contribute to the UK's net zero target. We will continue to work with the devolved administrations as we develop the policies and proposals set out in this policy statement and in the strategy, and to support research and innovation and the deployment of biomass technologies and biomass production.

[1] The Ten Point Plan for a Green Industrial Revolution (2020) https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

Structure of this document

This document is our next step in developing the policy proposals and a comprehensive plan for biomass sourcing and production and biomass use to best contribute to decarbonising the UK economy.

Chapter 1 outlines the biomass feedstocks in scope of the Biomass Strategy, our plans to refine our understanding of feedstock availability and our commitment to review and improve our sustainability criteria.

Chapter 2 sets out our overarching priority use principles for biomass use over the short-, medium- and long-term, and provides an overview of the role biomass already plays across sectors of the economy in line with these principles. In addition, this chapter also sets out our view on the role BECCS can play in contributing to net zero and the potential routes for BECCS deployment.

Chapter 3 describes the key research and innovation areas that need to be addressed to enable biomass, bioenergy technologies, and the wider bioeconomy to deliver net zero. Additionally, we present information about recent and upcoming research and innovation programmes addressing some of these challenges to highlight the progress made in these areas.

Finally, Chapter 4 presents information about the next steps for the strategy development and the actions we will take for the successful delivery of the strategy.

Chapter 1: Biomass Feedstocks

Biomass covers a broad and varied range of materials, and the current biomass resource supply is diverse. We define biomass as any material of biological origin (including biodegradable fraction of products, wastes and residues from biological origin). Sustainable biomass can be used as a low carbon alternative to fossil fuels for energy (heat, power, transport fuels), including as an energy source for industrial processes or as a raw material used to make products (such as bio-based plastics and materials from foundational industries) – see Figure 1 showing some examples.

For this policy statement and the forthcoming Biomass Strategy the following biomass feedstock types are in scope: conventional food and feed crops, perennial energy crops (Miscanthus and short rotation coppice (SRC)), short rotation forestry (SRF) and wastes, products (incl. forest derived products)[2], agricultural residues, forest residues, and residues from processing, as well as marine-based and novel feedstocks. Each type will have different sustainability implications and barriers to deployment.

Biomass is considered a renewable, low carbon energy source. This is because its inherent energy comes from the sun and can regrow in a relatively short time, unlike fossil fuels, such as coal; and the carbon that is released from the organic material was sequestered recently from the atmosphere, compared to fossil fuels where the carbon was sequestered hundreds of millions of years ago. Bioenergy with Carbon Capture and Storage (BECCS) can provide net negative emissions because the carbon captured in plant growth is captured, stored and

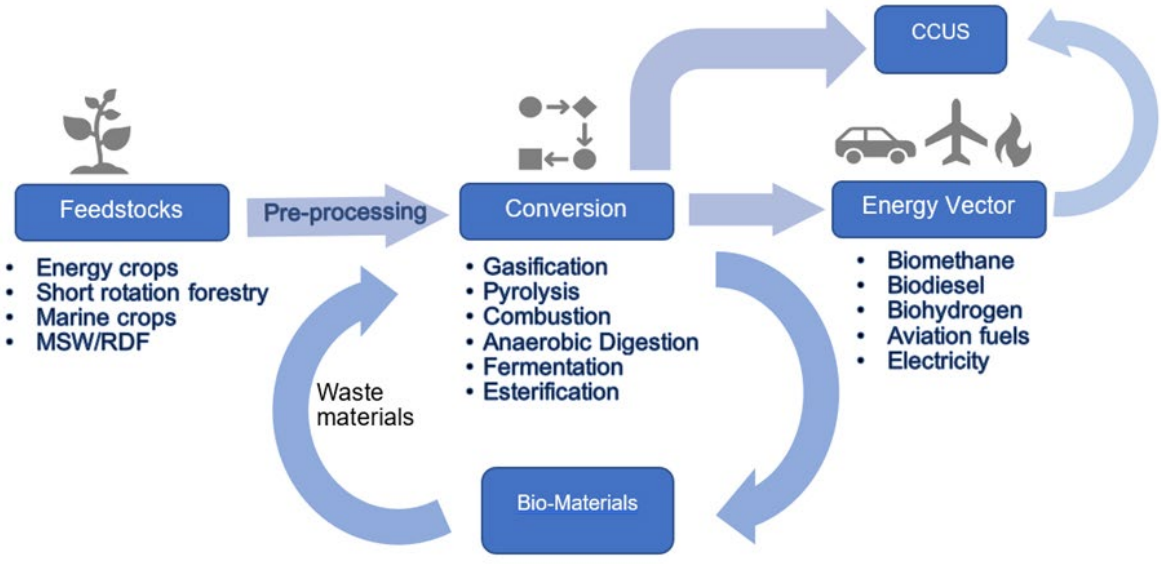


Figure 1:Schematic diagram representing potential routes for biomass processing and use across the economy.

[2] The use of other types of biomass products, i.e. a product of economic value or use that could lead to indirect impacts if used for energy use (e.g. distillers grain which could be used for animal feed) is not encouraged for bioenergy uses.

removed from the atmosphere, therefore there is a net decrease in atmospheric carbon. The Net Zero Strategy[3] has outlined that greenhouse gas removals (GGRs), which include BECCS, are essential to compensate for residual emissions from the hardest to decarbonise sectors, such as aviation, agriculture, and heavy industry.

Sustainable biomass

We are committed to using only sustainable biomass, whether derived from international or domestic sources. The UK has stringent sustainability criteria in place for the power, heat and transport sectors, and supports the use of biomass only where it is demonstrated to be sustainable and deliver genuine greenhouse gas (GHG) savings compared to fossil materials**.**

Sustainability requires an understanding of the life-cycle GHG emissions, biodiversity, ecosystem services (e.g., soil and water quality) and social issues (e.g. land tenure, labour rights). Bioenergy generation across the power, heat and transport sectors currently all have strict sustainability criteria[4][5][6] that must be followed to prevent unintended consequences of biomass use that could negatively affect biodiversity, GHG savings, the health and vitality of ecosystems, and ecosystem services. We define sustainable biomass as biomass that is cultivated, harvested and processed in line with these sustainability criteria.

The UK sustainability criteria for biomass use are some of the most stringent in the world. The sustainability criteria include protections for forests, peatland and wetland to ensure that the carbon stock, the area, and the health of the forest are maintained. The sustainability criteria also include GHG emission savings criteria, requiring that life-cycle emissions savings associated with the biomass use (production or cultivation, harvesting or collection, transportation, and processing of biomass) meet certain thresholds to ensure they deliver significant savings compared to any fossil counterparts. To promote the highest possible GHG savings and to reduce (direct and indirect) environmental risks, support schemes like the Renewable Transport Fuel Obligation (RTFO) also contain additional incentives for biofuels derived from wastes and residues and cap the contribution of food and feed crops. For biomass used in transport, risks of indirect land use change are also taken into account and included in regular reports on GHG savings.

The sustainability criteria do not cover air pollutant emissions as these are primarily associated with the use of biomass in heat and energy generation rather than with production. Air quality impacts associated with the use of biomass are primarily controlled through regulation and the design of support schemes as covered in Chapter 2.

We are reviewing our existing sustainability criteria and the current governance mechanisms across the transport, heat and energy sectors to understand any gaps, international and cross-

[3] BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy
[4] The Renewables Obligation Order 2015 https://www.legislation.gov.uk/ukdsi/2015/9780111138359/contents
[5] The Renewable Heat Incentive Scheme Regulations 2017 https://www.legislation.gov.uk/ukdsi/2017/9780111156476/contents
[6] The Renewable Transport Fuel Obligations Order 2007 https://www.legislation.gov.uk/uksi/2007/3072/contents

sectoral harmonisation opportunities, including options to incorporate sustainability criteria for biomass use in the wider economy, and to ensure the criteria for the sourcing of these feedstocks are in line with up-to-date scientific evidence and remain globally leading.

Understanding the sustainable biomass supply

As we look ahead to 2050 there is an increasing need to understand better what volumes and types of biomass the UK can expect to have access to from both domestic and international sources. This is a key question which the Biomass Strategy will aim to address.

Sustainable biomass is a finite resource and there is uncertainty about the makeup and amount of this resource in the near and long-term future. There is evidence to suggest that there is scope to increase the supply of sustainable biomass feedstocks by 2050 from both global and domestic sources. Analysis by the Climate Change Committee (CCC) in their 6th Carbon Budget report[7] suggests that there is potential to increase the current levels of imported biomass by threefold by 2050 depending on demand, but it would require strong global sustainability governance. In addition, the CCC's analysis also showed that in the UK between 0.7 million and 1.4 million ha of land could be dedicated to energy crop production, significantly increasing domestic biomass feedstock production. The Biomass Strategy will refine the role of domestic and imported biomass through building a stronger evidence base around its supply, demand and sustainability, and explore how the UK can continue to be an attractive destination for sustainable biomass feedstocks and biomass-based products.

Around a third of existing bioenergy feedstock/fuel demand (across the power, heat and transport sectors) comes from net imports, the majority of which is wood pellets produced from forestry residues that are used in low carbon electricity generation. As the UK transitions to net zero, our current modelling suggests that future domestic supply of sustainable biomass could meet around 10% of UK energy demand by 2050. This is based on our existing UK and Global Biomass resource model[8] first developed in 2011, which estimates the potential sustainable bioenergy resource that may be available to the UK to 2050. This model has played a key role in government's biomass and net zero policy development to date including supporting the development of the 2012 Bioenergy Strategy. However, biomass use has since changed in many important respects and there is now more up to date evidence around the amount of sustainable biomass that may be available to the UK currently and in the future from both domestic and international sources.

Biomass is now part of a diverse mix of renewable technologies supporting our decarbonisation efforts across the power, heat and transport sectors and there is a need to better understand where it can offer the greatest economic, environmental and social benefits compared to alternative technologies. Biomass also has the potential to help unlock emission reductions in the industrial sector, e.g. in heat generation in industrial processes, supporting their decarbonisation targets. There is also an increased interest in the role that biomass as a

[7] CCC (2020) Sixth Carbon Budget report https://www.theccc.org.uk/publication/sixth-carbon-budget/
[8] BEIS (2017) UK and Global Bioenergy Resource Model https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model

raw material can play to support decarbonisation of downstream supply chains in the wider economy as there are other sectors where there are no or limited low carbon alternatives to fossil fuels, for example, in the plastics and foundational industries (such as chemicals, cements, ceramics, glass, metals & paper)[9]. However, further analysis to better understand the potential of biomass in these sectors is needed. The CCC in their report on 'Biomass in a low carbon economy'[10] highlight this shift in the role of biomass stating that "sustainably harvested biomass can play a significant role in meeting long-term climate targets, provided it is prioritised for the most valuable end-uses".

Through the development of the Biomass Strategy, we will refine our estimates of biomass supply and demand to support the development of a detailed priority use framework which will set out where and how biomass can best support net zero, taking into account key environmental, social and economic metrics.

1.1 Feedstock availability to support future biomass use

To support the development of the priority use framework we are investing in the update of the UK and Global Bioenergy Resource Model to reflect the changing landscape of biomass use, ensure that it reflects the most up to date evidence base and remains flexible to the new evidence emerging in the future. As part of this we will update our evidence and assumptions on the biomass feedstocks in scope of the strategy, including reviewing and incorporating the evidence received through our recent call for evidence[11].

The following subsections consider the main biomass feedstocks that are used or could be used for energy (heat, power, transport fuels) and non-energy uses (building materials, chemicals etc.).

