Which biomass is the best source of alternative energy?

We talk about bioenergy, but what do we actually mean? The term bioenergy refers to renewable energy produced from material of biological origin. But is the term really exact? Does it create false expectations? “Bio” is often associated with something that is ecological, environmentally friendly and clean. Perhaps “energy from biomass” would be more appropriate? It’s a bulkier term than bioenergy, but also much more neutral.

The debate on bioenergy in Germany tends to revolve mainly around first-generation biofuels (biodiesel and bioethanol) whose sustainability is often questioned (“tank or plate” dilemma). Biomass used for the generation of energy includes materials from biological sources, such as wood, rape, maize, perennial plants as well as algae and cyanobacteria. Energy statisticians also include organic waste of animal (liquid manure) and plant origin, sewage and landfill gas as well as biogenic waste and industrial residues.

The production of energy from biomass is relatively complex and time-consuming. Biomass has two characteristics that make it unique among all renewable energy (RE) sources – it covers the entire energy portfolio (heating/cooling, electrical power and fuels) and there are no storage problems associated with it.

Before biomass can be turned into energy it needs to be grown, harvested, collected, distributed, treated, transported and stored. With a few exceptions, the same is also true for waste materials and microorganisms, which makes biomass relatively expensive as an energy source. Technologies are being developed that are aimed at reducing the volume of biomass (in order to achieve high energy output for less volume), finding better ways of storing, transporting (e.g., slurry from the bioliq procedure developed at the Karlsruhe Research Centre) and preparing it for conversion.

Biomass can be turned into solid, liquid and gaseous energy sources through different processes such as thermo-chemical (pyrolysis, gasification), physical-chemical (pressing/extraction, chemical conversion) and biochemical (aerobic fermentation, alcoholic fermentation), which generate power, fuels and
heating/cooling by way of combustion or complete oxidation.

Status quo: Biomass still among the favourites

With the announcement in May 2011 that it was to abandon nuclear energy, the German government’s energy concept therefore needs to envisage an increase in alternative forms of energy to boost Germany’s total energy supply. By 2020, around a quarter of Germany’s primary energy supply needs to come from renewable energies (2010: 22.6 percent). The intention is to use fossil coal and gas power plants in the short to medium term while the country shifts towards the use of renewable energies in the long term. The German government is aiming to increase the proportion of RE to 35 percent (2010: 16.8) in 2020, and 50 percent in 2030. The targets are not binding, nor is there a climate protection law in place.

Still quite “eco-friendly”: biomass is still the number one alternative source of energy in Germany.

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In 2010, RE accounted for 11 percent of the total consumption of energy in Germany; 72% of this was generated from biomass (BMWi, Energiedaten, 16th June 2011; 73 percent in BW in 2008). One third of all RE power was produced from biomass in 2010. Biomass was still the dominant type of RE in the heating market in 2010 (92 percent of the heat produced with RE). In the fuel sector, biodiesel and bioethanol are the only RE fuels produced, no alternatives exist as yet; in 2010, they covered 5.8 percent of the overall German fuel supply (2009: 5.5 percent).

Baden-Württemberg’s energy concept calls for an increase in renewable energies as part of the overall national power supply. By 2020, at least 38 percent of Baden-Württemberg’s power requirements (around double the 2010 figure - 16.6 percent, BW Ministry of the Environment, 14th August 2011) needs to be covered with renewable energies; biomass alone should provide around eight percent of this figure. Baden-Württemberg adopted the Biomass Action Plan (BAP) in 2010 to encourage the use of biomass; the state aims to make comprehensive use of biomass for energy production purposes and particular emphasis is placed on exploiting the sustainable potential of waste materials arising in the fields of agriculture, forestry, landscape conservation as well as municipal and industrial waste. In line with the recommendations of scientific panels, the action plan also focuses attention on the competition between the material and energetic use of biomass as well as the cultivation of renewable materials and traditional energy crops.

Biomass heats best

On a global level, biomass is covering an increasing proportion of RE power and heat supplies. The biomass heating market is growing, especially in Europe, the USA, China and India. The popularity of wood pellets and the cogeneration of heat and power is increasing and local biomass-driven heat networks have been identified as major future trends. China has the largest number of private household-type biogas plants. In Europe, purified biogas is fed into pipelines and used to replace natural gas in cogeneration heat and power plants as well as other types of power plants. Germany plans to run around 1,500 power plants with biomethane by 2020; this will require around six billion cubic metres of biomethane (University of Hohenheim, 13th September 2011).

Biofuels cover around 2.7 percent of the global road traffic fuel supply. USA and Brazil produce 88 percent of global ethanol; Europe remains the centre of biodiesel production, despite decreasing growth rates; aerospace companies, petrol companies and young, rapidly growing companies are becoming major players in the field of biofuels producers and consumers.

