

Biomass for electricity and heating Opportunities and challenges

SUMMARY

Biomass is a renewable energy source which can be used to produce electricity, heat and transport fuels. It accounts for roughly two thirds of renewable energy in the European Union (EU). Although biomass can come from many different sources, wood is by far the most common.

Under EU legislation, biomass is carbon neutral, based on the assumption that the carbon released when solid biomass is burned will be re-absorbed during tree growth. Current EU policies provide incentives to use biomass for power generation. At present, there are no binding sustainability criteria for biomass at EU level, although some exist at national and industry level.

Opportunities and challenges related to biomass have to do with greenhouse gas emissions (biomass can contribute to reducing carbon emissions, but emissions may not be fully accounted for); resource availability (biomass can contribute to energy security, but its sources are finite); environment and human health (increased use of biomass for energy can have adverse effects on air quality, soil properties and biodiversity). To address sustainability concerns, different responses have been put forward, including the principle of the cascading use of biomass, whereby it is used more than once, with energy conversion typically as the last step.

The European Parliament has called for EU sustainability criteria but has opposed legally binding rules for prioritising uses of wood. Stakeholders have expressed opinions on greenhouse-gas accounting, sustainability criteria and the cascading use of biomass.



Wood logs, a form of solid biomass.

In this briefing:

- Background
- EU policy
- Opportunities and challenges
- Sustainability
- European Parliament's position
- Stakeholders' views
- Main references

Glossary

Bioenergy: energy derived from biomass, either through direct use as fuel or after processing into liquids and gases.

Biomass: biological material derived from (recently) living organisms. Biomass includes wood, agricultural crops, waste and residues as well as manure.

Solid biomass: plant and animal biomass in solid form: woody materials (e.g. logs, chips, pellets, charcoal), solid agricultural waste (e.g. straw, rice husks, nut shells) and dry manure.

Background

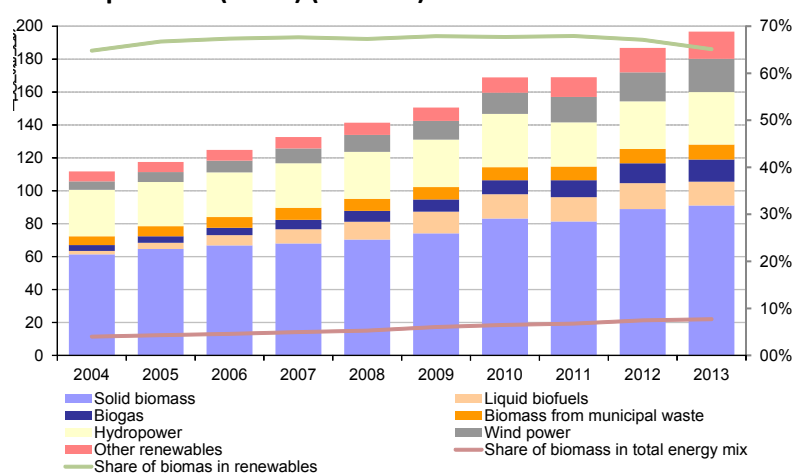
Biomass has been used as a fuel since humans first learned to control fire. Traditional biomass refers to wood, charcoal, agricultural residues and animal manure being used for cooking and heating in households. Modern biomass for energy use can be divided into five broad categories: wood from forestry or wood processing; agricultural crops grown specifically for energy applications; residues from agricultural harvesting or processing; food waste; industrial waste and by-products from manufacturing processes.

Biomass is considered a **renewable energy source** because it can usually be renewed in a few decades. Currently, bioenergy accounts for roughly 10% of global energy supply; two thirds of the biomass is consumed in developing countries for cooking and heating.