Biogenic wastes and residues

We will review the amount of organic waste, organic residue, and by-products of organic fraction of waste resource that could be available from the UK and globally. Wastes refer to the organic fraction of waste resources such as landfill gas, sewage gas, biogenic fraction of municipal solid waste and farm and food wastes. Residues refer to materials that arise alongside the cultivation of crops, of forestry, or from industrial processing. The predominant examples are forestry residues, e.g., low value pulpwood, sawmill residues, which are a result of conventional forest management, and agricultural residues produced from harvesting of arable crops (e.g., straw). There are also wastes and residues that are generated in industries and processing relating to animal husbandry, aquaculture, and fisheries.

[9] BEIS and Defra (2019) Standards for biodegradable, compostable and bio-based plastics: call for evidence https://www.gov.uk/government/consultations/standards-for-biodegradable-compostable-and-bio-based-plastics-call-for-evidence

[10] CCC (2018). Biomass in a low-carbon economy https://www.theccc.org.uk/publication/biomass-in-a-low-carbon-economy/

[11] BEIS (2021) Role of biomass in achieving net zero: call for evidence https://www.gov.uk/government/consultations/role-of-biomass-in-achieving-net-zero-call-for-evidence

The majority of biomass sourced from the UK comes from these biogenic waste and residue resources. In addition to uses as a biomass feedstock for energy uses, these waste and residue resources also have other non-energy uses. For example, an agricultural residue like straw could also be used in animal feed, bedding and to improve soil quality. The strategy will look at the best use of this resource to support our decarbonisation goals and will be guided by the waste hierarchy principles. The waste hierarchy principles aim to minimise waste, maximise value of waste as a resource and minimise environmental impact of waste management. In addition, the use of wastes as a biomass feedstock will continue to be in line with the individual strategies and policies in place across England and the devolved administrations. In England, the Resource and Waste Strategy[12], published in 2018, sets out how we will preserve material resources by minimising waste, promoting resource efficiency, and moving towards a circular economy. It includes commitments towards zero avoidable waste by 2050, near elimination of food waste to landfill by 2030, no more than 10% municipal waste to landfill by 2035 and 65% recycling of municipal waste by 2035.

There are similar strategies currently in place across the devolved administrations. The Scottish Government have set out priorities for moving towards a more circular economy and a pathway to deliver its world leading climate change targets in the Circular Economy Strategy[13], and in the update to the Scottish Government's Climate Change Plan[14]. These include commitments to end the landfilling of biodegradable municipal waste, recycling 70% of all waste and landfilling no more than 5% of remaining waste by 2025. In Scotland, local authorities are required to provide separate food waste collections in non-rural areas and businesses producing more than 5kg must take all reasonable steps to ensure a separate collection of their food waste. The Scottish Government through its Food Waste Reduction Action Plan will continue to take steps to reduce food waste, delivering against its target to reduce food waste by one third by 2025 (against a 2013 baseline).

We committed in the Resource and Waste Strategy to require the separate collection of food waste. The Environment Bill will require household food waste to be separately collected from all households and non-household municipal premises in England. Local authorities will need to collect this waste on a weekly basis. This food waste will be collected for recycling, which will increase the quantity of food waste collected for use as a biomass feedstock and reduce the amount of food waste which ends up in landfill. However, in the longer term (by 2050), greater waste prevention may offset this increase as the level of biomass feedstocks intercepted from the waste stream is expected to reduce. There is already a commitment to halve food waste by 2030. We expect that biogenic wastes will be prioritised for use in areas that align with the key priority use principles outlined in Figure 2 in Chapter 2.

In the transport sector, wastes and residues already account for more than two thirds of the feedstocks used to produce our renewable fuel supply (comprising 69% in 2019). Used

[12] Defra (2018) Resources and waste strategy for England https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england
[13] Scottish Government (2016) Making Things Last: A Circular Economy Strategy for Scotland https://www.gov.scot/publications/making-things-last-circular-economy-strategy-scotland/
[14] Scottish Government (2020) Securing a green recovery on a path to net zero: climate change plan 2018–2032 – update https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/

cooking oil has been the single most popular feedstock, accounting for 54% of renewable fuels supported in the UK in 2019 (and 79% of all biodiesel supply)[15]. The list of wastes and residues that can be used in biofuel production is extensive[16]. Grease removed from wastewater ("brown grease") and fats, oils and grease removed from sewers can be used in the production of biodiesel, as can food waste, waste pressings from vegetable oil, wastewater/sludge from palm oil production, or contaminated materials (e.g. from meat rendering processes or oil refining) that cannot be used in any products for human or animal consumption. While bioethanol is still mainly produced from crops, waste starch slurry has become an important feedstock over recent years and bioethanol that has been used for cleaning or in medical applications might also find its way back into the production process. Food waste, municipal organic waste, roadside grass, husks, residues from sugar beet processing, sewage sludge and wet manure were also feedstocks for biomethane used in transport in 2019.

Forestry residues and waste wood make up the majority of biomass supply used in electricity and heat generation in the UK, mainly in the form of imported wood pellets. As part of the Biomass Strategy, we will review the amount of forestry residues that could be available from the UK and globally as a source of sustainable biomass. We will also consider where environmental and social aspects of the sustainability criteria could be strengthened in line with the most up to date scientific evidence. Future availability of this feedstock from domestic sources will depend on a variety of factors, including the future landscape of the UK's woodlands and how these are managed in line with the individual tree policies across England and the devolved administrations.

In the heat sector, the non-domestic Renewable Heat Incentive (RHI) (now closed to new applicants) and the upcoming Green Gas Support Scheme (GGSS) (due to launch in Autumn 2021) both include a minimum requirement that 50% of biogas or biomethane (by energy content) must be produced using waste or residue feedstocks. With increases in future volumes of food waste expected from separate collections, this threshold may change, with the potential to increase the threshold if evidence around available food waste volumes and anaerobic digestion capacity indicates that this is appropriate. This is subject to a review which we have committed to mid-way through the GGSS.

Domestic arable crops

Our evidence on the amount of domestic arable (food and feed) crops for bioenergy use that could be available for bioenergy purposes will also be updated. Food and feed crops are currently being used for a range of bioenergy uses, and many conventional technologies for bioenergy conversion were developed with food and feed crops in mind. For example, wheat, maize and sugar beet are used in UK bioethanol production and maize and forage grasses in anaerobic digestion for the production of biomethane. For farmers, the opportunity

[15] DfT (2020) Renewable fuel statistics 2019: Final report https://www.gov.uk/government/statistics/renewable-fuel-statistics-2019-final-report

[16] A full list of feedstocks assessed to date under the RTFO is available here: https://www.gov.uk/government/publications/renewable-transport-fuel-obligation-rtfo-guidance-2021/list-of-feedstocks-including-wastes-and-residues-year-2021--2

to sell into bioenergy offers a secondary market for their surplus or lower quality crops, and associated agricultural residues. In 2019, 96,000 hectares of agricultural land in the UK were used to grow crops for bioenergy. This area represents just over 1.6% of the arable land in the UK, of this, 20% was used to produce feedstocks for biofuel (biodiesel and bioethanol) in the UK road transport market. The remaining 80% was predominantly used for producing feedstocks for heat and power production including 67,000 hectares of maize grown for anaerobic digestion in England[17].

However, some bioenergy support schemes now limit the contribution food and feed crops can make to any targets established under different schemes. This is to prevent land being diverted from food to fuel production on a large scale. With global food demand still growing, such a change in land use could distort markets and have severe impacts. While from a local perspective, the change might seem small with farmers simply switching from selling into one market to another, the overall demand for the original food or feed product will still need to be met to support food security. This in turn encourages production of a comparable food and feed crop elsewhere. This production could occur locally or indeed anywhere around the world, and in the worst cases, the demand will be met from newly cleared lands driving further deforestation. Should the use of food and feed crops for energy purposes – either directly or indirectly – lead to the destruction of carbon sinks such as primary forest and peatland, this can seriously undermine any carbon savings associated with their bioenergy use in the first place and hence it is important to discourage such land use change. For example, when factoring in risks of indirect land use change impacts, some biofuels from food and feed crops (in particular oilseeds) may perform worse than fossil fuels on a life-cycle basis.

For any sustainable production, potential detrimental impacts on water and soil as a consequence of intensive production will also need to be addressed. For example, crops like maize, whether grown as food or for energy generation, present risks for soil damage, erosion and associated run off to water, and are relatively poor crops for biodiversity. As such, the extent to which they are grown also needs to be monitored carefully.

Provided their use leads to significant GHG savings and other environmental risks and competition with food production are addressed, arable (food and feed) crops may continue to play a limited role in the bioenergy sectors. While the direct use of food and feed crop might be limited to prevent competition with food production, there can also be a significant role for residues from crops in bioenergy production, subject to them meeting the required sustainability criteria.

Perennial energy crops and short rotation forestry

We will establish the amount of land that could be used in the UK for perennial energy crop production and for short rotation forestry (SRF). Existing biomass support schemes (Renewables Obligation, Contracts for Difference, RHI & RTFO) already support the use of perennial energy crops such as short rotation coppice and Miscanthus grown specifically for

[17] Crops grown for bioenergy un the UK 2019 statistics available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943264/nonfood-statsnotice2019-10dec20v3.pdf

bioenergy purposes and as a material. However, only a small land area (~10,000 hectares) is cultivated with perennial energy crops in the UK at present, and this is mainly used for heat and electricity generation. Currently, there is little to no use of perennial energy crops for low carbon fuels supported under the RTFO due to a lack of commercial-scale processing capacities to convert these resources cost-efficiently into fuel. At present, there is a negligible area of SRF in the UK.

The availability of land and location of demand are two key spatial factors that will influence the future volumes of perennial energy crops and SRF that are cultivated in the UK. For example, cultivation may need to be sited in close proximity to the end use to ensure that supply chains are economically viable and to minimise the GHG emissions associated with the transportation of the feedstocks. Though SRF and perennial energy crops can be grown on low grade agricultural land, there may still be competition for the land, for example, for traditional forestry, or renewable energy (particularly on farm solar), housing and infrastructure, and grazing land. There are emerging opportunities for multifunctional land use: biomass could be grown in agroforestry systems and some land may be available in the future from responsible management of lowland peat (with biomass-friendly measures such as paludiculture currently in development).

Careful spatial planning is required to deliver the benefits of perennial energy crops and SRF whilst minimising detrimental natural capital impacts. In some cases, biomass production (e.g., arable crops for energy uses) could pose risks to the environment, as highlighted in the section above, and therefore require careful planning to ensure they are grown in suitable locations. In other cases, perennial energy crops could help support biodiversity or reduce pollution burdens when compared with annual crops. There could also be visual impacts on agricultural landscapes which could restrict planting acceptability in certain locations.

The CCC's 6th Carbon Budget report highlighted the significant potential for perennial energy crops and SRF to contribute towards our carbon budget targets by increasing soil and biomass carbon stocks while also delivering other ecosystem benefits. In their balanced pathway, the CCC suggests that up to 708,000 hectares of land could be dedicated to energy crop production, which has led to an increased interest in the role of perennial energy crops and SRF as biomass feedstocks to deliver GHG savings in the land use and energy sectors. The Defra land use net zero programme, which is currently building a spatial understanding of the land use trade-offs across a number of policy areas, will help determine the potential scale of future availability of domestically grown biomass and their potential for delivering GHG savings in a landscape where land use change will need to be optimised for multiple benefits. This programme will inform our understanding and evidence on the availability and mix of biomass feedstocks for uses across sectors.

