

Biomass rises and falls with available feedstock supply

WORLDWIDE, BIOMASS generated electrical capacity of around 88 GW (installed), including bio fired power- and CHP-plants. That made biomass the most widely used renewable source of energy within the global energy system in 2013.

Biomass organic matter is used to provide solid, gaseous and liquid fuels for the production of electricity, heat and fuels for transportation purposes. These three energy markets have been developed in different ways in recent years. While the production of transportation fuels (mainly bioethanol and biodiesel) are more or less constant, heat provision and electricity generation have significantly increased.

The heat market is widely characterized by an often informal fuel market, especially in less developed countries; thus the available data about the respective biomass use is very fragmented, even in industrialized countries. This is, to a lesser extent, true for the electricity market. Nevertheless, the available data base is weak and some of the figures outlined herein are rough estimations. But all estimates show that in recent years electricity generation from biomass has grown significantly.

Worldwide, electrical capacity of around 88 GW was installed in biomass fired power- and CHP-plants (status 2013) [43]. The electricity

generation resulting from this conversion plant park is between 308 and 616 TWh (2013) assuming a capacity factor between 0.4 and 0.8 (see Table 8). The top producers of electricity from biomass are as follows: the US, Europe, China, Brazil and India.

In 2013 around 5 GW of newly installed biomass capacity came into commercial operation globally [44]. Following is a breakdown:

- The US added around 15% (0.8 GW) of this new capacity. At year's end the total capacity within this country amounted to 15.8 GW with an electricity generation estimated to be between 55 and 110 TWh (2013).
- Brazil subjoined 0.6 GW (12%) of the newly installed biomass power. In 2013 11.4 GW was under operation in this Latin American country. This available capacity represents an electricity production between 40 and 80 TWh in 2013.
- Europe added around 1.7 GW (34%) in biomass capacity. This led to an overall installed power of around 34.5 GW by the end of

2013, representing 120 to 242 TWh (2013). Germany and Sweden generated 8 and 10%, respectively, of the total European electricity provision from biomass.

- China, another major player in this field, showed slower growth in 2013 due to limited availability of suitable biomass feedstocks. At year's end the total available capacity was around 6.2 GW, providing between 22 and 43 TWh of electricity.
- India has shown a strong development compared to China. Related to the previous years, the capacity additions have been approximately 40% (0.4 GW). By the end of 2013, a total capacity of 4.4 GW was available, representing between 15 to 31 TWh.

Solid biofuels

Electricity from solid biomass is provided in "classical" grate or fluidized bed-fired power plants as well as in cogeneration facilities (about 70%). These technologies dominate the market for electricity generation from biomass, with the grate fired system being the most widely used due to its robustness and cost-efficiency. In recent years, co-firing in coal-fired power plants was also a widely used option in some countries (e.g. UK, Netherlands, Belgium, Finland). Those applications are mainly dust fired power plants using modified wood pellets for co-combustion.

	Cumulated Installed capacity 2013	Growth rate 2012 to 2013	Capacity Factor	Electricity generation 2013
	[GW]	[%]		[TWh/y]
Solid biomass	60.5	4.2	0.4 - 0.8	212 - 424
Biogas	14.5	10.0	0.4 - 0.8	50 - 102
Municipal solid waste	10.5	5.0	0.4 - 0.8	37 - 74
Liquid biofuels	2.0	0.0	0.4 - 0.8	7 - 14
Total biomass	88.0	5.1	0.4 - 0.8	308 - 616

Table 8. Global electricity generation from biomass (2013) [45] [46] [47] [48] [49].

Biomass-based electricity is dominated by the use of solid fuels, especially within the wood industry.



Driven by increasingly demanding policy regulation, more and more innovative technologies with higher electrical efficiencies like biomass gasification are starting to enter the market – but still on a very low level without achieving significant market distribution. Globally, only very few gasification projects are under operation and/or under construction for electricity generation (e.g., Güssing and Oberwart in Austria, Ulm in Germany, and Gothenburg in Sweden).

Elsewhere, in China and India, for example, small-scale, fixed-bed gasifiers with a very simple design might be operated for rural electrification.

For electricity generation, biomass fuels based on wood and/or wood waste from forestry and the subsequent industries (especially the wood processing industry) are mainly used. Other sources: solid residues from sugar (i.e. bagasse in the bioethanol industry), residues from the pulp and paper production (i.e. black liquor) as

well as wood pellets. Demolition and other waste wood partly used in waste incineration plants supplement these solid biomass fuels. By contrast, wood from short-rotation coppices plays only a minor role within the electricity market based on solid biomass.