Development status
On a global level, heat is still mainly produced from the direct combustion of biomass, and it is this conversion technology that can compete with fossil fuels. Numerous technologies have been developed for the generation of power from biomass. Co-firing (in coal power plants) is still the cheapest way of producing electricity. Numerous large-scale biomass heating stations (e.g. cogeneration heat and power plants, local heat networks), including those used for the combustion of private household waste, have been established. The anaerobic fermentation of abattoir waste, liquids and many organic materials is currently seen as the best option for the generation of electrical power and/or heat. Germany’s biogas technology is a global leader (Bley, 69) in this industry, but this has led to clashes with nature, environmental and climate protection measures as a result of the promotion of crop (silage maize) for energy production.

The production of first-generation biofuels from sugar-, starch- and oil-containing plants as well as from fats and residue oils for use in the transport sector is fairly well established. There are plans to replace such fuels, which have political backing but are nevertheless highly controversial, with synthetic fuels produced from lignose-cellulose-containing biomass and waste materials. However, these second-generation biofuels have not yet reached the required degree of technological maturity. The use of algae and other microorganisms (third-generation fuels) for the production of oil is still in the research and development stage. Likewise, the regenerative production of hydrogen is still a long way from application.

Streamlining political decisions

Is Germany’s decision to abandon nuclear power and move towards renewable energies a true cross-departmental process, as the German government’s 6th Energy Research Programme (2011), a joint project between the Federal Ministry of Economics and Technology, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry of Food, Agriculture and Consumer Protection and the Federal Ministry of Education and Research, would appear to suggest? The National Biomass Action Plan of the Ministries of Agriculture and the Environment sets out the principles for increasing the use of biomass for sustainable energy supply. However, it still remains unclear how this will be done and which types of biomass energy will be integrated into Germany’s renewable energy mix. The action plan concludes that in principle all technologies could be eligible for funding but “the market will determine which usage applications and technologies will become established”.

Heat is produced from the combustion of wood, which to a growing extent comes in the form of pellets and wood chips.

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Many chemists believe that it would be a waste to use biomass in the production of energy. They would favor biomass being used as a source of raw materials before it is used for the production of energy. This does not really answer the question frequently posed by experts as to whether the industrial and material use of biogenic resources (the only renewable carbon source for the chemical industry) is not more sustainable than the use of energy crops that require a lot of nutrients and large cultivation areas. The German Federal Ministry of Research and Education launched its “National Research Strategy BioEconomy 2030” in an effort to deal with this issue more comprehensively. The strategy recognizes biotechnology as an important driver in this process and lays the foundation for creating a sustainable bio-based economy by 2030 that “uses renewable resources to produce enough food to feed the world as well as supplying raw materials and energy, protecting the climate and the environment and expanding Germany’s international competitiveness”.

Which type of biomass is the best?

It is generally agreed that the production of energy from biomass is a major part of the mix of regenerative energy systems and that individual usage applications need to become more efficient, reliable and sustainable. Germany’s indecisiveness in terms of the “correct” way to achieve greater use of biomass for the production of energy is not restricted to Germany alone, but is the general rule around in the world. Contradictory recommendations (see L. R. Lynd et al.) crop up everywhere. Major concerns are the competition between land used for the cultivation of plants for the production of food and animal feed and land used for the cultivation of energy crops. There does not yet appear to be any qualified scientific agreement on the potential impact the increasing use of biomass systems may have on the environment (climate protection), soil (erosion, water requirements, overfertilization) and on the air.

Politicians ignore the recommendations of scientists
Experts have contributed advice and recommendations to the German biomass-based energy policy, but they are rarely listened to. In 2007, the Scientific Advisory Council of the German Federal Ministry of Consumer Protection, Food and Agriculture accused politicians of “specifically funding bioenergy lines that are relatively expensive and frequently inefficient”, referring in particular to biofuels and biogas produced from the maize that became a particularly lucrative crop after the renewable resources bonus (NawaRo) was put in place.

The German Advisory Council on Global Change (WBGU), an independent, scientific advisory body set up by the German federal government in 1992, came up with similar criticisms in 2009. The WBGU heavily criticised the EU biofuel quota for its impact on climate change and recommended to use biogenic waste materials for the production of heat and power rather than energy crops. The council further advocated the use of electric cars. The council believes that the production of sustainable energy from biomass will “remain an important bridging technology in our move towards a sustainable energy system”, but will eventually be replaced by wind and solar energy.

What about using biomass for the production of aviation fuel?

The way energy researchers assess the contribution of biomass-based energy to the energy supply mix is quite revealing. They believe that air and heavy goods vehicle traffic, which requires energy sources with a high energy density, as well as some industrial manufacturing processes, require chemical energy sources (methane, hydrogen, "Renewable kerosene") that are produced from secondary biomass, by electrolysis and/or other CO2-neutral conversion technologies (Eberhardt, p. 20). In view of dwindling biogenic resources, energy researchers are calling for a better mobilisation and more effective use of biomass residue and waste, which would represent a paradigm change from disposal to provision (Baur, p. 88f). This idea is also in line with the “zero waste refinery” concept, in which waste is categorised as a residual product that can be returned to natural and industrial systems, thus ensuring an effective use of biomass for energy and material production with maximal resource usage and maximal material and energy yield, whilst also eliminating the concept of waste.

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