UK-derived forest products

We will establish the amount of UK-derived forest products that could be available to the UK for uses in the wider bioeconomy in the longer term. Forest products such as timber have an important role to play in supporting GHG abatement and displacing fossil fuels to produce a range of products with stored carbon across the economy, e.g., use of wood in

construction. Future availability of this feedstock from domestic sources will depend on the nature of the woodlands established and how the UK's woodlands are managed in the future. In England, the England Tree Action Plan (ETAP)[18], published in May 2021 set out a vision for at least 12% woodland cover in England by mid-century comprising a mix of managed and un-managed conifer and broadleaf woodlands that will support biodiversity and other environmental benefits, along with providing sustainable sources of hardwood and softwood timber and woody products to contribute towards a green economy. Furthermore, the ETAP set out that over £500 million of the Nature for Climate Fund would be spent on trees and woodlands between 2020 and 2025 to at least treble woodland creation rates by the end of this Parliament; this would reflect England's contribution to meeting the UK's overall target of planting 30,000 hectares per year by the end of this Parliament. ETAP also committed to explore a long-term statutory tree target in England within the public consultation on Environment Bill targets.

There are similar strategies and policies in place across the devolved administrations which will also have an impact on the future domestic supply of this feedstock. The Scottish Government has committed to an ambitious target of increasing woodland cover from around 19% of the total area of Scotland, to 21% by 2032 by increasing annual woodland creation from the current level of 12,000 hectares per year in 2020/21 up to 18,000 hectares per year by 2024/25 of which 4,000 hectares would be native woodland[19]. The Welsh Government has committed to tree planting targets of 43,000 hectares by 2030 and a total of 180,000 hectares by 2050[20].

The ETAP will be supported through the Nature for Climate Fund which will enable a new programme of planting by England's community forests, a new demand-led grant scheme (England Woodland Creation Offer launched in June 2021) and planting on vacant and derelict land. Additional funding of £124 million for the Nature for Climate Fund was announced in the Net Zero Strategy[21]. We will also provide funding for new leasehold woodland creation projects led by Forestry England and develop new regionally based Woodland Creation Partnerships, as well as provide support to bring more woodland into management. In most circumstances, under-management of woodlands can result in declining habitat quality, whilst woodlands managed for timber will deliver greater environmental and social benefits while also creating economic opportunities. The resulting increase in managed woodland cover in England by 2050 could also provide a source of domestic biomass supply in the form of forestry residues created as part of the management practice.

[18] Defra (2021) England Tree Action Plan 2021 to 2024 https://www.gov.uk/government/publications/england-trees-action-plan-2021-to-2024
[19] Scottish Government. Scotland's Forestry Strategy 2019-2029 https://www.gov.scot/publications/scotlands-forestry-strategy-20192029/pages/2/
[20] Welsh Government (2021) Written Statement: Trees and Timber https://gov.wales/written-statement-trees-and-timber
[21] BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy

Marine-based and other novel feedstocks

Evidence suggests that marine-based feedstocks, such as algae, seaweed, and kelp, can potentially play an important role as sustainable biomass feedstocks for the production of liquid biofuels, chemicals, high-value products, and bioenergy (through anaerobic digestion and gasification). The use of these feedstocks in pyrolysis, gasification, torrefaction, and combustion have been demonstrated globally, while seaweeds are already used in the materials and chemicals sector.

Separately, crops like hemp have great potential as a raw material in products, such as insulation, helping to decarbonise the building and construction sector. The BEIS Biomass Feedstocks Innovation Programme[22] is providing funding for five projects on algae, covering seaweed and microalgae, one on hemp, and two on semi-wild crops, such as heather and bracken. The projects are exploring the potential of these crops to be used as biomass feedstocks.

[22] Biomass Feedstocks Innovation Programme is providing £4 million in funding to 25 organisations to develop strong project proposals that will deliver commercially viable innovations in biomass production.

Chapter 2: Biomass use in a low carbon economy

Sustainable biomass is a versatile organic material, with a wide array of applications. It can be used as a lower carbon substitute for fossil-fuel based products in applications from power generation to hydrogen production and even as a substitute in materials and chemicals. Since the 2012 Bioenergy Strategy was published, biomass has played a prominent role in our decarbonisation efforts, primarily in the power, heat, and transport sectors, as supported by government incentives.

However, the context within which biomass is used has changed over the last decade, with our net zero target requiring the decarbonisation of all sectors of the economy. Technological advancements have led to the emergence of a greater variety of alternative low carbon technologies especially in the power, heat and transport sectors, which are becoming more affordable. Meeting our net zero targets will also depend on generating negative emissions which some biomass-based technologies have the potential to deliver. Whilst pursuing climate mitigation goals we want to ensure that the UK's decarbonisation pathways make the most of environmental, social and economic opportunities which may arise from the production and use of biomass, while also avoiding any unintended negative social, environmental and economic impacts.

Air Quality

It is vital to ensure that any negative impacts on the environment, including on air quality, from the use of biomass are fully understood and mitigated. Certain uses of biomass can impact air quality, for example ammonia emissions from digestate (a by-product of anaerobic digestion) can cause biodiversity loss and negative impacts on human health. The use of biomass for domestic or smaller industrial and commercial burning is also a significant contributor to the UK's PM2.5 levels. Depending on the type of abatement technology applied and in the absence of appropriate regulation, the expansion of biomass combustion for power generation with carbon capture and storage, could lead to significant emissions of PM2.5. The impacts of using biomass in different ways will vary depending on the fuels which are being replaced, the technologies used to clean pollutants, the scale of the plant in question, and the proximity of emissions to areas of population.

The UK has statutory ceilings in place for emissions of five of the most damaging air pollutants (including ammonia and PM2.5) and further targets on local concentrations of these pollutants. To ensure that these targets can be met, regulatory requirements that apply to the use of biomass (primarily through environmental permitting and Best Available Techniques) will need to develop over time as the use of biomass expands. Further research and innovation will also be required to ensure that impacts on air quality are better understood and improvements in abatement technologies developed. The Biomass Strategy will provide more detail on the interactions between biomass use and wider environmental commitments, and the actions being taken to ensure co-benefits are maximised.

2.1. Priority use framework

Recognising that sustainable biomass is a limited resource, it is important to ensure that biomass is prioritised within the economy where it offers the greatest opportunity to reduce greenhouse gas (GHG) emissions in 'hard to abate' sectors where there are fewer options to decarbonise through alternative low carbon technologies. To enable this and support future government policy development on biomass, it is necessary to set out a priority use framework that defines the best use of biomass across the economy in the short-, medium- and long-term towards our net zero target.

The Net Zero Strategy[23] set out that the primary method of achieving net zero is to undertake ambitious decarbonisation across society. Therefore, all biomass use (e.g. as an energy vector, as raw material in products, as part of greenhouse gas removals (GGRs), etc) needs to be alongside ambitious efforts to reduce whole supply chain emissions in line with net zero.

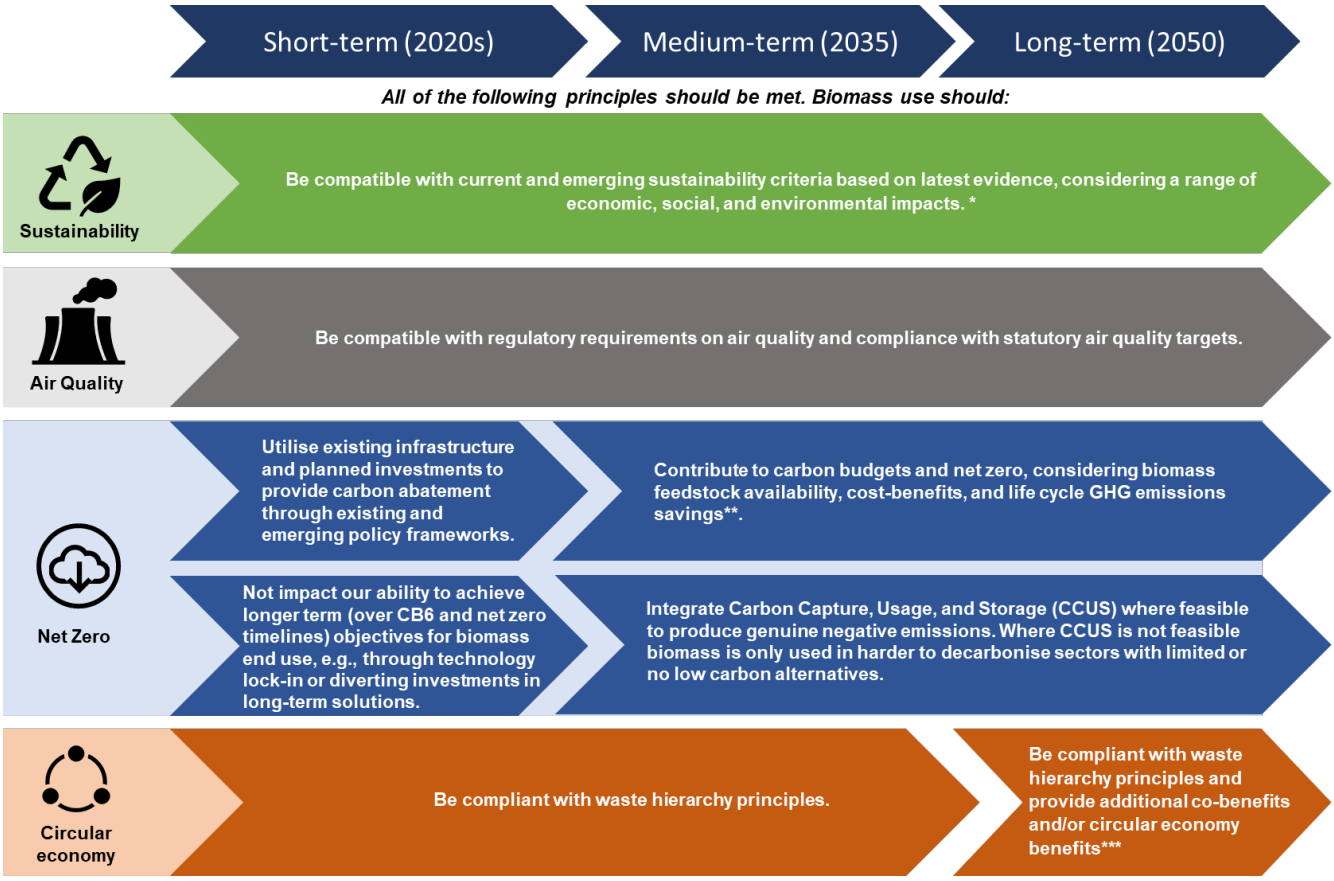
Figure 2 provides an outline of this framework, setting out the overarching principles and policy aims for biomass use in the short- (2020s), medium- (to 2035, corresponding to Carbon Budget (CB) 6 timelines) and long-term (to 2050). These have been developed with a key focus on how they can best support the delivery of our net zero target and meet wider environmental targets, including on air quality, to create a flexible framework under which the right biomass decarbonisation pathways can be developed and supported across the economy. In addition, the responses to our recent call for evidence on biomass[24] highlighted some key objectives to be included in the framework, which are as follows:

- Protection of the natural environment;
- Contributing to net zero, including the potential to generate negative emissions;
- Minimising air quality impacts;
- Maximising circular economy benefits; and
- Consideration of the role of biomass in 'hard to abate' sectors, considering alternative options.

These objectives have been reflected in the principles outlined in Figure 2. The strategy will set out a detailed priority use framework which will be developed in line with the principles and will provide an assessment of the decarbonisation potential of biomass use across various sectors. The principles listed in Figure 2 will be kept under review as we carry out further analysis and we will continue to engage with stakeholders and the wider community to build our evidence base and develop the strategy.

[23] BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy
[24] BEIS (2021) Role of biomass in achieving net zero call for evidence https://www.gov.uk/government/consultations/role-of-biomass-in-achieving-net-zero-call-for-evidence

Figure 2: Overarching priority use principles for biomass use over three timescales: 2020's, up to 2035, and to 2050.



* Further work is being carried out to review the UK's existing sustainability criteria, including exploring ways to harmonise the criteria across sectors to promote fair competition. Details to follow in the Biomass Strategy.

