Biomass Availability

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Introduction

The UK Department of Business and Industrial Strategy (BEIS) proposes to publish a new biomass strategy in 2022. This refreshed strategy is expected to build on the 2012 UK bioenergy strategy and will aim to bring together many government departments whose policies for net-zero involve the use of sustainable biomass. BEIS has also said it will take into account the CCC's recommendations, which called for the UK's bioenergy strategy to be refreshed, and will set out more details in its energy white paper. The 15th of June saw the close of a BEIS call for evidence in the role of biomass in achieving net-zero, to support development of the strategy, and a progress update is expected in the coming months.

This report takes a look at biomass availability with a focus on the UK – what feedstocks are available for various applications within the bioeconomy, with detail as to quantities and other considerations affecting availability.

Types of feedstock

Types of feedstock vary widely. It includes agricultural and agricultural by-products, processing residues from industry, and waste. Some examples include:

- cereal and oilseed processing residues – brans, husks, hulls, cobs
- vegetable oil processing wastes and residues - empty fruit bunches (palm oil production), seeds and pits (olive)
- nut and seed processing residues – husks and seed coats
- sugar processing residues – bagasse
- ethanol industry by-products – DDGS
- coffee processing waste – spent coffee grounds
- fruit processing wastes – pomace
- wine waste products
- Biobased fraction of municipal waste, which includes source-separated and non-source-separated. Separated waste can include for example food waste, green (garden) waste, paper and wood, or a combined mixture.

Background

Biomass and the bioeconomy

Biomass is material of biological origin excluding material embedded in geological formations and/or fossilized. For example, whole or parts of plants, trees, algae, marine organisms, micro-organisms and animals (bio-based products -vocabulary EN 16575). Biomass is essential to the bioeconomy. The bioeconomy is based on the conversion of biomass into more valuable items including biobased products, bioenergy and biofuels.

Biomass is a major contributor to world energy needs. An increase in biomass use for energy is motivated by a need to reduce carbon emissions and dependence on fossil fuels. Bioethanol, biodiesel and biomethane for example are being used in increasing proportions as fuel for transportation. Biomass for bioenergy (heat and power applications) also reduces this dependence and can offer additional options for waste management. Agricultural by-products can also offer

additional revenue streams for farmers and the rural economy. Biobased products represent a much smaller draw on biomass resources, given the current scale of global energy demand, however, what biomass is available and relatively cheap can influence the platform molecules from which many biobased products are derived. Supply into the bioenergy sector at large scale can also help to reduce logistical issues of biomass supply for smaller biomaterial markets.

It's estimated that around 1.2 billion tonnes of biomass was supplied and used in the EU in 2015. Agricultural crops account for about half of this biomass, with residues, grazed biomass, forestry and aquaculture making up the rest. Additionally, around 0.2 billion tonnes are supplied from secondary sources, like recycled paper or the recovery of wood from wood processing. Household and commercial waste makes up another category of biomass supply, the recovery of which is increasing.

Biomass is used for a variety of non-food uses, for example animal feed and bedding which consumes the largest share of crop residues. Energy including heat, power and biofuels accounts for around a quarter of non-food biomass consumption and various material uses such as wood products and furniture, textiles, and different types of innovative bio-based chemicals accounting for approximately another quarter. The overall use of biomass in the EU grew by around 8.5% from 2010-2015. Most of the increase was due to rising demand for bioenergy, growing by 32%, followed by increased demand for bio-based materials growing nearly 50%.

Challenges

While the availability of biomass from woody resources, wood processing by-products, major crops and energy crops has commonly been widely reported, it is much more difficult to obtain information on the availability of agricultural residues and processing by-products. In part because these descriptors cover a very wide range of materials which in many cases are or have commonly been treated as ‘wastes’. As such they have not been widely traded to date, often having been used or discarded locally, and information on arisings is rarely collected or collated.

