BIOMASS CROP END USES

Biomass crops are:

- non-food crops where the whole aboveground plant material is harvested to produce bioenergy or other materials and chemicals.
- usually herbaceous or woody perennials with high calorific value and growth rates, but low nutrient and management demands.
- efficient ways to remove carbon dioxide (CO_2) from the atmosphere.

BIOENERGY

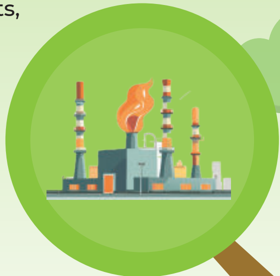
Biomass crops can be used much like traditional fossil fuels to generate heat and power in. e.g.,

Large scale power generation – burning biomass to generate electricity re-releases *contemporary* carbon captured during photosynthesis and is carbon neutral. Capturing and storing this carbon makes the process carbon negative. The combustion of fossil fuels releases *ancient* carbon, resulting in net *increases* in CO_2.

Combined heat and power (CHP) – mostly used in large commercial/industrial applications, CHP produces electricity/power whilst capturing and using the associated thermal energy at/near the site of production (10 to 30 % more energy efficient than conventional technologies).

Domestic fuel – burning logs, chips, pellets, and briquettes in biomass boilers for domestic heat and hot water.

Anaerobic digestion – microorganisms break down biomass in the absence of oxygen, producing biogas with a high methane content. Capturing and burning the biogas produces carbon neutral heat and/or electricity. Residual digestate (indigestible plant material and dead microbes) is nutrient rich and can be used as a fertiliser.



MATERIALS

Biomass crops can be used to manufacture multiple bio-based products, including materials in the chemical sector (i.e., bioplastics), which is heavily dependent on fossil fuels.

Lignin (a major component of plant cell walls) is non-toxic, biodegradable, and has antibacterial and antioxidant properties. It is an abundant and valuable biomaterial with utility for:

Delivery of active ingredients – lignin-based microparticles can be developed as precise, targeted, controlled-release carriers of active ingredients (fertilisers/herbicides/pesticides) for agriculture, or medicinal compounds for healthcare.

Construction materials – novel biomass products (i.e., 'hempcrete' blocks) are carbon sinks, removing more CO_2 from the atmosphere than emitted in manufacture, and storing CO_2 after the building's end of life. Other products include insulation materials, fibreboards, furniture, and moulded products for car bodywork.

Textiles – e.g., hemp and Miscanthus fibres can be blended with cotton, silk, and other fibres for geotextiles to help meet growing demands for environmentally responsible textiles.

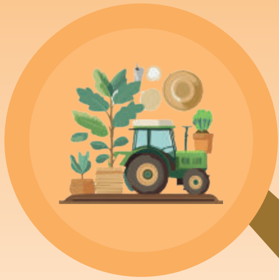
Packaging – bio-based packaging materials (with minimal environmental impacts and low carbon footprints) are increasingly sophisticated replacements for synthetic plastics, the accumulation of which constitutes 60 % to 80 % of global waste and poses a serious threat to the biosphere.

AGRICULTURE

Animal bedding – the physical and biological properties of biomass crops compare well to alternative bedding materials. Farmers can grow their own bedding, building self-sufficiency and reducing transport and emission costs.

Compost – biomass-based compost reduces the use of peat with its associated greenhouse gas emissions.

Phytoremediation – for example using biomass crops to stabilise or remove pollutants from contaminated sites (e.g., heavy metals, pesticides, leachates from landfill).

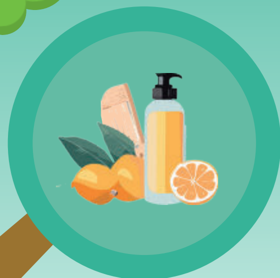


HEALTH AND BEAUTY

Biomass crops are a source of natural polymers and bioactives, with multiple utilities in physical and chemical applications for the health and cosmetic industries, including for:

Pharmaceuticals and food supplements – e.g., salicin (for pain relief), xylitol (a sugar substitute), and multiple compounds with anti-inflammatory and antioxidant properties.

Cosmetic and skincare – e.g., hemp and eucalyptus extracts are high in essential fatty acids, polyunsaturated fatty acids, antioxidants, and other nutrients, useful as moisturizers and included as components in cosmetic products including soaps, shampoos, lip balms, massaging oils and other skincare and hair products.



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Biomass Connect is funded by Department for Energy Security & Net Zero

BIOMASS CROP END USES – further considerations

Method	Capture process	Carbon storage pool	Category	Readiness	Mitigation potential	Storage timescale
Afforestation, reforestation, agroforestry, forest management	B	VSS	Conventional	High	Large	Decades to centuries
Peatland & coastal wetland restoration	B	VSS	Conventional	High	Small	Decades to centuries
Soil carbon sequestration in croplands & grasslands	B	VSS	Conventional	High	Large	Decades to centuries
Durable wood products	B	BE	Conventional	High	Small	Decades to centuries
Biochar	B	VSS	Novel	Medium	Moderate	Centuries to millennia
Mineral products	G	BE	Novel	Medium	Small	> Ten millennia
Enhanced rock weathering	G	M	Novel	Low	Large	> Ten millennia
Biomass burial	B	VSS	Novel	Low	Large	Centuries to millennia
Bio-oil storage	B	GF	Novel	Medium	Moderate	> Ten millennia
Bioenergy with carbon capture & storage	B	GF	Novel	Medium	Large	> Ten millennia
Direct air carbon capture & storage	G	GF	Novel	Medium	Large	> Ten millennia
Ocean fertilisation	B	MS	Novel	Low	Moderate	Centuries to millennia
Ocean alkalinity enhancement	G	M	Novel	Low	Large	> Ten millennia
Biomass sinking	B	MS	Novel	Low	Large	Centuries to millennia
Direct ocean carbon capture & storage	G	GF	Novel	Low	Large	> Ten millennia

Legend:

- **B** Biological
- **G** Geochemical
- **VSS** Vegetation, soils and sediments
- **BE** Built environment
- **GF** Geological formations
- **MS** Marine sediments
- **M** Minerals

Category: Conventional; Novel

Readiness: High; Medium; Low

Mitigation potential: Large; Moderate; Small

Storage timescale: > Ten millennia; Centuries to millennia; Decades to centuries

Adapted from Smith, S. M., Geden, O., Gidden, M. J., Lamb, W. F., Nemet, G. F., Minx, J. C., Buck, H., Burke, J., Cox, E., Edwards, M. R., Fuss, S., Johnstone, I., Müller-Hansen, F., Pongratz, J., Probst, B. S., Roe, S., Schenuit, F., Schulte, I., Vaughan, N. E. (eds.) The State of Carbon Dioxide Removal 2024 - 2nd Edition.

Credit: Liliana Resende, Oxford Smith School

An important consideration in biomass crop end use is their potential for carbon dioxide removal (CDR), which is a necessary strategy to reduce historic greenhouse gas emissions and achieve the Paris Agreement on climate change.

The State of Carbon Dioxide Removal 2024 report highlighted a wide range of possible CDR methods, many of which involve biomass (highlighted in the graphic to the left). It shows that:

- the 'readiness' of biomass crops for CDR is high,
- the mitigation potential is large,
- and storage timescales range across all the categories (from decades to > ten millennia).

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