Biofuel

In brief

Biofuels are transportation fuels derived from agriculture, forestry or other organic feedstocks. Bio-ethanol and bio-diesel are currently the most common biofuels used in transport, although other biofuels are also in use, such as pure vegetable oil and biomethane. The main drivers for the production and use of biofuels are the security and diversification of energy supply, reduction of oil imports and dependence on oil, rural development and the reduction of greenhouse gas (GHG) emissions.

The technology

In the EU, agricultural biomass is the main feedstock for biofuels. Rapeseed is the main raw material for bio-diesel production while cereals and sugar beets are the main sources for bio-ethanol. Forestry biomass is currently dedicated mainly to power and heat applications.

Bio-ethanol production is based on a fermentation process using starch or sugar. The production of bio-diesel is based on extraction, refinement and esterification processes using plant oil, such as rapeseed and sunflower.

Biogas, or ‘green’ natural gas, could see increased use in the transport sector in the future, as the agricultural feedstock for bio-gas or synthetic natural gas production holds great potential.

New technology developments, such as hydrogenation, could help to match the predicted growth in demand for bio-diesel by diversifying the feedstock used as raw material.

At present, bio-fuels blending limits in the EU are set according to conventional fuel standards, mostly to ensure a compatibility with conventional power trains and refuelling.

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EU-28 GHG Emissions from Transport 2012

Total navigation 13.9%
Total civil aviation 12.8%
Railways (*) 0.6%
Other 0.8%
Road transportation 71.9%

YEAR 2012

(*) Excluding indirect emissions from electricity consumption

EU Transport in Figures, Statistical Pocketbook 2014
infrastructure. Up to 10% in volume can be made for pure bio-ethanol and 22% for Ethyl-Tertiary-Butyl-Ether (ETBE). In the case of fatty acid methyl esters (FAME), the limit is up to 7% in volume. However, the revision of the fuel quality directive may change these blending limits, and higher FAME blending is allowed once it is clearly labelled as such at the pump.

In terms of technical limits, bio-ethanol and bio-diesel can be blended at up to 10% and 7% respectively without significant changes on vehicle engines or delivery infrastructure. In Sweden, flexible fuel vehicles that can operate with ethanol blending levels of 85% have been commercialised since 2002.

**Ongoing research**

Europe needs to assess biomass availability and develop technologies and logistics for sustainable feedstock production, management and harvesting.

The European Industrial Bioenergy Initiative (EIBI), set up by the EU in 2010, has, among other things, prioritised the development of lignocellulosic materials as a feedstock for bio-ethanol production. This consists of mobilising the cellulosic components of different plants through a saccharification stage prior to the fermentation process. Biomass-based dimethyl ether (DME) is also currently under development. This can be produced from the gasification of biomass or black liquor and is currently being demonstrated as a transport fuel in heavy-duty vehicles.

Third generation biofuels, including hydrogen produced from biomass, are expected to make a significant contribution in passenger car and urban transport markets as of 2030. Biofuel production from algae is presently at the research and development stage, focusing on evaluating the optimum strains of algae, investigating process development and oil extraction.

One major aim for the technology platform is to bring to commercial maturity the currently most promising technologies and value-chains to promote large-scale, sustainable production of advanced biofuels. For instance, feedstock-flexible thermochemical pathways, characterised by the use of high-temperature transformations, and biochemical pathways, characterised by the use of biological and chemical processes, should be developed.

For thermochemical pathways, research aims include the optimised use of advanced catalysts, the improvement of gas cleaning technologies and the quality and stability of bioliquids.

Within the biochemical pathways, three value chains will be optimised for the production of gas and liquids from biomass, including feedstock pre-treatment and downstream processing and the optimised use of advanced enzymes.

**The industry**

The Directive 2009/28/EC on promoting the use of energy from renewable sources, sets a 10% binding minimum target for 2020 for the share of renewable fuels in transport petrol and diesel consumption. This is to be achieved by all EU Member States by 2020, and builds on the 2003/30/EC Directive, which set the goal of achieving a 5.75% biofuels share by 2010.


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**Fact file**

**Production costs**

The production cost (2012) of ethanol and biodiesel is still higher than that of petrol and diesel:

- EU-produced bioethanol (wheat, sugar beet) costs around EUR 109/MWh
- EU-produced biodiesel (rapeseed) costs around EUR 95/MWh

These prices are forecast to increase in 2015 to EUR 115/MWh for ethanol and EUR 96/MWh for biodiesel and, by 2020, to EUR 140/MWh for ethanol and EUR 98/MWh for bio-diesel (OECD/FAO).

It is not yet possible to estimate accurately the production cost of second-generation biofuels but they are higher than those of first generation biofuels.

- In Brazil, the cost of sugarcane bioethanol can be lower than that of fossil fuel, but this is unlikely to be replicated in other countries, and the effect of all subsidies in Brazil, for both fossil and bio-fuels must be also taken into account.