Another aspect to consider is that biomass, and indeed waste available to the bioeconomy is often dependant on definitions, which are continually being defined and re-defined. When is a waste still a waste, if it has a use? Defining waste and by-products directly ties in with regulation – additionally, how subsidies and incentives are handed out. What constitutes a waste or a residue relies on interpreting specific policy guidance in the UK and existing UK law on waste. In some cases, utilising waste biomass isn’t economically viable without financial incentive.

Policy Influence in the UK

UK energy policy encourages the increased use of biomass for power, heat and transport fuels and therefore understanding biomass availability is critical. UK policy has strict sustainability criteria around what biomass types are eligible for support. Therefore, for both business and policy development, knowing what’s available means knowing what to support or discourage.

In addition, over the past decade or so there has been a legislative push for a reduction in the amount of biodegradable waste sent to landfill, therefore more should become available for utilisation. The UK aims to work towards eliminating food waste and biodegradable waste to landfill by 2030, as laid out in the 2018 Resources and Waste Strategy.

Factors impacting availability or suitability

Accessibility is an important consideration. Biomass can be available in the volumes required, but the sources can be widely dispersed, in such case collection of biomass can become a hindrance.

Biomass availability needs to take into account logistical considerations as well as composition, which for some biomass feedstocks, can play a large part in whether it can be considered available or useful. Drying or pelleting is sometimes necessary for ease of transportation and storage. In addition, the composition of waste is generally variable. When destined for AD treatment for example, nutrient content of the feedstock plays an important factor in the management of feedstock blending and site logistics and storage – the managing of an AD facility is a constant task.

When considering agricultural residues as a resource, seasonality plays a part in their availability. For example, one of the potential challenges of using slurries and manures for AD sites from smaller-scale dairy and beef enterprises is the seasonality of supply, as cattle are often turned out to grazing for up to 6 months of the year.

Another factor can simply be the price of the feedstock. Many factors influence the prices of feedstock. Energy content or nutrient content plays a part, as well as the expense of collecting, alongside availability and competition for resources. For example, used cooking oil is estimated to cost between £12.77 and £17.02 per GJ of energy, compared to sugar cane bagasse, estimated at £5.05 to £7.16 per GJ.

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Agriculture

Agricultural crops can be grown for food, however, not all of the crop is destined for food. Much of the produced biomass is residue, like leaves and straw, and can be available for other uses. For example, the UK in 2020 produced just under 19 million tonnes of cereals. Cereal straw production in 2020 was estimated at 6.1 million tonnes. Animal bedding is one well established use of straw, however, there is still opportunity for further agricultural residue utilisation.

In 2019, 96 thousand hectares of agricultural land in the UK was used to grow crops for bioenergy, which represents just over 1.6% of the arable land in the UK. Of the proportion of land used for bioenergy, 20% was allocated to use for biofuel production (biodiesel and bioethanol) in the UK, with the remainder mostly used for heat and power production. 280 million litres of biofuel were produced from UK grown crops for the UK road transport market. Just over 6.7 million tonnes of oil equivalent of plant biomass were used to produce electricity and heat in the UK.

Biomass power production primarily utilises woody biomass and agricultural residues such as straw. In the UK the forest area available for wood supply is 3.11 million hectares. However, biomass power in the UK particular for large plants involves sizeable imports of wood pellets and other suitable feedstocks. The use of straw in the power sector has also grown in recent years and demand is now just under 1 million tonnes per annum based on installed capacity. However, straw transport prices tend to limit its use to the vicinity of collection.

Waste and Residues

UK biodegradable municipal waste sent to landfill in 2019 was 6.6 million tonnes, which amongst other materials, includes food waste, green waste, cardboard and paper. The UK's Resources and Waste Strategy looks to reduce biodegradable waste sent to landfill and identifies 5 key aims, one of which is to work towards eliminating food waste to landfill by 2030. Food waste as a resource is

expected to increase in availability when separate food waste collections will be required across all Local Authority areas (households and businesses) as of 2023. WRAP estimates that food waste arisings within UK households, hospitality & food service, food manufacture, retail and wholesale sectors at around 9.5 million tonnes annually in 2018.