** Compared to GHG emissions of appropriate counterfactuals.

*** e.g., by-products are used to make other high value products which can be utilised elsewhere in the economy.

The next sections of this chapter set out the current and emerging government position on biomass uses across the economy. It sets out how biomass is currently used and incentivised across the different sectors and provides an early indication of future support in line with the priority use principles outlined in Figure 2.

2.2. Electricity

The use of biomass in energy generation in the UK's power sector has helped to dramatically reduce the use of fossil fuels. The proportion of renewable generation outstripped fossil fuels for the first time in 2020 as a result of record renewable generation. Renewable electricity now represents 43.1% of total generation (134.6 TWh), up from 36.9% in 2019. Biomass provided a key contribution to this record increase, with around 12.6% of total electricity generated from biomass in 2020. This contributed to fossil fuel generation reaching a record low (117.8 TWh), dropping from 75.4% of generation to 37.7% over the last ten years, with coal generation at just 1.8% in 2020 down from 28.2% in 2010.

The Energy White Paper set out our goal of a fully decarbonised, reliable, and low-cost power system by 2050. A low-cost, net zero consistent electricity system is most likely to be composed predominantly of wind and solar both in 2035 and in 2050. Ensuring the electricity system is reliable as well as net zero consistent means intermittent renewables need to be complemented by technologies which can provide dispatchable or baseload power, such as bioenergy.

Biomass-based electricity generation has been incentivised in the UK under the Renewables Obligations (RO), and in Great Britain under the Contracts for Difference (CfD) scheme and the Feed in Tariff (FIT), while the supplier-led Smart Export Guarantee (SEG) also includes generation from biomass. The RO and the FIT is now closed to new entrants, while the CfD and the SEG are open for new applicants. In 2020 total electricity generation from bioenergy was 39.3 TWh, most of which was delivered by facilities supported under these schemes[25]. In the upcoming CfD allocation round 4 the following biomass technologies are eligible: landfill gas, energy from waste (EfW) with combined heat and power (CHP), sewage gas, advanced conversion technologies, dedicated biomass with CHP and anaerobic digestion >5MW[26]. These schemes require generators to comply with land and GHG emissions related sustainability criteria. Generating stations report against the sustainability criteria on a monthly or quarterly basis (dependent on the scheme and project scale) and also provide an annual sustainability audit report to verify the sustainability information. Emissions are reported to the relevant parties, with the majority of schemes directly reporting this information to Ofgem, whilst all relevant information under the CFD is submitted to the Low Carbon Contracts Company who currently utilise Ofgem's expertise in this area as a technical advisor.

The Government recognises there are parallel emerging priorities for Carbon Capture and Storage (CCS)[27], and we are considering options on where this can be deployed in the energy sector to deliver 'negative' emissions. We acknowledge the Climate Change Committee's (CCC) recommendation on Bioenergy with Carbon Capture and Storage (BECCS) and will be considering this using the priority use framework described above, where we will review the role of biomass in electricity generation, as well as looking at options for deploying BECCS in other industries (see section 2.7 for further detail). In line with the CCC's recommendation, we intend for future large-scale biomass-based electricity generation to not be supported without the addition of CCS, and we are considering routes to support power BECCS. However, we will complete developing the priority use framework before making any decisions, including whether and what changes may need to be made to the CfD scheme beyond allocation round 4. Therefore, there are no current plans to change how we support biomass under the CfD.

[25] DUKES 6.4 capacity of and electricity generated from renewable sources https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904825/DUKES_6.4.xls

[26] BEIS (2021) Contracts for Difference: Allocation Round 4 https://www.gov.uk/government/collections/contracts-for-difference-cfd-allocation-round-4

[27] The Ten Point Plan includes a commitment to deploy Carbon Capture, Usage and Storage (CCUS) in two industrial clusters by the mid-2020s, and a further two clusters by 2030 with an ambition to capture 10 $MtCO_2$ per year by 2030. (https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title)

In July 2021, the UK Government, in partnership with the Welsh Government, published a call for evidence to seek views on an expansion to the 2009 Carbon Capture Readiness (CCR)[28]. The expansion would involve removing the 300MW threshold from the requirements. This would cause some smaller technologies which were previously implicitly excluded from CCR to become captured by the requirements; for example, combustion plants which produce heat, biomass, EfW and CHP.

We acknowledge the role of small-scale systems in the generation of baseload and dispatchable power for the grid, and we recognise that these systems may not have access to the CO_2 transport and storage infrastructure needed for CCS. Any future changes to support for small-scale fuelled technologies under the CfD will depend on the priority use framework, any new information on the best use of the biomass, and the emergence of other government support schemes. Further details will be set out in the Biomass Strategy in 2022.

The Government recognises that deployment of CCS at waste management facilities, such as EfW facilities, will be necessary for meeting net zero, as they are a source of fossil-based emissions. In 2019, EfW accounted for 1.4% (6.2 $MtCO_2e$) of total UK emissions[29], with all waste management accounting for 4% (19 $MtCO_2e$) of total UK emissions, which was a significant decrease of 71% since 1990, largely driven by a reduction in biodegradable waste to landfill. The Resources & Waste Strategy for England[30] (RWS), published in December 2018, sets out the Government's commitment to make the UK a world leader in using resources efficiently and reducing the amount of waste we create as a society. EfW facilities accept residual waste streams unsuitable for recycling, estimated to comprise approximately a 50:50 ratio of fossil and biogenic material. Therefore, CCS at EfW facilities offers an opportunity to generate 'negative' emissions from the capture of biogenic CO_2 emissions, which have been identified as having an essential role in meeting net zero (see section 2.7 for further information).

There is a risk that increased combustion of biomass could have unintended consequences for air quality and human health due to emissions of particulate matter (PM). As set out in the 2019 Clean Air Strategy[31] we are therefore continuing to consider the case for setting tighter emission controls for biomass installations to reduce PM pollution from energy generation.

2.3. Heat

The use of biomass in heat generation has increased in recent years. Renewable heat generation across all technologies (e.g., bioenergy technologies, active solar heating, heat pumps, etc) has increased by 7.6% between 2019 and 2020 with most of the increase

[28] BEIS and Welsh Government (2021) Decarbonisation readiness: call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements https://www.gov.uk/government/consultations/decarbonisation-readiness-call-for-evidence-on-the-expansion-of-the-2009-carbon-capture-readiness-requirements
[29] BEIS (2021) Final UK greenhouse gas emissions national statistics: 1990 to 2019 https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019
[30] Defra and Environment Agency (2018) Resources and waste strategy for England Resources and waste strategy for England - GOV.UK (www.gov.uk)
[31] Defra (2019) Clean Air Strategy https://www.gov.uk/government/publications/clean-air-strategy-2019

generated from use of biomass resources. In 2020, biomass (including biodegradable waste) totalled 2.9 Mtoe representing 71% of renewable heat, 80% of which is accounted for by plant-based biomass and from wood consumed in residential sector, and much of the remainder from the use of heat pumps (27% or 1.1 Mtoe)[32].

The recently published Heat and Buildings Strategy[33] outlined the strategic approach the UK Government is taking to the decarbonisation of the heat and buildings sectors. The Scottish Government published its Heat in Buildings Strategy[34] on 7th October 2021, setting out a vision and actions for the decarbonisation of heat in homes and buildings in line with Scotland's statutory climate targets. Currently, less than 5% of energy used for heating homes and buildings comes from low carbon sources[35].

Electrification of heat is currently one of the few proved scalable options for decarbonising heat. In the 'Ten Point Plan for a Green Industrial Revolution', the Prime Minister announced our aim to install 600,000 heat pumps a year by 2028, up from approximately 35,000 per year currently[36]. Heat pumps will have a role to play in all future heating scenarios, therefore this is a 'no-regrets' target as it will be necessary even if hydrogen were to become the primary fuel source for heating buildings.

Developing the market for low carbon heat networks will also be a no-regrets action, in recognition of the CCC's recommendation for around 18% of UK heat to come from heat networks by 2050 as part of a least cost pathway to meeting net zero.

Subject to proving safety, feasibility, consumer experience and other costs and benefits, hydrogen could play an important role in helping to decarbonise heating. We will work in partnership with industry and other key stakeholders to test and evaluate the potential of hydrogen as an option for heating our homes and workplaces, ahead of taking strategic decisions on its role in 2026.

Biomass has a role in decarbonising certain properties, such as off gas grid homes that are unsuitable for heat pumps or where there are no other alternatives, and where appropriate mitigations can be set in place to minimise air quality impacts. Biomass is also used to generate biomethane for injection into the gas grid, or to directly use for heat.

Biomass use in heat is supported via the following policy measures and financial incentives:

[32] BEIS (2021) Digest of UK Energy Statistics (DUKES) 2021 https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2021
[33] BEIS (2021) Heat and buildings strategy https://www.gov.uk/government/publications/heat-and-buildings-strategy
[34] Scottish Government (2021) Heat in Buildings Strategy - achieving net zero emissions in Scotland's buildings https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings/
[35] CCC (2019) Net Zero – The UK's contribution to stopping global warming https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/
[36] BSRIA (2020), 'Heat pumps market analysis' https://www.bsria.com/uk/product/rg76mr/world_market_for_heat_pumps_2020r2019_8a707622/

Domestic and Non-Domestic Renewable Heat Incentives

The Renewable Heat Incentive (RHI) is a government financial incentive scheme to promote the use of renewable heat in Great Britain. A variety of renewable heating technologies were eligible for the Domestic and the Non-Domestic RHI schemes, including biomass boilers. The Domestic RHI also supports pellet stoves, while Non-Domestic RHI supports the production of biomethane alongside other renewable heat technologies. The schemes were integral to the expansion of the biomass industry since their inception. Under the Non-Domestic RHI between 2011 and 2021 there were 17,971 accredited full applications using biomass technologies[37] (not including biomethane) with a total capacity of 4,775.8 MW. These had generated 45,831 GWh of paid for heat, representing 70% of the total heat generated and paid for under the scheme. Under the Domestic RHI between 2014 and 2021 there were 12,303 accredited applications using biomass systems with a total estimated capacity of 319.3 MW generating 2,881 GWh of paid for heat (46% of the total)[38].

The Non-Domestic RHI in Great Britain closed to new applicants on 31st March 2021, while the Domestic RHI is due to close to new applicants on 31st March 2022.

The RHI schemes established stringent sustainability criteria for biomass use and the schemes incentivised the development of a sustainable biomass fuel supplier list. Participants under the schemes must meet the government's environmental objectives by using an approved sustainable fuel from a supplier listed on the Biomass Supplier List[39], or self-reporting against the sustainability requirements. The Biomass Strategy will set out potential improvements to biomass sustainability criteria and governance in the various end uses and any future support scheme in the heat sector where biomass is an eligible fuel will consider these recommendations.

While the Non-Domestic RHI is closed to new entrants, government continues to be committed to ensuring that environmental and health objectives continue to be met. As a result, following a recent consultation, the Government aims to introduce new annual maintenance checks for biomass boilers and new fuel quality standards from 2022, with the aim to reduce emissions of harmful particles from all boilers supported by the non-domestic RHI.

Boiler Upgrade Scheme

The Boiler Upgrade Scheme (previously named the Clean Heat Grant)[40], the successor policy to the Domestic RHI, will launch in Spring 2022 and will provide financial support for the installation of heat pumps and in limited circumstance biomass boilers in domestic and small non-domestic properties in England and Wales. Support for biomass boilers will be limited to

[37] Biomass technologies include small (< 200 kW), medium (200-1000 kW), and large (> 1000 kW) solid biomass boiler, and biogas.
[38] BEIS (2021) Renewable Heat Incentive statistics. RHI monthly deployment data: July 2021 https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-july-2021
[39] BEIS Biomass Suppliers List https://biomass-suppliers-list.service.gov.uk/
[40] BEIS (2021) Future Funding for Low Carbon Heat Consultation and government response https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat

properties that are located in a rural area and are not currently heated by mains gas. This is to avoid incentivising burning biomass in urban areas where particulate pollution is more acute.

