Bioenergy

In brief

Bioenergy is produced by means of several technology chains, from the production of biomass – cultivation, harvesting, transportation, storage and eventually pre-treatment – to its use in a conversion process to produce the final form of energy required: electricity, heat, combined heat and power (CHP) or biofuel for transport. Bioenergy is already the largest source of renewable heating in Europe and biomass plays an important role in power generation. The use of biofuel for transport has risen steadily over the past decade due to significant public support, but potential competition for land between fuel crops and food crops, as well as concerns regarding sustainability issues, are limiting market growth. This has accelerated the need for better forestry and land management practices, as well as the development of more sustainable advanced biofuels.

The technology

Several technologies can be used to convert biomass into heat and electricity, all based on two main processes: thermo-chemical (combustion, pyrolysis and gasification) and biochemical/biological (digestion and fermentation). Bio-energy technologies are at different stages of development, from commercial status (biomass combustion, biogas production) to near commercial and demonstration (thermal gasification) to research and pilot stage (pyrolysis).

A wide range of biomass materials can be used to generate bioenergy, including fuel-wood, wood industry residues, forest logging residues, agricultural waste and residues, residues from the food and paper industries, the organic fraction of Municipal Solid Waste, sewage sludge and dedicated energy crops, such as short rotation forestry/short rotation coppice (SRF/SRC) and energy grasses. Traditional biomass is also an important source of bioenergy.
source of energy, especially in small, domestic appliances and isolated communities.

New, densified forms of better quality biomass, such as wood pellets and briquettes, are increasingly used in both domestic and industrial contexts, despite their higher cost. Modern domestic wood chip and pellet boilers, for example, have much higher efficiencies (up to 90%) compared to traditional log heating systems (10-30%).

The most cost-effective option for producing heat and electricity from biomass and municipal solid waste (MSW), is co-firing with pulverised coal in existing boilers, as only small changes are needed in the fuel feed system. Direct co-firing is already being achieved where 15% of the coal is replaced with biomass. This percentage could potentially be increased to 50-80% with pre-treatment involving torrefaction (heating in the absence of oxygen).

With co-firing, biomass can be deployed in large amounts without any (or only minor) investment costs, because the existing plants and structures can be used.

Furthermore, when co-firing with small proportions of biomass (up to 20%) the plant’s electrical conversion efficiency (35-45%), can be significantly higher than for dedicated large-scale biomass plants (25-35%).

The collection of methane-rich gas from landfill sites is economically viable and has been deployed on a large scale, up to 4-6 MW. Another conversion technology, pyrolysis – the conversion of biomass to liquid, solid and gaseous fractions – remains interesting, but more research is needed to make it commercially viable.

**Ongoing research**

There is considerable interest in developing bio-refineries that would allow for the efficient and cost-effective processing of biomass simultaneously into high value chemicals, bio-based products (e.g. furfural-based products) and energy (biofuels, biogas, heat and/or electricity, obtained using the low-value fractions of biomass).

There is a pressing need to demonstrate bioenergy technologies on an industrial scale, including innovative biofuel value chains. The Bioenergy Technology Roadmap of the EC SET-Plan aims to bring the most promising technologies to maturity, with an estimated budget of EUR 9 billion over 10 years. Meanwhile, the European Industrial Bioenergy Initiative (EIBI), launched in 2010, aims to make the costs of producing bioenergy more competitive with fossil energy and to strengthen EU leadership for renewable fuels for transport. The EIBI Implementation Plan for 2013 – 2017 describes the core activities aimed at building and operating demonstration projects with large market potential.

Funding of over EUR 600 million was agreed in 2012 under the New Entrants Reserve (NER 300) for eight bioenergy/biofuel demonstration projects, although three bioenergy projects have since cancelled their decision to invest. In 2013, a new public-private partnership was announced with the aim of investing EUR 3.8 million up to 2020.

There are still significant uncertainties regarding the potential for biomass energy and more attention needs to be devoted to developing new feedstocks with higher yield, increased oil or sugar content, etc. Improved forest and agricultural management practices would help to increase the supply of Advanced conversion paths based on biological and chemical processes

![Diagram of Advanced conversion paths based on biological and chemical processes](image)

**Main markets:**
- **Renewable transport fuels as gasoline components E85**
- **Renewable renewable transport fuels for jet and diesel engines**

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**Source:** European Biofuels Technology Platform
Fact file

- The main sources for bioenergy are wood and residues from forestry and wood processing (85%), followed by waste (10%) and agricultural biomass (5%).
- About 2 090 TWh of biomass will be used to provide around 1 630 TWh as bioenergy in 2020, including biofuels.
- Biomass electricity generation in the EU increased from 69 TWh in 2005 to 123 TWh in 2010 and 133 TWh in 2011. It should reach 232 TWh in 2020 according to the EC Energy Roadmap 2050.
- Biomass dominates the renewable heating market, where bioheat accounts for 92% of renewable heating and 13.1% of total heat in the EU in 2010. Most is used for domestic heating.
- In 2010 there were 452 plants converting municipal and other wastes to energy, contributing 95 TWh to the energy supply. (EC/JRC 2014)
- Typical conversion efficiencies in incineration plants range from 20-25% for electricity and 10-15% for combined heat and power (CHP) systems. New CHP systems using MSW are expected to reach 25-30% electrical efficiency and 85-90% overall efficiency in CHP.
- Methane-rich gas from landfill sites accounted for over one-third of biogas produced in the EU in 2011, but this is expected to decrease over time.