Waste wood too is a resource that is increasingly optimised. Every year five million tonnes of waste wood is generated in the UK. The majority of this is used for the panel board industry, but is also used as animal bedding and in play areas. It is also being increasingly used as a biomass fuel.

Residues from paper production in 2013 amounted to nearly 0.4 million tonnes used by the 52 paper mills in the UK. This is derived from 1.1 million tonnes of wood pulp, of which 0.9 million tonnes is imported. As for paper recycling, 7.9 million tonnes of paper were collected for recycling in 2013, of which 3.8 million tonnes were used domestically.

Feedstocks for AD

To run a biogas plant using animal by-products (ABPs) approval from the Animal and Plant Health Agency (APHA) is required. ABPs are divided into 3 categories, based on the risks they pose, with category 1 being high risk and category 3 being low risk. Food waste is generally classed as containing animal by-products, therefore falls under this categorisation.

Feedstocks that don't contain food waste are generally relatively simple to source, receive and process from a technical and regulatory perspective, as they do not require complex pre-treatment such as de-packaging and pasteurisation, and will allow the digestate to achieve PAS110 end-of-waste status, for use in agriculture and horticulture.

Crops can be grown specifically for anaerobic digestion, for stabilising or supplementing other feedstocks such as low yielding slurries or variable quality food waste. Such crops include maize, grass silage, energy beet and whole crop cereals. Crops have been grown for use in AD in the UK for the past decade. Currently, the estimated cropping area required by operational AD plants in the UK amounts to 93,000 hectares. This is predominantly maize, with lesser amounts of grass silage, whole crop cereals (including rye) and fodder beet being grown. Definitive production figures are not available, as the market is so dynamic, the composition and type of feedstock used in AD facilities change year on year. However, the biogas generating potential of crop feedstocks is significant.

In the UK an estimated 90 million tonnes of manures and slurries are generated each year. Manure and slurry are valuable feedstocks for AD, given their high availability, low cost, and favourable biological characteristics. It is worth noting, that the EA has issued guidance to confirm that solid and liquid digestate produced via the anaerobic digestion of manures and slurries will not be treated as 'waste' if used as fertiliser.

Crop residues are a suitable feedstock for AD. Crop residues are defined as 'production residues' produced as an integral part of the commercial production of agricultural crops; these may include damaged or misshapen fruit or vegetables, trimmings and other plant parts which are not the intended end product, such as straw, leaves or tops. These can be collected from the field or a packing unit, prior to leaving the farm gate. However, their use is often constrained by the ability to process such residues. The lignocellulosic content, of straw in particular, means processing requires specific pre-treatment technology to break down the cell structure to release the inherent energy during AD. In addition, such residues, which often includes damaged and already degrading materials, have a relatively short shelf life – a maximum of 1-2 months.

Advanced biofuel feedstocks.

Biobased feedstocks for energy and fuel can have differing levels of sustainability. The Renewable Energy Directive (2009/28/EC) (RED) promotes certain types of biofuels produced from a list of materials with a dedicated target within the transport sub-sector, defined in its Annex IX. The contribution of advanced biofuels and biogas produced from the feedstock listed in Part A of Annex IX as a share of final consumption of energy in the transport sector is required to increase from 0.2 % in 2022, to 1 % in 2025 and at least 3.5 % in 2030.

Wastes are defined in the RED and waste framework directive (2008/98/EC) as "any substance or object which the holder discards or intends or is required to discard". Based on this definition, examples of wastes in Annex IX include used cooking oil (when not used for other uses), industrial and municipal wastes and sewage sludge. They are end-of-life products, but many of them have an energy use, or even an animal feed use in some regions, as is the case for used cooking oil. Therefore, despite being categorized as wastes they might still have valuable uses and potentially cause displacement emissions when diverted for biofuel production. The RED defines processing residues as "a substance that is not the end product(s) that a production process directly seeks to produce. It is not the primary aim of the production process and the process has not been deliberately modified to produce it."

More Feedstocks on Global Level

A variety of feedstocks are available across the world, however, not all are available or traded. The following are some examples.