Numerous biomass feedstocks can be converted using a variety of conversion routes in order to produce **three types of bioenergy**: heat, electricity and transport fuels. **Electricity** and **heat** are generated through combustion of solid biomass or biogas in systems ranging from small-scale domestic stoves to industrial power or heating plants. Burning solid biomass in traditional power plants alongside fossil fuels, in a process known as 'co-firing', is seen as a cost-effective option that makes use of existing coal plants with only minor adjustments. In addition, combined heat and power, also known as 'co-generation', can be used to convert biomass into electricity, while extracting waste heat for supplying it to district heating or industrial facilities. **Transport fuels**, also known as biofuels, are mainly derived from energy crops, although advanced biofuels (based on waste and residues) are under development. For more details on biofuels, read the EPRS briefing on [EU biofuels policy](#).

The **final energy consumption from biomass** in the EU28 has grown from 72 million tonnes of oil equivalent (Mtoe) in 2004 to 128 Mtoe in 2013. Although the total share of biomass among renewable energy sources has remained stable (at 65%) over the past decade, the share of biomass in the overall energy mix has grown from 4% in 2004 to 7.7% in 2013. At present, 46% of renewable energy in the EU comes from **solid biomass**

Figure 1 – Renewable energy sources in EU28, in million tonnes of oil equivalent (Mtoe) (2004-13)



Data source: Eurostat ([nrg_100a](#)), 2015.

(almost exclusively wood). According to the [European observatory on renewable energy](#), in 2013, solid biomass accounted for 3% (7 Mtoe) of the electricity produced in the EU and 15% (8.8 Mtoe) of the heat produced in industrial units. A further 63.5 Mtoe of heat from biomass was produced by domestic users. The per capita use of biomass for heating and electricity in EU Member States in northern Europe is significantly higher than the EU average. In 2013, the European [solid biomass and biogas sectors](#) generated turnover of close to €42 billion and employed 380 200 people, including many in rural areas.

Conversion routes

Thermochemical conversion pathways include [combustion](#), the most widely used route to turn biomass into energy; [gasification](#) (based on a partial oxidation process), converting biomass into biogas; [pyrolysis](#) (based on thermal decomposition in the absence of oxygen), converting dry biomass into oil, charcoal or [biochar](#); and [hydrogenation](#), converting vegetable and animal oils into liquid fuel. **Biochemical conversion pathways** include [anaerobic digestion](#) (in the absence of oxygen), converting biomass into methane; [transesterification](#), used to produce biodiesel from oils; and [fermentation](#) (followed by distillation), used to produce bioethanol from sugars.

A [report](#) by the International Renewable Energy Agency (IRENA) indicates that many biomass power technologies are mature and production costs can be in the range of electricity generation rates in the OECD, in particular where low-cost agricultural or forestry waste is available. The European Commission [notes](#), however, that in most cases, electricity generation from biomass currently requires some level of public financial support.

The European Commission [expects](#), based on national estimates, that the supply of biomass for heating and electricity will continue to increase (from 103.3 Mtoe in 2012 to 132 Mtoe in 2020), with the relative share from agriculture (mainly residues and agricultural by-products) and biodegradable waste increasing significantly. The European Commission also expects imports from third countries to increase by 2020, largely in the form of wood chips and wood pellets.

Wood pellets

[Wood pellets](#), small cylinders produced from compacted sawdust, are being used increasingly as a source of bioenergy in power plants, domestic heating appliances, residential heating systems and industrial boilers for heat production. According to [data](#) from the European Biomass Association, 18.3 million tonnes of pellets (or 79% of global consumption) were consumed in the EU in 2013. A third is now being imported, mainly from the USA, Russia, Ukraine and Belarus. Global wood pellet consumption is [projected](#) to rise from 22 to 50-80 million tonnes by 2020.