**Productivity per land area in the EU:**

- Bioethanol: in the order of 1–2 tonnes of oil equivalent per hectare (toe/ha) using cereals as feedstock and 2–3 toe/ha for sugar beet.
- Biodiesel: 0.8–1.2 toe/ha from different oil-seed crops, and about 3.8–4 toe/ha from oil palm.
- Second-generation lignocellulosic biofuel productivity is in the order of 2–4 toe biofuels/ha. (EC/JRC, 2013)

**EU labour needs and job creation**

According to analyses by the International Institute for Sustainable Development (IISD), the bio-ethanol sector had created 70,272 jobs in the EU-27 and the bio-diesel sector had created 51,639 jobs (2011 figures).

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however, would limit the amount of food crop-based biofuels to the current consumption level of 7% up to 2020, with the shortfall to be made up by waste-based feedstocks and advanced biofuels. The European Industrial Bioenergy Initiative anticipates that advanced biofuels will cover up to 4% of transport energy needs by 2020.

**Barriers**

The cost competitiveness of biofuels with regard to conventional fuels remains a key barrier to deployment, although advanced technologies promise to deliver more environmental benefits per product output, better economics and higher front-end feedstock flexibility than the current first generation processes. Demonstration projects on a relevant industrial scale are crucial, though capital intensive, to acquire feedback on cost and technical performance.

The sustainability of biomass production, along with the allocation of resources between electricity, heat and transport fuel production, as well as the competition for biomass resources with non-energy sectors, are critical issues that are currently being addressed and debated. Certification and support schemes will be key to ensuring that biomass supply meets sustainability criteria. Feedstock markets would also need to be optimised towards energy markets, ensuring a balance between domestic biomass production and international trade.

There remain environmental, social and economic concerns associated with first generation biofuels from food crops. These mainly relate to the impact of biofuels on the environment, biodiversity and water resources, as well as the knock-on effects of land-use changes, real GHG emission reductions and the true cost of CO2-avoided emissions. These issues need to be addressed.

**Needs**

There is a need for better coordination of R&D and demonstration efforts at the EU and national levels. An important priority is to build a European knowledge community on bioenergy.

For second-generation biofuels, the R&D and demonstration infrastructure and promotion instruments are still not mature. Here, the technology needs to be demonstrated at a relevant industrial scale prior to a mid-term commercialisation target. Also, more R&D and demonstration efforts should be devoted to upstream areas, such as land use, crop yields and bio-energy production.

These operations are costly. A long-term, coherent policy framework needs to be put into place, along with innovative financing mechanisms that pool together government, industrial and investor resources.

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*Baseline scenario projections*
Close cross-sectoral coordination between agriculture, forestry, the oil industry and car manufacturers is essential in order to balance the evolution of the EU vehicle fleet and the delivery infrastructure as the penetration of biofuels grows.

There also needs to be an overall harmonisation of standards, administration procedures, incentives and regulations across the EU. Sustainability certification schemes to avoid market distortion and competition are needed, as well as tools for resource mapping and life-cycle analysis.

Better communication on the benefits of using biofuels will also improve social acceptance.

**Installed capacity**

Around 7.3% of EU gross energy consumption comes from biomass resources and two-thirds (67%) of all renewable energy sources (RES) comes from biomass (2012 data). In 2011 the consumption of biofuels in road transport amounted to 14.5 Mtoe (4.6%) in the EU-27. Hart Energy’s Global Biofuels Outlook (2013) suggests that approximately 16.5 Mtoe of biodiesel will be consumed in the EU in 2020, and just over 4 Mtoe of bioethanol.

**Fact file**

**Deployment costs**

Capital investment and operation costs are in line with fossil industry refinery costs:
- Investment costs for a bioethanol plant in the EU are about EUR 640 – 2 200 per kW of transport fuel.
- Investment costs for a biodiesel plant are about EUR 210-860/kW of transport fuel.
- Investment costs for advanced bioethanol plants range from EUR 1130 – 1150/kW of transport fuel.
- Investment costs for biomass-to-liquid (BTL) diesel from energy crops are between EUR 750 – 5600/kW of transport fuel. (Ecofys, 2011)

**Anticipated greenhouse gas savings**

The diversity of feedstock, the large number of biofuel pathways and their complexity leads to considerable uncertainty about greenhouse gas (GHG) savings from biofuels, especially if potential indirect increases in emissions from the change of land use is factored in. However, according to the Renewable Energy and Fuel Quality Directive, the use of different types of second-generation biofuels could lead to GHG emissions savings of 70-90% compared to the corresponding use of fossil fuels.

**Security of Supply**

- The EU Member States’ National Renewable Energy Action Plans (NREAPs) estimate that biofuel use in transport in the EU-27 is likely to reach about 336 TWh (28.9 Mtoe) in 2020.
- According to the NREAPs, the greatest contribution in 2020 is expected to come from biodiesel with 20.9 Mtoe, followed by bioethanol/bio-ethyl tertiary butyl ether (ETBE) with 7.3 Mtoe and other biofuels (such as biogas and vegetable oils) with 0.7 Mtoe.
- The contribution made by biofuels produced from wastes, residues, non-food cellulosic material and ligno-cellulosic material is expected to reach 2.6 Mtoe, or almost 9% of the estimated biofuel consumption, in the EU-27 in 2020 (JRC, 2013).

**For further information:**

- SETIS section on biofuels
- Biofuels
- European Biomass Association
  [http://www.aebiom.org](http://www.aebiom.org)