Globally, 1.8 million tonnes of castor oilseed are produced. Castor oil is extracted and refined from the castor bean and has a wide variety of uses, such as a lubricant in high-speed engines and aeroplanes. Hydrogenated castor oil is used in polishes, ointments, waxes, printing inks, cosmetic, hair dressings, soaps and disinfectants and medicinal treatments.

After shelling, 4.5 million tonnes of cocoa beans are produced around the world, leaving large amounts of the cacao shell and is currently mostly used at source or disposed of.

Used cooking oil (UCO) is recycled and filtered oil considered a waste product from the hospitality and food sectors. It's often collected by oil recycling from foodservice outlets and processing facilities. However, most domestic oil waste is not currently collected. Currently, there is strong competition for UCO as a resource for biofuels due to its heavy incentivisation over virgin oils. This is the case in the UK for example, where UCO-derived biodiesel dominates UK biodiesel.

The vast majority of dry distillers grain (DDGS) are produced as a co-product of ethanol production. The majority of DDGS is sold for ruminant animal feed – its high energy and protein levels make it ideal for this purpose. The market for protein globally is a strong one, hence is commonly traded.

Competition for Resources

Significant use of residue by-products is already made by the processing industry from which it arises, such as bagasse from sugar cane, lignin from pulping operations. This extends to the over-sizing of boilers at processing plants to supply excess power to the grid to optimise the use of the resource, to maximise the use of by-products as a resource.

In other cases, significant use is made of materials in the animal feed sector. For example in the UK, a high proportion of wheat straw collected from the field is used as livestock bedding (around 60%), with barley straw being more palatable and typically used as feed (around 80%). Oat straw is also

highly palatable and favoured as a feed by the livestock sector (around 90-100%). Conversely, oilseed rape straw is less palatable and although highly absorbent, it is coarser in texture and rarely used as bedding (around 20%). In addition to its value in the livestock sector, 20% of the straw produced is typically left on the field to address carbon retainment needs and soil improvement.

Biobased product production has received little attention in this report. Biomass is used widely for traditional uses, but the volume of biomass used for novel biobased products is small compared to biofuels and bioenergy, but the market is growing. The extent to which biomass can be utilised for products is wide and varied.

Consumer demand and innovative technologies are now creating new economic opportunities with cleaning and personal care ingredients. While materials – such as polyethylene and polyethylene terephthalate (PET), commonly used in packaging, and polyvinyl chloride (PVC), commonly used for plastic piping – derived from biomass are all commercially available now. These biobased products can offer significant GHG emission savings over their fossil counterparts and, given that they're relatively new, they may offer further savings as processes and supply chains develop.

In order to achieve net zero, we must look at biomass with a whole-systems approach. A biomass strategy should be based on a long-term vision of how to minimise GHG emissions across all sectors of the economy using all available options. Biomass should be directed (where technically, geographically and environmentally appropriate) to those applications where decarbonisation options are limited or non-existent, where the alternative approach is particularly GHG intensive, and where there are opportunities for carbon storage and negative emissions.

The utilisation of biomass for bioenergy, biofuels and biobased products can help to reduce the emissions of greenhouse gases and contributes to an increasingly circular economy. However, there are many factors relating to its availability for any given potential application, which should be considered for its effective uptake. NNFCC has specific knowledge and expertise regarding biobased feedstock availability and can give strategic and practical advice for producers, processors and end-users.

Sources and References

Internal knowledge of NNFCC, based on an understanding of typical arisings in processing supply chains, typical processing locations, current means of use or disposal, cost and ease of transport as well as likely suitability for use in combustion or AD systems.

Trade statistics such as FAOSTAT and international trade statistics based on EU CN 8-digit traded commodity codes

European Commission. Knowledge Centre for Bioeconomy: Biomass. Publication: Food, feed, fibres, fuels. Enough biomass for a sustainable bioeconomy?

DEFRA. Crops Grown For Bioenergy in the UK: 2019. Agriculture in the United Kingdom 2020

In the absence of definitive data on residue arisings, estimates were derived based on an understanding of the composition of parent materials or reported residual arisings in typical or individual processing facilities