Off-gas grid regulations

Currently, there are around 1.1 million fossil fuel heated homes in England which are not connected to the gas grid, and which use some of the highest carbon heating fuels including oil and coal. Electrification of heat is the one pathway to net zero proven to work at scale in homes off the gas grid. Low temperature air source heat pumps deliver high levels of energy efficiency, low carbon emissions and are consistent with net zero emissions as the electricity grid decarbonises. They are also commercially available, can be deployed at scale across most fossil fuel heated homes off the gas grid, and have lower running costs than many other low carbon heating systems.

Alongside the publication of the UK[41] Heat and Building Strategy, we are consulting on new regulations to phase out heating systems using high carbon fossil fuels such as oil and coal in homes off the gas grid from 2026, with a 'heat pump first' approach to replacement systems.

We recognise that not every home off the gas grid will be suitable for a low temperature heat pump, and these will require an alternative low carbon heating solution that is consistent with the pathway to net zero and wider government objectives on environmental sustainability and air quality. We anticipate in most of these cases, high temperature heat pumps and solid biomass will be suitable alternatives. In addition, net zero-consistent liquid biofuels – fuels which are 100% bio-derived or which can demonstrate a clear and rapid trajectory to removing all fossil fuel content, and with sustainable feedstock - may become a further alternative in the future low carbon heating mix off-grid where heat pumps cannot be used. Solid biomass and liquid biofuels will be required to derive from sustainable sources, compliant with air quality rules, and be suitable for consumers. Updated sustainability criteria set out in the Biomass Strategy will be utilised to ensure sustainable sourcing and environmental and health protections.

Long-term future of use of solid biomass and net zero consistent liquid biofuels (which could include hydrotreated vegetable oil (a form of biodiesel) and bio liquid petroleum gas) in off-grid homes will therefore be determined by the number of properties that take up an air source heat pump, the off-grid household’s choice of alternative net zero consistent heating system where heat pumps cannot be used, the likely available supply of sustainable biomass, and considerations around best use across sectors.

Biomethane – Green Gas Support Scheme

Biomethane plays an important role in helping to decarbonise the gas grid as it is the only commercially scalable technology currently available for greening the gas grid. In 2020 biomethane produced under the non-domestic RHI accounted for 1% of heat in buildings, based on analysis of Digest of UK Energy Statistics (DUKES) and RHI published statistics. Anaerobic digestion is a carbon efficient way of processing organic waste (e.g., food waste,

[41]UK wide - although some of the individual elements will affect England only.

manures, etc) when best practice is used. As with other bioenergy technologies, feedstock supplies limit the amount of biomethane which can be produced. However, biomethane plays an important, if limited, role as identified by the CCC, who say biomethane is valuable across all decarbonisation scenarios[42]. Following the introduction of separate household food waste collection as mandated in the Environment Bill we expect an increase in the availability of suitable sustainable feedstocks for biomethane production. Using minimum thresholds on support schemes, we encourage the use of wastes in biomethane production over the use of bioenergy crops. We recognise that arable crops can be useful for biomethane producers for managing feedstock supplies when wastes fluctuate, and we are keen not to encourage overreliance on them in biomethane production.

Biomethane injection to the gas grid is currently supported via the Non-Domestic RHI, which closed to new applicants in March 2021. The Government's Green Gas Support Scheme (GGSS) is expected to launch on 30th November 2021 and will be open in Great Britain until 2025. It is designed to provide tariff support for biomethane produced via anaerobic digestion and injected into the gas grid, for a tariff lifetime of 15 years. The scheme aims to increase the proportion of green gas in the grid by trebling it compared to current volumes, delivering up to 8.2 $MtCO_2e$ of GHG savings over its lifetime. To secure these savings and to help prevent negative environmental and health impacts, the GGSS will include stringent sustainability criteria, have clear requirements for mitigating ammonia emissions to air (due to the challenge that increased use of digestate will pose for meeting statutory ammonia emissions targets), as well as a requirement that at least 50% of the biomethane (by energy content) generated derives from waste or residue feedstocks as defined in the Environmental Protection Act (1990). A mid-scheme review of the waste feedstock threshold and ammonia reduction technologies will take place.

The GGSS tariff support for biomethane is committed to 2040/41, but support for deployment of new biomethane currently ends with the closure of the GGSS to new applicants, which is expected to happen in Autumn 2025. In the Future Support for Low Carbon Heat consultation and government response[43], we outlined plans to focus on market-based mechanisms for any potential future support for biomethane beyond the GGSS. This received broad support from consultation respondents, with suggestions that a supplier obligation or CfD-style mechanism may be appropriate to support the biomethane industry from the mid-2020s and beyond. The Government is currently exploring options for potential successor arrangements to the GGSS. This may also include more innovative production technologies beyond anaerobic digestion, such as advanced gasification (which can produce a variety of fuel products, including biomethane or hydrogen, from a range of feedstocks).

[42] CCC (2018) Biomass in a Low Carbon Economy https://www.theccc.org.uk/publication/biomass-in-a-low-carbon-economy
[43] BEIS (2021) Future Funding for Low Carbon Heat Consultation and government response https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat

2.4. Transport

Low carbon fuels in transport, in particular biofuels, play an important role in helping to decarbonise the sector, contributing up to a third of carbon savings in the transport sector under existing carbon budgets. In 2019, they constituted 5.1% of total road and non-road mobile machinery fuel, providing average life-cycle GHG emissions saving of 83% compared to fossil fuels. Renewable transport fuels are predominantly produced from wastes and residues (69% in 2019), with used cooking oil the single most important feedstock (54% of all renewable fuels), and UK-derived feedstocks contributing 11% of supply[44].

We expect low carbon fuels, including biofuels, to continue to play a significant role in transport decarbonisation in the long-term. While currently almost all fuels are used in road transport (blended into standard petrol and diesel), by 2050 we would expect fuels produced from biomass to be mainly (or even exclusively) used in aviation - and produced in combination with CCS to ensure they are net zero. Demand for liquid and gaseous fuels in road transport is expected to decrease over the coming decade, though they will still be required for achieving GHG savings from the remaining existing fleet. Heavy Good Vehicles (HGVs) might rely on renewable fuels for longer where alternative decarbonisation options may remain more limited.

The use of low carbon fuels in the transport sector has been supported though the UK's Renewable Transport Fuel Obligation (RTFO), a certificate trading scheme, since 2008 as well as through different advanced fuel demonstration competitions (for an overview see section below). We recently consulted on a separate future mandate for sustainable aviation fuels (SAF). In the recent Transport Decarbonisation Plan[45], the Government committed to further increases to RTFO targets, additional measures to encourage uptake in the aviation and (for non-biomass fuels) maritime sectors as well as determining whether further measures are needed to overcome market barriers to using fuels with higher biocontent in HGVs. We are also planning to develop a low carbon fuel strategy for publication in 2022 to set out a vision for the deployment of low carbon fuels across different transport modes in the period to 2050.

Renewable Transport Fuel Obligation

The RTFO is the main support mechanism for renewable fuels including biofuels. It obligates fuel suppliers to provide a specified percentage of renewable fuels as part of the fuels they supply (by volume), with targets being set on an upward trajectory to 2032 and continuing beyond that date.

Renewable fuels supported under the RTFO need to comply with a range of sustainability criteria, including minimum GHG savings, with indirect land use change impacts also being included in the reporting. There are additional incentives for renewable fuels produced from

[44] DfT (2020) Renewable fuel statistics 2019: Final report https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932933/renewable-fuel-statistics-2019-final-report.pdf
[45] DfT (2021) Transport Decarbonisation Plan https://www.gov.uk/government/publications/transport-decarbonisation-plan

wastes and residues which account for two-thirds of the fuels supported under the RTFO, while the use of food and feed crops is capped.

The RTFO also includes a sub-target for so-called 'development fuels'. These are waste-derived fuels and renewable fuels of non-biological origin of strategic importance. They include for example drop-in fuels, hydrogen and fuels for aviation.

Advanced Biofuel Demonstration Competitions

The **Advanced Biofuel Demonstration Competition** (ABDC) was designed to demonstrate the viability of a UK advanced biofuel industry and contribute to the de-risking of investment in future projects. Launched in 2014 the ABDC successfully led to the construction of two advanced low carbon fuels plants: Nova Pangaea Technologies in Teesside (awarded £4.5 million for ethanol production) and Advanced Biofuels Solutions in Swindon (£11 million in grants for a synthetic natural gas plant).

The **Future Fuels for Flight and Freight Competition** (F4C), which was launched in 2017 and made up to £22 million of capital funding available to projects to produce low carbon waste-based fuels to be used in aeroplanes and lorries specifically. The objective of the F4C is to stimulate UK development and deployment of advanced, sustainable low carbon aviation and HGV fuels to help realise our long-term decarbonisation obligations, deliver economic benefits, and position the UK at the forefront of the global advanced low carbon fuel industry.

The **Green Fuels Green Skies Competition** (GFGS) will provide up to £15 million in grant funding to UK SAF projects during the 2021/22 financial year. It supports the early-stage development of UK SAF plants. The competition aims to enable the SAF sector to deploy new technologies at a commercial scale that can reduce aviation emissions in the near-term and to try and help de-risk the future scale-up of projects. Eight projects were shortlisted for funding in July 2021[46].

Sustainable Aviation Fuel

Sustainable Aviation Fuels (SAF) are one of the key levers available to government and industry to accelerate the transition to net zero aviation. These advanced fuels, obtained from a wide range of waste feedstocks or electricity, can be easily dropped into existing conventional jet fuel and can achieve life-cycle GHG emissions savings of over 70% compared with conventional jet fuel, when fully replacing kerosene.

To accelerate SAF deployment and tackle the barriers faced by developing SAF projects, we have gradually introduced a world-leading, comprehensive programme of interventions aiming to commercialise the domestic SAF industry and deliver carbon savings. On top of competition funding, we have recently consulted on a UK SAF blending mandate[47]. The proposed long-

[46] DfT (2021) Green Fuels, Green Skies (GFGS) competition https://www.gov.uk/government/publications/green-fuels-green-skies-gfgs-competition/green-fuels-green-skies-gfgs-competition-shortlisted-proposals
[47] DfT (2021) Mandating the use of sustainable aviation fuels in the UK consultation https://www.gov.uk/government/consultations/mandating-the-use-of-sustainable-aviation-fuels-in-the-uk

term obligation aims to generate demand for SAF, provide an incentive to SAF producers and signal to investors the vital role the Government believes the technology will play in the UK.

The SAF mandate consultation includes proposed requirements for SAF to adhere to strict sustainability criteria. These will ensure significant GHG emissions savings are delivered and will prevent negative environmental consequences.

The consultation also proposed that only waste-derived biofuels, renewable fuels of nonbiological origin, SAF from nuclear origin and recycled carbon fuels can contribute towards the SAF mandate obligation, as these fuels can deliver high carbon savings and do not typically present significant direct or indirect land use or wider environmental impacts. It is not envisaged that crop-derived biofuels will be permitted. We are currently reviewing the responses received to the consultation and will continue to refine these proposed criteria in the coming months.

2.5. Industry sector

Biomass as an energy source in the industry sector

In March 2020, we published Government's Industrial Decarbonisation Strategy (IDS)[48], setting out how the UK can have a thriving industrial sector aligned to net zero, without pushing GHG emissions and businesses abroad. Building on the pathway set out in the IDS, our recently published Net Zero Strategy sets out how we will meet our Carbon Budget 6 ambition of reducing industrial emissions by 63-76% by 2035, compared to the 2019 level[49]. This is consistent with the expectation set out in the IDS that industrial emissions will need to reduce by around two-thirds by 2035. Alongside increased efficiency and use of CCS, the use of fossil fuels will need to be replaced with low carbon alternatives such as electricity, low carbon hydrogen and bioenergy. To be on track to deliver net zero, we expect that at minimum, in all future scenarios, 20 TWh per year of fossil fuel use will need to be replaced with low carbon alternatives in 2030. In addition, we committed to support the increased requirement for fuel switching in the Net Zero Strategy, with an ambition to replace around 50 TWh of fossil fuels per year by 2035.