EU policy

The **policy framework** is set by the 2009 [Renewable Energy Directive](#), establishing a mandatory 20% share of renewable energy sources in the EU final energy mix by 2020. The Directive, which lists biomass as a renewable energy source, aims inter alia to achieve greater mobilisation of existing timber reserves. It mandates Member States to draft [national renewable energy action plans](#) and sets conversion efficiency thresholds above which Member States may promote bioenergy technologies.¹

Under the EU's and the global² regulatory framework, **greenhouse gas emissions** (GHG) associated with biomass combustion are not included in the energy sector, based on the assumption that carbon released when solid biomass is burned will be re-absorbed during tree growth; however, resulting changes in carbon stocks are reflected in the agriculture, forestry and other-land-use sector (currently not subject to emission

reduction commitments). In 2013, Parliament and Council adopted a [Decision](#) defining accounting rules for GHG from land use, land-use change and forestry, as a first step towards the inclusion of those activities in the EU emissions-reduction commitment. At global level, the [REDD+ Programme](#) aims to address emissions from deforestation and forest degradation (accounting for nearly 20% of global GHG emissions) and to promote sustainable forest management.

In the EU, policies provide **incentives to use biomass for electricity generation**. On the one hand, because its GHG emissions do not fall under the EU Emissions Trading Scheme (ETS), biomass has an advantage over (fossil) energy sources subject to the EU ETS. A 2011 [report](#) by the International Energy Agency notes that EU ETS allowances in a price range of €15-25 per tonne may encourage the use of biomass as a fuel, but are too low to incentivise the construction of new biomass plants. Moreover, financial incentives at national level (for instance in the UK) have played a key role in the conversion of coal power plants into wood plants.³ A 2012 [study](#) by the International Institute for Sustainable Development estimates that electricity generation from biomass in the UK and Germany received deployment subsidies of between 5 and 9 eurocents per kWh over the period 2000-09.

The Renewable Energy Directive does not specify any **sustainability criteria for biomass** (although it sets such detailed criteria for biofuels). In 2010, the European Commission listed [non-binding sustainability criteria](#) regarding biomass for electricity and heating, and recommended their adoption by Member States. However, their implementation is patchy⁴ and some stakeholders have expressed concerns that divergent national sustainability criteria can be a barrier to (intra-EU) trade in solid biomass. Nevertheless, there are a series of sustainability schemes relevant to energy biomass: criteria and indicators for sustainable forest management by [Forest Europe](#), an intergovernmental body; certification schemes for forestry products (e.g. [FSC](#) and [PEFC](#)); and industry-led initiatives (e.g. the [sustainable biomass partnership](#) or the [ENplus certification](#) for wood pellets).

As regards **forest biomass**, the European Commission adopted a [new EU forest strategy](#) in 2013, addressing the increasing use, overall, of forests for a variety of purposes, including bioenergy. It aims to ensure and demonstrate that all EU forests are managed according to [sustainable forest management](#) principles by 2020.

The European Commission has [announced](#) that by 2017 it will put forward a new Renewable Energy Directive for the period beyond 2020, aimed at reaching at least 27% of renewable energy in the EU energy mix by 2030 and setting out, among other things, a 'bioenergy sustainability policy'.

Opportunities and challenges

Greenhouse gas emissions

Burning solid biomass (the most common biomass conversion route) emits more CO₂ per unit of energy generated than fossil fuels, because wood is less energy-dense and contains more moisture. However, when looking at the wider cycle of emissions, biomass can reduce CO₂ emissions. European Commission data [published](#) in 2010 ([updated](#) in 2014) estimate **savings in GHG emissions** for various types of biomass, compared with typical fossil-fuel emissions. The data indicate that biogas produced from wet manure generates most savings,⁵ reaching up to 100%; biogas produced from maize (whole crop) generates emission savings ranging from negative values (emissions

higher than fossil fuel reference) to more than 50%, depending on the technology adopted; and solid biomass combustion produces emissions savings generally above 60% both for power and heat produced, and reaching over 70% in some cases.