The industry

The use of renewable energy sources for heating has considerable potential for growth, since the heating and cooling sector represents about 50% of final energy consumption.

Growth in the use of biomass for heating and cooling has been rather slow compared to the growth rates in the renewable electricity and transport sectors. Biomass must play a crucial role in meeting the 20% target for renewables by 2020 and reducing greenhouse gas emissions in the EU-28, with the necessary sustainability constraints.

Barriers

Deployment of bioenergy requires demonstration projects at a relevant industrial scale, which are costly but crucial for improving and certifying technical performance, as well as reducing costs. A lack of long-term policies has also discouraged investment in bioenergy technologies, preventing their deployment at the larger scale. Member States have addressed this by introducing a range of incentives, including research programmes, tax reduction and exemptions, investment subsidies and feed-in tariffs for renewables.

The cost competitiveness of bioenergy production remains a key barrier to the deployment of biomass technologies, particularly with respect to relatively cheap fossil fuels. As unconventional natural gas, like shale gas, become increasingly available, the price of coal has dropped.

Sustainable biomass production, along with the development of efficient and reliable logistics for biomass mobilization and supply are critical factors for the successful large-scale deployment of bioenergy.

The low energy density of biomass means that it is most economical when it is produced a short distance from the biomass plant. It can quickly become uneconomical to transport biomass over longer distances. Large-scale production of energy crops (short rotation coppice, short rotation forest and energy grasses) can be a solution for increased biomass supply due to their favourable economic and environmental characteristics.

Another major issue for further deployment of bioenergy is the competition between alternative uses for land and for existing biomass resources for food, feed, fibre and fuel. Public perception of bioenergy as being unsustainable under certain circumstances is slowing industrial development and support schemes in some Member States. The European Commission has provided recommendations for national sustainability schemes to be applied to biomass used for power and heat generation. These recall the sustainability requirements already applied to biofuels and bioliquids, where the consequences of changing land use to grow biomass feedstock, for example, have to be taken into account.

Needs

Further research is needed to establish various bioenergy technologies, to develop better approaches to improve bioenergy production and system integration and to increase cost effectiveness, as well as demonstrate technologies at an industrial scale.

Technological development is expected to improve process efficiency in direct combustion, gasification systems, anaerobic digestion, gas treatment and the introduction of higher performance steam cycles and biomass gasification combined cycle systems. More research effort should be devoted to upstream areas, such as feedstock production.

There is also a need to develop more integrated systems, such as bio-refineries, where bioenergy is just the final, low-value product, using only the residues of the other processes. Coordination with the non-energy biomass industry, and between biomass
**Fact file**

**Deployment costs**

- The capital costs of biomass heat plants range from EUR 300–700/kWth.
- Biomass-based CHP plants have typical capacities of 1–50 MWe with overall efficiencies of 80–90% and investment costs of EUR 2 000–3 000/kWe.
- Fluidised Bed Combustion of biomass permits higher electrical efficiencies of 30–40% at investment cost in the range EUR 2 500–3 500/kWe.

- The capital cost of a biogas plant with a gas engine or turbine is estimated to be in the range of EUR 2 500–5 000/kWe.
- The capital cost of a landfill gas plant coupled with a gas engine or turbine is estimated to be between EUR 1 200 and 2 000/kWe.

**Anticipated carbon dioxide savings**

- Biomass in itself is considered to be “carbon neutral” in that the amount of carbon it absorbs while growing is the same as the amount it produces when burned. However, additional GHG emissions associated with the supply chain may be significant. These emissions are accounted for in the Renewable Energy Directive for example.
- Additional emissions from land use change (direct and indirect) are a major issue and should be properly considered.
- Finally, the temporal imbalance between carbon absorption and emissions during the biomass life cycle may delay the expected GHG savings significantly, depending on the feedstock considered.

**Installed capacity**

The installed bioenergy power capacity in the EU-27 reached 29 GW in 2010 and is expected to reach 43 GW in 2020. In the reference scenario of the Energy Roadmap 2050, this capacity could rise further to 52 GW by 2030 and even 87 GW by 2050.

The contribution of biomass-based electricity rose from a 2.6% share of power generation in 2005 to 3.7% in 2010 and could reach 7.3% in 2050.

The direct use of biomass for heating is expected to rise from 13.5% in 2010 to 33% in 2050. In some Member States, such as Sweden, over 60% of heating already comes from the direct use of biomass.

Of the total biomass, 66% is used for heat production, 31% for electricity and cogeneration and 3% for liquid fuels. By 2020, the contribution to the EU energy mix from bioenergy – competing on the energy market without public subsidies and in accordance with the sustainability criteria of the EU Renewable Energy Directive – could be at least 14%.

**For further information:**

- SETIS page on Bioenergy
  http://setis.ec.europa.eu/technologies/bioenergy
- European Biomass Association
  http://www.aebiom.org/
- European Biomass Industry Association
  www.eubia.org

use for heat and electricity and for biofuels is of prime importance. Cross-sectoral coordination between agriculture, forestry, and the pulp and paper and wood processing industries is required. A long-term and coherent policy framework, an innovative financing mechanism and harmonisation of incentives and regulations across the EU all need to be put into place before the technology reaches commercial maturity.