Biomass already plays a role in industry (particularly in the cement, chemicals, food & drinks, and paper sectors), and is seen as a particularly useful energy source in off gas grid sites. The IDS indicated that we may need to prioritise use of biomass in industry where it can be combined with CCS. The application of BECCS to plants that use biomass has significant potential to reduce industrial GHG emissions while also delivering vital negative emissions. Modelling used in the IDS identified that BECCS may be particularly cost effective in the cement, glass and paper industry.

[48] BEIS (2021) Industrial Decarbonisation Strategy https://www.gov.uk/government/publications/industrial-decarbonisation-strategy
[49] BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy

Since publishing the IDS, the consideration of the role of biomass in line with the priority use framework has indicated that, with the limited supply of affordable and sustainable biomass, its use in applications alongside BECCS should be prioritised, otherwise its use will be limited to applications where there are limited alternative options to decarbonise. The approach to policy support for the deployment of BECCS in industry is set out later in this paper. In all industry applications biomass use will be required to comply with sustainability criteria and air quality requirements as set out in the priority use framework in section 2.1.

Most applications in industry involve incineration of biomass, but more efficient 'advanced conversion technologies' like gasification are being developed. The Industrial Energy Transformation Fund (IETF) currently supports industrial fuel switches to biomass as a decarbonisation measure only where there are limited commercial alternatives in the near term. Biomass projects are only supported when they involve switching away from fossil fuels used in high temperature applications (greater than 240 degrees Celsius). Biogas to fuel direct combustion or combined heat and power projects are also supported where the site is based off the gas grid, and injection of the fuel into the grid would not be feasible. The scheme design of the IETF is likely to evolve as the needs of industry develop.

Industrial use of biomass in chemicals, materials and construction sectors

The biomass call for evidence[50] highlighted that biomass can play an important role in displacing fossil fuel-heavy materials in the chemicals, materials, and manufacturing sectors, supporting sustainable production and the decarbonisation of these sectors. Particular consideration should be given to directing biomass to higher value, higher employment, markets such as fine and speciality chemicals, materials (etc.) to ensure maximum value extraction from the finite biomass feedstocks and to maximise end-of-life energy recovery from biomass waste arisings. The enabling technology for this is industrial biotechnology (IB), and further consideration is needed on how to encourage this sector.

The Bioeconomy Strategy[51] published in 2018 set out the broad range of opportunities that are available where the use of bio-based feedstocks and materials can be used to address challenges in food, chemicals, materials, health and the environment. Such innovation helps to drive UK global competitiveness in emerging markets and key industries, stimulating new investment and helping to increase our domestic resilience. Innovation opportunities outlined in the Bioeconomy Strategy include:

- Creating new routes to high value industrial chemicals;
- Producing new types of bio-based materials for suitable applications;
- Providing sustainable, healthy, affordable, and nutritious food for all;
- Increasing the productivity, sustainability and resilience of our agriculture and forestry;

[50] BEIS (2021) Role of biomass in achieving net zero call for evidence https://www.gov.uk/government/consultations/role-of-biomass-in-achieving-net-zero-call-for-evidence
[51] BEIS (2018) Bioeconomy Strategy: 2018 to 2030 https://www.gov.uk/government/publications/bioeconomy-strategy-2018-to-2030

- Manufacturing medicines of the future and making existing ones more efficiently.

Further research and innovation are needed in these areas to improve our understanding of how bio-based materials can best contribute towards our climate and environmental goals, as highlighted in a recent call for evidence on standards for bio-based, biodegradable and compostable plastics [52].

Scotland has a National Plan for Industrial Biotechnology and Biorefinery Roadmap to drive growth of the bioeconomy and promote the transition away from fossil fuels to bio-based feedstocks[53].

Taking advantage of these opportunities in the bioeconomy is dependent on having in place the right policy and legislative environment. Investors need confidence that innovative solutions can be brought to the marketplace without obstruction and will find consumer acceptance and approval. By its nature the bioeconomy is cross cutting and operates across different industrial sectors connecting a wide range of disciplines. That means there can be a need to draw together different sectors such as industrial biotechnology and synthetic biology, aquaculture, agriculture and food technology, medicines manufacturing and chemicals. New supply and value chains often need to be developed where resources are captured, treated, and used in the best ways possible. There is also a need for a suitably skilled workforce as new jobs might need a different set of skills compared to more traditional ones. Additionally, there is room for a greater understanding of how the bioeconomy contributes to key UK and global priorities such as net zero which will give greater confidence that changes to more traditional methods are worthwhile.

The CCC recommended that the use of wood in construction should increase as it contributes towards GHG abatement through storing carbon and displacing fossil fuels. Timber is a commonly used building material, with 22% of English new builds using timber frames in 2016 - but we can go further. In Scotland around 75% of new-build homes are timber framed, showing that building practices are already available to increase timber use. This could reduce embodied carbon (emissions from making materials) in construction, while community woodland management (National Forest Company) can also lock away carbon long term and drive investment into tree planting and establishment.

Guided by market analysis, fire safety and structural considerations, key opportunities for the safe growth of timber use will be in low-rise buildings using traditional and certain modern methods of construction, and in a wide range of commercial and non-residential settings.

The England Tree Action Plan[54] outlined the following commitments around increasing the use of wood in construction:

[52] BEIS and Defra (2019) Standards for biodegradable, compostable and bio-based plastics: call for evidence https://www.gov.uk/government/consultations/standards-for-biodegradable-compostable-and-bio-based-plastics-call-for-evidence
[53] Life Sciences in Scotland (2019) National Plan for Industrial Biotechnology – Driving Progress to 2025 https://www.lifesciencesscotland.com/supporting-strategies/national-plan-industrial-biotechnology
[54] Defra (2021) England Tree Action Plan 2021 to 2024 https://www.gov.uk/government/publications/england-trees-action-plan-2021-to-2024

- Provide financial support to develop innovative timber products through the Forestry Innovation Fund;
- Work with key construction stakeholders, including the Green Construction Board, Construction Leadership Council, House Building Federation, and Federation of Master Builders to develop a policy roadmap on use of timber;
- Drive an increase in the use of certain modern methods of construction, some forms of which can encourage use of sustainable materials such as timber;
- Work with Homes England and delivery partners to explore ways to increase timber use in the delivery of housing programmes;
- Increase public demand for sustainably sourced timber through procurement policies;
- Encourage research into barriers to uptake of timber, including looking at timber strength grades and the fire resistance of engineered timber structures.

Separately, there are opportunities to scale up the use of bio-based plastics replacing fossil fuel feedstocks. However, uncertainties remain around the life-cycle GHG emissions of these alternatives, and more work needs to be done to determine under what conditions and in which applications biomass use in the chemicals and products sector can form part of the long-term priority use of biomass. Any future use of biomass in these areas will be expected to comply with the overarching priority use principles, including updated sustainability criteria, as set out in Figure 2. In all these end uses controls on pollutant emissions (such as PM) from installations will continue to evolve. This will help ensure that the decarbonisation of industry delivers co-benefits for air quality.

Another potential area of interest is carbon capture and useage (CCU) and biomass – where we recognise that there is considerable interest in CCU associated with biomethane production as a way of accessing potentially low-cost volumes of CO_2, albeit from dispersed sources. We will continue to engage with industry to better understand the opportunity this presents.

2.6. Hydrogen

As set out in the recently published UK Hydrogen Strategy[55], low carbon hydrogen will be essential for achieving net zero and meeting our CB6 target. It is particularly useful in decarbonising ‘hard to electrify’ UK sectors, such as parts of industry, and in providing flexible energy across power, heat and transport. The Prime Minister’s Ten Point Plan for a Green Industrial Revolution[56] set out that, working with industry, government is aiming for 5GW of low carbon hydrogen production capacity by 2030, with a hope to see 1GW production capacity by 2025. Beyond this, the Hydrogen Strategy suggests that to meet our CB6 and net zero targets, there is likely to be a substantial ramp up to 7-20GW of production capacity needed by 2035 to meet demand for 55-165TWh across multiple end use sectors. By 2050 analysis by BEIS

[55] BEIS (2021) UK Hydrogen Strategy https://www.gov.uk/government/publications/uk-hydrogen-strategy
[56] The Ten Point Plan for a Green Industrial Revolution https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

suggests 250-460TWh of hydrogen could be used across the economy making up 20-35% of UK final energy consumption.

There are a variety of ways to produce low carbon hydrogen including several involving biomass feedstocks – such as biomass gasification and reformation of biomethane from anaerobic digestion. As discussed in Section 2.7 below, the addition of CCS infrastructure can enable these production routes to deliver negative emissions as well as hydrogen. In some cases these are at relatively low Technology Readiness Levels (TRLs) and require further innovation to reach commercialisation and scale but already show promise – with both CCC and BEIS analysis suggesting a potentially increasing role for biomass gasification with CCS as a hydrogen production route from the 2030s. Across all production technologies, the proportion of hydrogen supplied from biomass will depend on a range of assumptions and market drivers and hence has considerable uncertainty. However, BEIS analysis suggests that biomass gasification with CCS could provide up to 20% of total hydrogen production in 2050[57].

To ensure that government support for hydrogen delivers against our emissions targets, the Low Carbon Hydrogen Standard consultation[58] published alongside the Hydrogen Strategy sets out how we are planning to define low carbon hydrogen. This definition will underpin access to support offered to producers through the £240m Net Zero Hydrogen Fund[59] and proposed hydrogen business model[60], allowing us to incentivise and provide certainty on emissions reduction from hydrogen supply across the energy system. The standard will include a key criterion on overall carbon intensity of hydrogen from all sources, including sustainable biomass. It will also be subject to stringent sustainability criteria for biomass, in line with wider BEIS policy on this matter, to ensure genuinely low carbon hydrogen is produced from biomass and negative impacts on the environment and biodiversity are avoided.

We intend to say more on the role of potential hydrogen production technologies, including those using biomass, in early 2022.

2.7. Bioenergy with Carbon Capture and Storage (BECCS)

Both Government and the CCC modelling have found that GGRs will be required to offset residual emissions in sectors that are difficult to decarbonise completely, such as heavy industry, agriculture and aviation. The Government has committed to establishing the role which Bioenergy with Carbon Capture and Storage (BECCS) could play in reducing carbon emissions across the economy and, as part of a wider Biomass Strategy, setting out how the technology could be deployed.

[57] BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy
[58] BEIS (2021) Designing a UK low carbon hydrogen standard consultation https://www.gov.uk/government/consultations/designing-a-uk-low-carbon-hydrogen-standard
[59] BEIS (2021) Designing the Net Zero Hydrogen Fund Consultation https://www.gov.uk/government/consultations/designing-the-net-zero-hydrogen-fund
[60] BEIS (2021) Design of a business model for low carbon hydrogen consultation https://www.gov.uk/government/consultations/design-of-a-business-model-for-low-carbon-hydrogen

If adopted early, GGR technologies could provide an opportunity to help meet our nationally determined contribution (NDC) in 2030, and Carbon Budgets 5 and 6. This timeline is in line with Government commitment to deploy CO_2 transport and storage infrastructure at four carbon capture usage and storage (CCUS) clusters by 2030 at the latest, with a minimum of two being established in the mid-2020s. The Government estimates that by 2050 between 75 and 81Mt of CO_2 removals delivered by engineered GGRs are needed to meet net zero. The Net Zero Strategy[61] set an ambition of deploying at least 5 $MtCO_2$ per year of engineered removals by 2030, in line with recent CCC and the National Infrastructure Commission's recommendations to set a plan for the deployment of engineered removals, as well as our own internal analysis of our ability to significantly scale-up the sector over the 2020s, of which BECCS could be a major route. The CCC and the National Grid's 2020 Future Energy Scenarios (FES)[62] also indicate that it is not possible to achieve net zero without BECCS. Therefore, where biomass is used, the Government will seek to explore where there are opportunities to support its use in combination with BECCS, in line with the priority use principles outlined in Figure 2.