The **GHG balance of electricity and heat generation from biomass** depends on the type of feedstock used, the amount of fertiliser used, carbon stock changes due to land use, transport mode and distance travelled, amount of energy used in processing (including farming) and efficiency of the conversion pathway. A 2014 [comparison](#) of life cycle analysis studies of forest bioenergy carried out for the European Commission suggests it is possible to identify low- and high-risk scenarios in terms of GHG emissions from forest bioenergy. The report adds that, as a given feedstock can be involved in both low- and high-risk scenarios, risks cannot be limited or removed by policies favouring certain feedstocks and discouraging others.

Biomass **GHG emission accounting** under the Kyoto Protocol and the Renewable Energy Directive is based on changes in forest carbon stocks and emissions from the combustion of biomass being reflected in the agriculture, forestry and other land use sector. A 2013 [study](#) by the Commission's Joint Research Centre identifies this as a key aspect for the validity of the assumption of biomass carbon neutrality. However, some experts have been critical of GHG accounting implementation: emissions from biomass imports from most third countries are not accounted for; emissions from the combustion of biomass are omitted (although compensated by potential regrowth); the accounting methods used may either partially or fully hide emissions from biomass use.⁶

Resource availability

Biomass can contribute to the **security of energy supply** in two main ways. Firstly, because it can be stored easily in various forms (e.g. wood and its derivatives, biogas, biofuels), biomass is a stable renewable energy source that can balance the use of variable renewable sources such as wind and solar energy. Secondly, biomass can contribute to reducing reliance on specific energy sources in third countries, in so far as the majority of biomass demand is met from domestically produced raw material. Indeed, the EU forest area has grown by about 2% over the past decade.

However, there has been some debate about the **availability of biomass** as a resource. In 2010, a [report](#) drafted for the European Commission (known as the 'EUwood' study) estimated that although demand for wood for material and energy use could probably be met by 2020, supply would be insufficient to meet demand by 2030. The study suggests that 58% of the theoretical potential of European forests could be exploited; the main constraints identified were environmental considerations related to soil productivity and uncertainties linked to attitudes of private forest owners, who control 60% of EU forests. However, a [study](#) published in 2014 by the European Forest Institute highlights a series of aspects: wood demand for material uses is likely to be lower than forecast as a result of a decline in the pulp industry and the impact of the financial crisis; international trade is not taken into account in the EUwood study; and market mechanisms can help to bridge gaps between supply and demand.

Carbon debt

The assumption that solid biomass is carbon neutral is subject to conditions. In the short term, burning wood emits carbon and decreases the capacity to sequester carbon (wood has a carbon content of around 50%), thereby creating a 'carbon debt'. The GHG compensation occurs with regrowth over a much longer time frame, known as the 'carbon payback period'. According to the European Environment Agency, depending on the assumptions used in calculations, the payback period may be estimated at 5–30 years (for forest residues), to over a century (for intensified harvesting of old trees).

The large-scale development of bioenergy from forests and agriculture could have **indirect impacts on other sectors** relying on biomass as raw materials (e.g. construction, pulp and paper industry, and biochemistry) or induce (indirect) land-use change. Competition is likely to increase, especially as regards lower-grade wood, which could push wood prices upwards.

Impacts of EU energy biomass policy on third countries

Given the unequal distribution of global vegetation stocks (as shown in a [map](#) published by the US Department of Energy) and world trade flows, EU energy biomass policy is likely to impact on third countries. The European biomass industry [considers](#) the southeastern region of the United States and British Columbia, Canada, as important sources of biomass fuel with strict regulations, a long-established history of responsible forestry, and great potential for increased production. However, NGOs have raised [concerns](#) about the use of whole trees to produce wood pellets intended for export to Europe. The use of whole trees, as opposed to waste and residues, could worsen the pellets' GHG balance and have a higher negative impact on biodiversity.

According to a European Parliament [study](#) from 2012, South America and Africa are expected to become significant exporters of biomass to the European Union. While this could have positive effects for local populations (e.g. in terms of job creation or improved forest management), it could also impair the access of rural communities to land and water, adversely affect food and energy security of local populations, and lead to deforestation and forest degradation, as natural forests are replaced with monoculture plantations.