These solid biofuels dominate the world biomass-based electricity production with a share of about 70%. The installed electrical capacity in conversion units using solid biomass sums up to about 60.5 GW by the end

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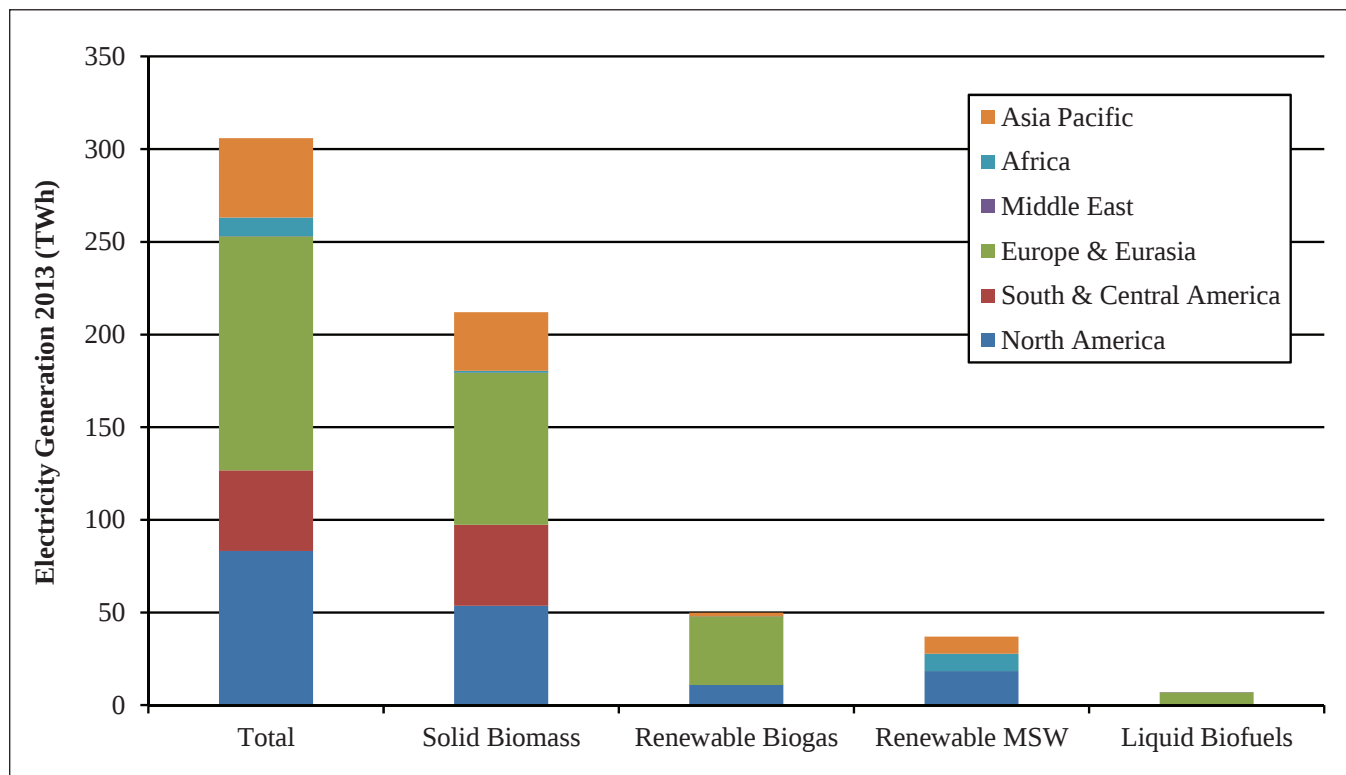


Figure 6. Regional breakdown of electricity generation from biofuel sources in 2013 (estimated minimum annual output, total 308 TWh, Table 8) [58] [59] [60] [61] [62].

of 2013. This biomass-based capacity rose by around 4.2% compared to 2012 [50]. Assuming a capacity factor of 0.4 to 0.8, this installed power represents an electricity generation between 212 and 424 TWh globally, based on solid biofuels (see Table 8).

The electricity generation from biomass is globally dominated by the US and Brazil. In the United States, solid biofuels provide approximately 66% of the worldwide biomass-based electricity generation. In fact, more than 100 biomass power plants came into commercial operation, representing 450 MW in 2013 (or 3% more than 2012). This led to an overall installed power of 14.8 GW in the US by the end of 2013, mainly using wood as a fuel (i.e. 52 to 104 TWh).

In Brazil, the solid biomass-based electricity generation increased about 10% to 8.6 GW. Here, mostly herbaceous biomass (bagasse) was utilized; in 2013 the bagasse-based electricity generation accounted to approximately 10% of the national electricity production (i.e. 30 to 60 TWh) [51] [52].

The biomass-based electricity capacity in Europe amounted to roughly 28 GW by the end of 2013. Year to date, about 8% of biomass based power has been newly installed. These power plants are characterized by an electricity generation between 98 and 196 TWh, assuming a capacity factor of 0.4 to 0.8. More than the half of this electricity generation has been provided with cogeneration plants. The top producer of biomass-based electricity in Europe is Germany (13.1 TWh), followed by Finland (10.6 TWh), Sweden (10.5 TWh) and Poland (8.8 TWh). In the UK, biomass based electricity generation gains are being registered. Co-firing in coal fired power plants is a widely used option in the UK.