When undertaken sustainably, BECCS can deliver negative emissions because carbon sequestered in biogenic material is captured and stored after combustion, resulting in a net decrease in atmospheric CO_2 overall. Some organisations including trade associations, university researchers and NGOs raised concerns over the net negativity of BECCS in the biomass call for evidence[63] and asked how the Government might support BECCS to deliver negative emissions. To ensure that BECCS delivers genuine negative emissions, strict biomass sustainability criteria will be developed for BECCS. These criteria will build on the existing sustainability criteria for biomass that are being reviewed as part of the Biomass Strategy. Research and updated regulation will also be required to understand and address any air quality impacts from BECCS, including emissions associated with carbon capture solvents.

The Government is clear that any BECCS deployment must be genuinely and credibly 'net-negative', meaning it must remove more GHG emissions from the atmosphere than it creates, and store them in long-term geological storage. This assessment would include all GHGs (including methane and nitrous oxide) from the whole BECCS supply chain, including carbon capture at the capture plant and eventual store. For this reason, the Government convened a GGR Monitoring, Reporting and Verification (MRV) Task and Finish Group[64] with the aim of understanding the current position on MRV for negative emissions in the UK, what regulatory frameworks and standards currently exist, identifying the gaps that exist, and the work required to fill them. The Group identified a need for HMG to develop detailed MRV protocols for all non-geological sequestration GGR approaches (e.g. biochar, or enhanced weathering), and by

[61] BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy
[62] National Grid ESO (2020) National Grid's 2020 Future Energy Scenarios https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents
[63] BEIS (2021) Role of biomass in achieving net zero: call for evidence https://www.gov.uk/government/consultations/role-of-biomass-in-achieving-net-zero-call-for-evidence
[64] BEIS (2021) Monitoring, reporting and verification of GGRs: Task and Finish Group report https://www.gov.uk/government/publications/monitoring-reporting-and-verification-of-ggrs-task-and-finish-group-report

2024 establish an independent function to sit between project developers and HMG. Alongside this, we will develop a BECCS policy that will ensure that BECCS delivers genuine negative emissions, in parallel with the review of our existing sustainability criteria.

Principally, the Government is clear that the purpose of BECCS, and other GGRs is to balance the residual emissions from sectors that are unlikely to achieve full decarbonisation by 2050 and will not be substitutes for ambitious mitigation to achieve net zero. This is consistent with responses to our call for evidence, suggesting the Government targets the use of biomass so that it mitigates emissions released from hard-to-decarbonise sectors.

Routes to BECCS

BECCS can be deployed alongside various technologies, including conventional combustion technologies, gasification, sustainable fuels production, steam methane reforming and anaerobic digestion, delivering both low-emission energy and fuels, as well as negative emissions. However, existing policies and emissions markets are not designed to value the negative emissions produced by BECCS projects. The Government has therefore committed to consulting on business models for engineered GGRs in Spring 2022, which will set out our preferred support mechanisms to incentivise negative emissions from a range of GGR technologies including BECCS and direct air capture with CCS (DACCS). This will build on business models already under development in specific sectors, as described below.

A key interdependency for BECCS and other engineered GGR technologies is the transport and storage infrastructure at the CCUS clusters, or where CO_2 transport is feasible. It may also be affected by the regional access to biomass resource, therefore future BECCS deployment would need to be located strategically. The Cluster Sequencing Process launched by BEIS in May 2021 aims to deliver a minimum of two clusters by the mid-2020s and four by 2030, at the latest[65]. Hynet and East Coast Clusters have been confirmed as track 1 clusters for the mid-2020s and will be taken forward into Track-1 negotiations. The Scottish Cluster was announced as a reserve cluster if a back-up is needed. A Phase 2 update, due soon, will outline how GGR projects, including BECCS, can potentially participate in the Cluster Sequencing Process.

The UK Emissions Trading Scheme (UK ETS) is one possible long-term market-based solution for all types of GGR from nature-based to engineered approaches such as BECCS. The UK ETS is a mechanism of carbon pricing to support businesses to decarbonise at the least cost, currently covering power, heavy industry and aviation sectors – around a third of UK emissions. The existing UK ETS promotes the use of biomass in these sectors by "zero-rating" biomass combustion provided certain sustainability criteria are met. The Government is exploring the inclusion of GGRs in the UK ETS, or a separate but linked market, in the future. There could, in the future, also be some other innovative methods of capturing CO_2 from processes (explored in the innovation competition mentioned in Chapter 3) that stimulate

[65] BEIS (2021) Cluster sequencing for carbon capture, usage and storage (CCUS) deployment: Phase 1 https://www.gov.uk/government/publications/cluster-sequencing-for-carbon-capture-usage-and-storage-ccus-deployment-phase-1-expressions-of-interest

markets for negative emissions alongside providing other co-benefits, such as circular economy benefits.

The following subsections focus on how BECCS could be deployed in the power, industry, hydrogen and biofuel sectors in support of net zero.

Power BECCS

Modelling to inform the Net Zero Strategy suggests that by 2050, engineered removals at large scale, between 75 and 81 $MtCO_2$ per year, will be needed to help compensate residual emissions. This will be equivalent to 45-80% of total emissions captured across the UK economy and we expect to see predominantly the scale up of power BECCS alongside DACCS and BECCS with gasification technologies. Based on available evidence, power BECCS could be a major GGR in this period, thanks to opportunities to retrofit existing large-scale biomass plants, providing a long-term future for this capacity. In total, power BECCS is expected to deliver a steady increase of engineered removals between the late 2020s and 2035. This assessment is supported by recent CCC[66] and National Infrastructure Commission (NIC)[67] reports, which both saw a role for power BECCS in contributing to our nearer term 2030 and 2035 targets. Beyond that, the portfolio of BECCS and other GGRs deployed at scale will expand as other technologies mature and demand from end-use sectors increases. A recent BEIS study on GGRs[68], suggests that power BECCS removals are currently estimated at a TRL of 7, and hydrogen BECCS at TRL of 5[69].

CCUS Business model support is already under development in the industrial and power sectors[70], however it is recognised that the existing models are not designed to value the negative emissions of BECCS projects in the power sector. The need to define the revenue mechanisms that will be used to reward CO_2 removals was also expressed by multiple stakeholders in response to our call for evidence. Therefore, in January 2021 we established an independent investigation into potential commercial frameworks that could meet this need, the final report of which was published recently[71]. Following this, the Government intends to develop a business model for power BECCS that will reward verified negative emissions while delivering value for money. We will also consider options on how we may incentivise operators to continually reduce supply chain carbon intensity. We are clear that any decision to award support would only be made subject to the development of a suitable business model and full value for money and affordability assessment, alongside the requirement for compliance with biomass sustainability criteria.

[66] CCC (2020) Sixth Carbon Budget report https://www.theccc.org.uk/publication/sixth-carbon-budget/
[67] National Infrastructure Commission (2021). Engineered Greenhouse Gas Removals https://nic.org.uk/studies-reports/greenhouse-gas-removals/engineered-greenhouse-gas-removals/
[68] BEIS (2021) Greenhouse gas removal methods: technology assessment report https://www.gov.uk/government/publications/greenhouse-gas-removal-methods-technology-assessment-report
[69] Technology readiness levels (TRLs) were estimated on a scale 0-9, following BEIS internal methodology.
[70] BEIS (2020) Carbon capture, usage and storage (CCUS): business models https://www.gov.uk/government/publications/carbon-capture-usage-and-storage-ccus-business-models
[71] BEIS (2021) Investable commercial frameworks for 'power-BECCS' https://www.gov.uk/government/publications/investable-commercial-frameworks-for-power-beccs

BECCS in Industry

Section 2.5 identified a potential role of BECCS in the industrial sector, particularly the cement, glass and paper industry, where the use of sustainable biomass combined with CCS could deliver negative emissions alongside the decarbonisation of these industries. As well as this, as mentioned in Section 2.2, there is also potential to combine CCS with EfW facilities, which will result in negative emissions due to the presence of biogenic material in residual waste (approximately 50:50 in content). Future support for EfW and CCS at installations yet to be planned will depend on the development of parallel policies, which may affect the best route for supporting CCS or reducing emissions from the waste sector. Options to deploy could include retrofitting existing EfW installations, or building new installations as CCS ready, including advanced EfW plants (e.g., gasification plants) that convert waste into liquid or gaseous renewable transport fuels (see also hydrogen BECCS section below).

To facilitate the demonstration of CCS at waste management facilities (including EfW) we set out an initial minded-to position, subject to further work to support the deployment of CCS at waste management (including EfW) facilities under the Industrial Carbon Capture (ICC) business model, but it was noted that this was subject to change as we continue to develop our approach. In October this year, it was noted that this work is ongoing, and we have not yet reached a final decision on eligibility of waste management projects. Government intends to provide an update in the Cluster Sequencing Phase 2 launch later this year.

Hydrogen BECCS

The UK Hydrogen Strategy sets out how government is supporting the production of low carbon hydrogen. As discussed previously, the production of hydrogen in combination with BECCS is one of a suite of technologies, which will establish a cost-effective and credible production mix for our pathway to net zero, supporting decarbonisation across transport, industry, power and heat.

Prior to scaled-up deployment of hydrogen BECCS, further innovation and technological developments are expected during the 2020s. Current BEIS analysis indicates that BECCS technologies could then begin to contribute significantly to hydrogen production in the 2030s, helping to meet the anticipated increase in hydrogen demand with cost-competitive and carbon negative production. By 2050, the BECCS production route could be one of three types of technologies to dominate domestic hydrogen production, a conclusion supported by CCC CB6 advice. The projected upscale in H_2 BECCS in the BEIS net zero modelling[72] has stimulated a need to investigate innovation requirements for biohydrogen production, including feedstocks pre-processing for gasification, syngas upgrading, and treatment for hydrogen that is deployed alongside CCS. These innovation requirements are being addressed through the development of a new BEIS Innovation Programme as part of the £1 billion Net Zero Innovation Portfolio[73]. This programme will also recognise the role of BECCS at anaerobic digestion plants in

[72] Further information in the Technical Annex of the BEIS (2021) Net Zero Strategy – Build back greener https://www.gov.uk/government/publications/net-zero-strategy
[73] BEIS (2021) Net Zero Innovation Portfolio https://www.gov.uk/government/collections/net-zero-innovation-portfolio

combining CCS and hydrogen production, at the anaerobic digestion or hydrogen-plant level (see section 3.2 for further information about the programme).

As production increases to meet rising demand, key scenarios modelled by BEIS at the time of the Net Zero Strategy publication suggest hydrogen BECCS could contribute a total of up to 30 $MtCO_2$ per year in negative emissions in 2050. However, the proportion of hydrogen supplied by each technology (including non-biomass routes) depends on a range of assumptions and market drivers, which will impact upon the extent of its negative emissions potential.

Other potential routes for support for hydrogen BECCS could be via the Renewable Transport Fuel Obligation, where earlier this year the Government consulted on proposals to reward bio-hydrogen with development fuel certificates where it has been produced from advanced technologies such as processes which make use of CCS. As anaerobic digestion is an already established technology, following the recent clarifications to the gas mass balance rules, biomethane could potentially be delivered through the grid to a centralised hydrogen BECCS plant with access to the CCUS transport and storage infrastructure. A further update on this amendment is due later this year.