Environment and human health

Increased use of biomass for energy can have detrimental impacts on **air quality**. Wood burning, in particular, emits particulate matter (PM), benzene, benzo(a)pyrene (BaP) and other substances into the air, with significant effects on human health, for instance asthma and respiratory diseases. The European Commission estimates that solid fuel combustion in households accounts for about one third of all PM emissions, which are considered to cause 430 000 premature deaths a year in the EU.

The removal of residues (typically branches and tree tops left after felling, as well as stumps and roots) for bioenergy can have an impact on **soil** properties. Extracting forest residues, which have a very high nutrient concentration, may affect soil quality, hinder natural regeneration and limit future production potential. On cropland, removing straw traditionally used as a soil improver may increase soil erosion, reduce water retention and limit soil temperature regulation (although it may be beneficial in some areas). Harvesting forest residues may reduce the amount of carbon stored in temperate forests, since carbon is stored primarily in soils rather than in above-ground biomass. A 2010 [meta-study](#) found that in temperate forests, (increased) harvesting results in an average 8% decrease in total soil carbon.

Biomass extraction can also affect **biodiversity**, in particular through deforestation, degradation of forest ecosystems and conversion of natural forests to tree plantations. Residue harvesting may affect species living off biomass residues such as dead wood or crop roots. Changes in the structure of forest soils may induce harmful effects on biodiversity. However, positive impacts on biodiversity may also occur if forests become better managed or when invasive alien species are removed.

Sustainability

Sustainability concerns have been raised from various angles. The 2011 [European Forest Sector Outlook Study II](#) published by the United Nations Economic Commission

for Europe (UNECE) found that the use of high volumes of wood, in order to meet renewable energy targets by 2030, could result in a deterioration of forest resources and ecosystems. In the agricultural sector, the European Commission [notes](#) that increased biomass supply from the most likely sources (dedicated crops such as maize and residues such as straw) could have a negative environmental impact on soil, water and biodiversity. A 2014 [study](#) carried out by the International Institute for Sustainability Analysis and Strategy (IISAS) for environmental NGOs underlines the lack of consistency between EU bioenergy, forest and waste policies; the partial reflection, in incentive schemes, of GHG emissions from bioenergy; and the absence of coherent sustainability regulation at EU level regarding biomass for electricity and heat.

A 2012 [report](#) for the European Commission proposes **sustainability criteria** and indicators for energy biomass. The European Environment Agency underlines that policy measures preventing negative impacts on natural resources and biodiversity would reduce GHG emissions. However, the IISAS study mentioned above suggests that forest biomass potential would be reduced by up to 30% if stringent sustainability requirements were in force.

A number of experts highlight resource-efficiency as a guiding principle when using biomass for energy. This could be implemented inter alia through a **cascading use of biomass**, whereby biomass is used more than once, typically with material use(s) as the first step(s) and energy conversion as the last step. Based on a sequence of choices about material and energy uses for biomass, this principle would seek to ensure a longer lifespan, the highest value possible and/or production of various streams from one source. A 2012 [study](#) by CE Delft, a consultancy, estimates that implementing the cascading use of biomass could contribute 10–12% to the EU emissions reduction target by 2030. However, other experts point out that for some biomass types (e.g. forest residues), energy conversion is the sole economically viable or available option.

The European Parliament's position

Parliament called, in its resolution of 9 July 2015 on the [circular economy](#), for the implementation of a cascading use of resources, notably in the use of biomass. It also asked the Commission, in its resolution of 5 February 2014 on the [2030 climate and energy policies framework](#), to propose sustainability criteria for solid and gaseous biomass, taking into account lifecycle greenhouse gas emissions in order to limit the inefficient use of biomass resources. However, in its resolution of 28 April 2015 on a [new EU forest strategy](#), Parliament also recognised the value of wood for energy purposes and opposed legally binding rules for prioritising the uses of wood, as this would restrict the development of new and innovative uses of biomass.