In Asia, China and India are the key producers. In these countries the solid biomass-based electricity capacity is about 4.7 and 4.2 GW, respectively, with an electricity generation between 17 and 33, as well as 15 and 30 TWh (2013), respectively. In China the growth slowed down because of limited availability of suitable solid

biomass. By contrast, the biomass addition in India was around 10% below the national target (0.4 GW) [53] [54].

Renewable municipal solid waste

Municipal solid waste (MSW) consists of about 50% organic matter. This MSW is often used in thermal waste treatment facilities to provide electricity and heat. The biggest players using MSW are Europe, the US and Japan. Worldwide, approximately 255 Mio. t of MSW have been used in thermal treatment facilities in 2013. As in recent years electricity generation by MSW incineration grew worldwide with an average annual rate of 5.5%. Assuming this rate is also true for 2013, the installed capacity of waste-to-energy facilities likely grew to 10.5 GW worldwide.

With this installed power an electricity generation has been realised globally between 37 and 74 TWh in 2013. Europe heads the MSW-based electricity generation with about 19.7 TWh and an MSW capacity

of 2.8 GW, followed by the US with 10.0 TWh and Japan with 3.2 TWh (2013). In Europe, more than the half (55%) of generated electricity from MSW is provided in conventional fired power plants and about 45% of the electricity from MSW is generated in cogeneration power plants [55].

Biogas

Biogas is produced by anaerobic digestion of organic material (e.g. organic waste, animal manure, energy crops, sewage sludge, dumped municipal solid waste). This gas, called landfill gas, sewage gas or simply biogas, is produced naturally in

generation systems is also valid for 2013, a globally installed biogas-fired electrical power of roughly 15 GW can be estimated. This capacity allows for an electricity output between 50 and 102 TWh (2013).

Europe is the top producer of biogas-based electricity; in all other countries, biogas production for electricity generation is at a very low level and – if any plants are available – an exemption often realised only due to financial support from the public purse. Due partly to political instability and the difficult economic situation in some EU countries the growth slowed in last year, however. For example in recent years (2010,

only a negligible role in the global energy system. Additionally, due to an economic challenging environment, electricity generation based on liquid biofuels has stagnated in recent years. For 2013 it is expected that the worldwide annual electricity generation remained at the same level seen over the last three years (i.e. 7 to 14 TWh). The world's largest producers of electricity from liquid biofuels are Italy and Germany. In Brazil and Argentina, cogeneration plants fueled by liquid biofuels are under operation.

Outlook

Biomass-based electricity reflects a significant market. But so far this

In general, electricity generation from various biomass sources is clearly increasing on a global scale. All current indications suggest this trend will continue.

landfills during the aftercare period, in wastewater treatment facilities to stabilise the remaining organic material (e.g. sewage sludge) and in purpose-designed anaerobic digesters fed, e.g., by animal manure, agricultural residues, food waste and other organic residues from municipalities. While Germany is one of the biggest biogas producers globally, it generates mainly biogas in purpose-designed digesters. Elsewhere, such as in the US, UK, Italy and France, most biogas is derived from landfills.

This gas can be used for electricity generation in cogeneration facilities mainly based on reciprocating engines with electrical capacities in the higher kW- and lower one digit MW-range or after purifying as biomethane to be injected into the natural gas grid in basically all power generating conversion units operated with natural gas.

Assuming that the annual growth rate of 7.5% of the worldwide installed capacity in biogas-based electricity

2011 and 2012) the annual growth rate averaged around 18% in Germany. (The expected rate for 2013 is about 10%.) This led to an electricity generation of 50 TWh (2013) within the EU (installed capacity: 8 GW).

Germany is the biggest biogas producer within the EU. By the end of 2013, the installed capacity was about 3.4 GW, with an electricity generation of about 24 TWh. A rapid increase in biogas production is expected in the UK, Italy, Poland, France and the Czech Republic in the years to come [56] [57].

Liquid biofuels

Liquid biofuels can be produced from plants containing starch (e.g. corn for bioethanol), sugar (e.g. sugar cane for bioethanol) or oil (e.g. oil palm for vegetable oil or FAME). However, the transport sector is the main market for such liquid biofuels. Hence the use of liquid biofuels for electricity generation within power and/or cogeneration facilities plays

market is dominated by the use of solid fuels, especially within the wood industry based on grate fired system. It is expected that this market will grow significantly in the years to come. Additionally, there is a certain market for MSW, which is also likely to see considerable growth in the coming years.

Electricity generation is not the only driver; the force pushing these technologies is waste incineration. In addition, biogas used in cogeneration plant could be an additional growing market if the organic matter to be used within the biogas plants is available at low or no costs (i.e. organic waste streams from the food processing industry), and providing the heat can be used efficiently and cost-effectively.

In general, electricity generation from biomass is clearly increasing on a global scale. Despite some inherent challenges, all current indications suggest this trend will continue long into the future.