BECCS and Biofuel Production

Finally, similar to hydrogen production, the production of liquid and gaseous biofuels can also be combined with CCS. Some biofuel production plants already regularly capture CO_2 that would otherwise have been emitted as part of their production process. At the moment, this stored CO_2 is sold into the market (e.g. foods and drinks or nuclear industry) rather than stored. As the finished fuel will still be burnt in an engine, in contrast to other BECCS technologies, there will still be some biogenic carbon emissions attached to the process. However, by replacing fossil fuels and reducing emissions as far as possible, this technology can still provide a significant contribution to net zero where limited alternatives to liquid and gaseous fuels exist. The CCC, most recently in its advice on the 6th carbon budget, has been clear that CCS will need to be combined with biofuel production in the medium to long-term, including for SAF production.

Chapter 3: Research and Innovation

The deployment of biomass will be part of an overall transition that will also rely on wider changes to our ways of living, working and managing the environment around us. Therefore, we need to take a whole systems approach to decision making on biomass, and this requires research and innovation to refine our understanding of the impact of interactions between the technologies, sectors, behaviours, and policies needed to achieve our climate and environmental goals.

Research and innovation are key enablers for biomass, bioenergy technologies, and the wider bioeconomy to deliver against net zero. The Net Zero Research and Innovation Framework[74] set out the research and innovation requirements for the delivery of the Net Zero Strategy and relevant sector strategies, including the Biomass Strategy.

The Net Zero Innovation Portfolio (NZIP)[75] is a £1 billion fund which will play a key role in enabling the UK to end its contribution to climate change by providing funding to accelerate the commercialisation of low carbon technologies, systems and business models in power, buildings, and industry sectors among others, with some funding streams relating directly or indirectly to the use of biomass. There are also a series of other existing and emerging UK government and UKRI funding opportunities that will address the challenges and evidence gaps related to the role of biomass in meeting net zero, and some are highlighted here.

3.1. Key research and innovation needs

The Biomass Strategy call for evidence[76] sought information on innovation needs to maximise the use of the sustainable biomass supply and meet our decarbonisation targets without needing substantial amounts of productive land or having wider negative environmental, economic, social and health impacts.

A key challenge in determining the role of biomass in net zero is understanding how we can have a flexible and technology agnostic approach to biomass use and bioenergy deployment, while also meeting the priorities for reducing greenhouse gas (GHG) emissions and making biomass technologies cost and performance competitive with established fossil-based technologies and products. Achieving this requires research and innovation, in both the feedstock supply side, and the demand side. Flexibility on the feedstock side requires innovation in the development of processes and technologies that are feedstock agnostic, and the development of adequate pre-treatment steps to improve the quality and utilisation of often variable and low value feedstocks. Flexibility on the end use side requires innovation in

[74] BEIS (2021) Net Zero Research and Innovation Framework https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework
[75] BEIS (2021) Net Zero Innovation Portfolio https://www.gov.uk/government/collections/net-zero-innovation-portfolio
[76] BEIS (2021) Role of biomass in achieving net zero: call for evidence https://www.gov.uk/government/consultations/role-of-biomass-in-achieving-net-zero-call-for-evidence

technologies that increase resource use efficiency and reduce the cost of deployment to deliver high value products and/or specific decarbonisation needs.

Responses to the call for evidence highlighted several other themes where further research and innovation are required to enable our ambitions on biomass, which are detailed below, alongside some existing innovation competitions, funds and research projects addressing these challenges.

Creating a sustainable biomass supply

The need to create and secure a sustainable and reliable supply of quality biomass is a key area for innovation. To facilitate this, as mentioned in Chapter 1, BEIS will fund an update to the UK and Global Bioenergy Resource Model, which estimates the potential sustainable bioenergy resource that may be available to the UK up to 2050. The previous update took place in 2015 and this project will ensure the latest iteration of the model will be based on the most up to date evidence.

To drive innovation in the development of UK feedstocks, the BEIS Biomass Feedstocks Innovation Programme[77] provides £4 million of NZIP funding to support innovation in the production of sustainable biomass across 25 'Phase 1' contracts, with up to £26 million available to develop the best of the Phase 1 proposed solutions. The programme will support a range of innovation projects on energy crops and forestry (long rotation and short rotation), and achieve improvements in yield, efficiency, cost reductions and profitability for such feedstocks. It will accelerate the commercialisation of innovative products developed through the programme.

Focussing on the farming side, Defra's Farming Innovation Pathways competition[78] aims to develop new solutions and exploit opportunities to drive productivity and environmental sustainability in agriculture and horticulture. Also, Defra's new Farming Innovation Programme[79] to stimulate industry-led R&D and innovation in agriculture and horticulture will run from 2022/23 to 2028/29.

Innovation in routes for BECCS

The unique position of biomass to deliver negative emissions from Bioenergy with Carbon Capture and Storage (BECCS) has already been addressed in Section 2.7. Innovation needs relating to BECCS include finding opportunities to focus on technologies with the potential for the highest efficiency and carbon savings, such as combined heat and power (CHP) and gasification (pre-combustion), especially where they can be integrated with hard to decarbonise sectors such as aviation fuel production or industry.

[77] BEIS (2021) Biomass feedstocks innovation programme https://www.gov.uk/government/publications/apply-for-the-biomass-feedstocks-innovation-programme
[78] Defra (2021) Farming Innovation Pathways (FIP) – feasibility studies https://apply-for-innovation-funding.service.gov.uk/competition/853/overview
[79] Further information about the programme can be found at https://www.ukri.org/news/ukri-and-defra-to-launch-farming-innovation-pathways-competition/

Gasification has been identified as a key area of innovation, as it could provide a route to gain flexibility in both feedstock use, and useful products. This is the focus of a BEIS NZIP Innovation Programme currently in development, which will provide funding to innovate and improve CAPEX, OPEX and overall performance in feedstock pre-processing for gasification, syngas upgrading and treatment for the generation of biohydrogen with co-deployment of CCS.

It is recognised that routes for deploying BECCS should be extended to other non-thermochemical or combustion options, such as fermentation or anaerobic digestion routes, which could be cost competitive with other routes for BECCS. The pending NZIP Innovation Programme, mentioned above, also considers the development of biohydrogen from other sources such as anaerobic digestion.

A key challenge to BECCS, and other GHG reduction technologies, is commercialisation, and the pathway to which requires demonstration. The BEIS Direct air capture and GGR Innovation Programme[80] seeks to do this by taking a portfolio approach to support a range of different GGR approaches initially, including BECCS, with the aim to take the most promising forward to piloting. So far, a total of 23 projects have been funded for phase 1, of which 11 use biomass as a significant input - comprising four BECCS projects, five biochar projects, and two that use biochar in combination with another technology. The competition looks to have invested c. £70 million by March 2025.

Research is also needed to understand the permanency, additionality of GGRs via the use of biochar, and evaluate any unintended consequences via trials, and this is addressed in a UKRI Strategic Priorities Fund for Greenhouse Gas Removals Demonstrator project titled, “A Biochar Demonstration Programme Addressing Uncertainties over Permanency of Storage, Environmental Health and Soil Impacts” run by Nottingham University.

There is also a need to explore routes for BECCS that do not have ready access to a CO_2 transport and storage network. The CCUS Innovation 2.0 Competition will provide £19.5 million in grant funding available for projects developing novel CCUS technology and processes that reduce the cost of deployment. The competition will aim to fund projects at mid to late-stage technology readiness levels throughout the full chain of CCUS.

Air quality impacts

Research and innovation will be required to address evidence gaps in relation to air quality impacts and to ensure that increased use of biomass does not compromise our ability to meet statutory air quality emissions ceilings and ambient concentration targets, such as those for ammonia and particulate matter (PM).

Ammonia emissions are associated with the nutrient-rich digestate by-product of anaerobic digestion, which can be used as a fertiliser, however it can lead to the release of ammonia when stored or spread on land. To address this, the UK Government has committed to funding

[80] BEIS (2020) Direct Air Capture and other Greenhouse Gas Removal technologies competition https://www.gov.uk/government/publications/direct-air-capture-and-other-greenhouse-gas-removal-technologies-competition

a technoeconomic study into technologies to reduce ammonia emissions from digestate, which will inform a mid-scheme review of this aspect of the Green Gas Support Scheme. The study will examine the available technologies that can be best applied to address or mitigate the environmental impacts of digestate; their effectiveness in environmental impact mitigation; the associated costs and, where possible, potential of adding value to digestate as a product itself. Among other things, the study will also produce information on the studied technologies' market readiness and stage of development, current deployment and barriers to deployment, and case studies on previous use of technologies.

The use of biomass for domestic burning is also a significant contributor to the UK's PM2.5 levels, and the Government intends to review the impact of new and innovated fuels, such as waste based fuels, on human health and the environment. Defra is currently undertaking a research study to develop emission factors for domestic solid fuels, including wood, in order to better understand air pollutant emissions from domestic combustion.

Biomass in non-energy sectors

There is a clear opportunity for biomass to be utilised in non-energy sectors for the production of high value renewable chemicals and materials. Respondents to the call for evidence called for more support for the biorefinery concept, and to focus on creating a circular economy by increasing the role of biomass in material and construction applications. We will explore the role of industrial biotechnology and material processing of biomass into high value products using techniques known to synthetic chemistry, engineering biology and bio-catalysis.

Summary

The funding opportunities and projects listed here demonstrate some of the ongoing efforts to address key science and innovation gaps to realise greater benefits from biomass for decarbonisation. The results and engagement created through the innovation projects will be used to inform the development and implementation of the Biomass Strategy.

We will continue to review emerging and future opportunities for research and innovation, particularly in the industrial bioeconomy for domestically produced biomass, assessing implications of land use change, impacts to agricultural operating models, and where the greatest potential for sector growth and trade lies. We will engage with industry, research councils and academics to develop and influence future funding opportunities.

Chapter 4: Next Steps

This document forms part of a conversation, alongside the recent biomass call for evidence, to develop the policies needed to make the best use of biomass across the economy in support of net zero. We will take a coordinated, cross-cutting approach to deliver a comprehensive view in the Biomass Strategy on how biomass can best support our net zero goal and wider environmental targets considering the interactions and challenges between the various sectors of the economy. We want to build on the policies, research, and activities outlined in this document by working with industry and business groups, academics and researchers, local authorities, environmental NGOs, community and interest groups, and the public. We will do this through various forms of engagement, centred around our key objectives of the strategy.

Over the coming months we will continue to engage with stakeholders and the public on all parts of the strategy, which we will publish in late 2022.

We will complete the following list of actions for the development of the strategy to deliver the objectives of the strategy:

- Engage with stakeholders to review the priority use framework principles presented in Section 2.1 to ensure it is consistent with net zero and environmental targets. In the strategy we intend to present a detailed priority use framework that sets out the best use of biomass across the economy to achieve net zero alongside wider environmental goals.
- We will identify key policy gaps we need to address to deploy biomass in the priority areas for net zero and develop frameworks to support these policies. We will set out further information about these in the strategy.
- We will review the amount of sustainable biomass through our work on the UK and Global Bioenergy Resource Model and present the findings of the review in the strategy.
- We will review the current sustainability criteria for biomass applied across government, taking into account environmental and social aspects. Using these analyses, in the strategy we will present options for ensuring any identified gaps within sustainability criteria, governance, and the regulatory landscape are addressed across sectors where biomass is used. We will also set out options for a post-subsidy market where the impact of carbon pricing needs consideration.
- In parallel we will assess the regulatory landscape for pollutant emissions from biomass to ensure any gaps are addressed and to consider the case for tightening emissions standards.
- We will use the outcomes of these activities to develop a comprehensive and detailed strategy with clear actions for the coming decade.

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