Stakeholders' views

Environmental NGOs [BirdLife, European Environmental Bureau, and Transport & Environment](#) advocate reassessing the assumption of biomass carbon neutrality, introducing new carbon accounting methods and improving reporting and transparency under the EU ETS. They also support ambitious environmental safeguards, with a view to ensuring that biomass use for energy is only incentivised when it delivers GHG emissions reductions, and call for a cap on the maximum contribution of biomass to EU renewable energy targets. [FERN](#), an NGO focusing on forests, advocates EU-wide binding sustainability criteria, measures based on the cascading use principle, and phasing out biomass use in large power plants.

With regard to carbon emissions accounting, biomass sector association [AEBIOM](#) highlights that emissions from biomass are offset by the growing amount of forest in the EU, while substituting biomass for coal reduces overall CO₂ emissions. Regarding the cascading use of biomass, the [Confederation of European Forest Owners, European farmers and agri-cooperatives \(Copa-Cogeca\) and the European Landowners' Organisation](#) believe it would disrupt the market, as illustrated by Sweden's experience, and would prove impossible to implement on the ground. Instead, they advocate measures securing forest productivity and wood mobilisation. [AEBIOM and Eurelectric](#) call for EU-wide binding sustainability criteria for biomass based on reliable science and focusing on major environmental concerns.

Main references

[EU bioenergy potential from a resource efficiency perspective](#), European Environment Agency, 2013.

[Recycling agricultural, forestry & food wastes and residues for sustainable bioenergy and biomaterials. Technology options for feeding 10 billion people](#), European Parliament, DG IPOL, 2013.

Endnotes

- ¹ Conversion efficiency varies according to the conversion pathway. For biomass, the minimum conversion efficiency is set at 85% for residential and commercial applications and 70% for industrial applications. Estimates provided in a 2013 report by the European Environment Agency suggest that three conversion routes meet these criteria: 'combustion to produce heat only' (efficiency of at least 85%), 'solid biomass cogeneration' (efficiency between 65% and 85%), and 'biogas/biomethane' (efficiency between 50% and 85%).
- ² The United Nations Framework Convention on Climate Change (UNFCCC) and its protocols (in particular the Kyoto Protocol).
- ³ The [Tilbury](#) power plant was closed in 2013 because it failed to qualify for government incentives to burn biomass instead of coal, despite its partial conversion to biomass in 2012. The [Lynemouth](#) coal power plant received government support for its conversion to biomass in 2014, although the European Commission subsequently opened an [investigation](#) into the legality of the state aid granted. The [Drax](#) coal power plant, the UK's largest power plant, is in the process of partial conversion to biomass, enabling it to claim government subsidies in the form of 'renewable obligation certificates'.
- ⁴ A review of the implementation of these recommendations by Member States found that about half of them have adopted rules promoting higher efficiency in energy production, but only a few have implemented GHG-saving criteria; some have introduced sustainable forest management criteria; and a number have introduced rules addressing competition with other biomass uses.
- ⁵ The main reason for the high emission savings is that biogas produced from wet manure enables to avoid emissions of methane, a powerful greenhouse gas.
- ⁶ According to a [Chatham House study](#) to be published in autumn 2015.

Disclaimer and Copyright

The content of this document is the sole responsibility of the author and any opinions expressed therein do not necessarily represent the official position of the European Parliament. It is addressed to the Members and staff of the EP for their parliamentary work. Reproduction and translation for non-commercial purposes are authorised, provided the source is acknowledged and the European Parliament is given prior notice and sent a copy.

© European Union, 2015.

Photo credits: © tanawatpontchour / Fotolia.

eprs@ep.europa.eu

<http://www.eprs.ep.parl.union.eu> (intranet)

<http://www.europarl.europa.eu/thinktank> (internet)

<http://epthinktank.eu> (blog)