The use of solid biomass – such as wood and straw – for energy purposes can be greatly expanded by utilizing the gasification technology. The first plants for commercial use of this technology are currently being built in various countries in Europe. European Energy Review reports.

Second-generation biofuels:

By Stefan Schroeter

Every day, some 30 trucks haul wood from nearby forests to the biomass plant in Bischofferode/Holungen, Thuringia. There, the wood is being dried, cut into chips and finally burnt in a boiler with the help of circulating fluidised bed combustion. The produced steam powers a turbine and a generator, and the generated electricity is then fed into the grid of regional supplier Eon Thuringer Energie. Because of the German renewable energy law (EEG), a feed-in tariff that supports alternative energy sources, electricity from biomass is compensated with 9.1 cent per kilowatt-hour over the next two decades. That's a pretty good business for the owners of the plant, the SWL Stadtwerke Leipzig GmbH.

What has started as a local company in the Saxon city has since widened its business horizon to a national and even international level. The company is currently building another wood-based power plant in Piesteritz, a chemical industry hub in Saxony-Anhalt. Both plants will have a production capacity of 20 Megawatt (MW), which is the upper power limit for a plant benefiting from the increased compensation made possible by the EEG. The sophisticated steam turbine technology also enables a very effective use of the burnt fuel. 'We are achieving an efficiency rate of 37 percent during our electricity generation process,' Klaus-Joachim Pfeuffer, a senior SWL official, says about the Bischofferode plant. 'That means we are already close to the efficiency levels of coal-fired power plants.'

'Some of the German networks are so antiquated they need to be completely rebuilt'

The problem with plants of such size: it is rather difficult to sell the heat generated during the power production process. While the chemical industry hub Priesteritz will have installations for heat extraction, they have not been included in the plant in Bischofferode – the economically underdeveloped region simply lacks potential customers.

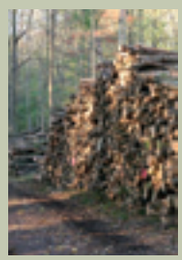
The cost-effective compensation of the EEG has nevertheless lured several investors into building these new power plants. In Germany, some 160 plants are using mature wood and pulpwood in their fuel cycle. Their installed electricity production capacity adds up to 920 MW – comparable to that of a large coal-fired power plant. For 2007, the Bundesverband BioEnergie (BBE), an industry group, expects another 55 MW of production capacity to be installed. And if Germans walk through their forests, they can see with their own eyes that wood as an energy source is becoming increasingly attractive. While it took forest holdings quite a while to clear the grounds from deadwood after a storm, the wood now disappears rather rapidly. Even smaller, less organized forests are now cut back very thoroughly.

Biomass as an energy source is most effective in smaller, decentralised plants where transport routes for fuels are short, and where the heat generated can be used as extensively as possible for heating or industrial purposes. For smaller plants, however, the steam turbine technology used in Bischofferode and Piesteritz makes no sense, because its much lower steam temperature and pressure would cause the efficiency to starkly drop. An alternative for these plants is the use of the Organic Rankine Cycle (OCR) technology, which can use lower boiler temperatures to generate power. During the OCR process, instead of heating water, an organic medium with a lower boiling point – such as silicon oil – is used to drive turbine and generator. The Potsdam-based Danpower GmbH has successfully operated an OCR plant in Schoeneck, Saxony since 2006.

Gasification brings out potential

A key role when it comes to using solid biomass for energy purposes could fall to the gasification technology, which nears its commercial viability. The technology does not burn the biomass in a boiler rather, a gasifier-reactor produces a high



the wave of the future

quality synthesis gas (also called syngas) that like natural gas can be used in engines or in turbines for electricity and heat generation.

When asked to name the advantages of the technology, Andreas Schuette, managing director of the Fachagentur für Nachwachsende Rohstoffe Guelzow (FNR), points to high efficiency levels and a broad array of natural resources that can be used in the process. 'The potentials of solid biomass are possibly fully convertible by using thermo-chemical gasification,' he says.

Add to that a broad product line-up and you are not only able to produce electricity and heat from syngas, but also synthetic natural gas (SNG) and bio-fuels. 'Morevover, syngas can also be used by the chemical industry', Schuette says.

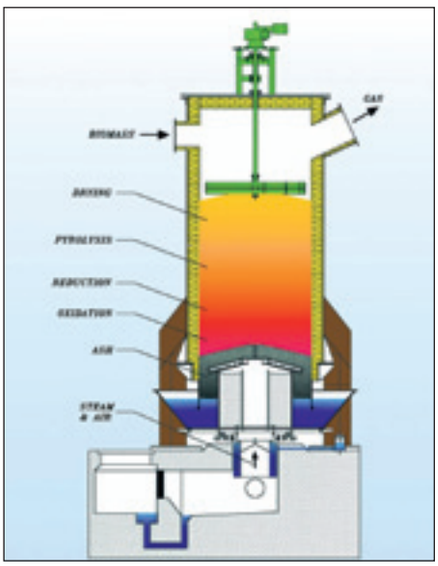
The idea is promising. That's why scientists all over Europe for years have researched a number of gasification technologies for biomass. Experts say wood chips from logging remains are relatively easy to handle. So is low-contamination mature wood that needs more extensive fumes cleansing. Yet in Germany, because of the biomass boom triggered by the EEG, wood prices have already climbed significantly and mature wood has become scarce since so many plants have been built in the past years.

A resource that still harbours great potential is straw. Peter Turowski, member of the Technologie- und Förderzentrum Freising, says straw can be converted to bales, chips and briquettes, which can then be used in the energy generation cycle. Straw is underused as a biomass source, Turowski says, probably because it is regarded by the industry as a relatively tough to handle fuel.

Yet even for easier to handle solid biomass fuels, few commercial-use units have been built. Alexander Vogel, a biomass expert from Leipzig, blames the inferior technological development for that. Currently, there are still mainly prototype units that have an operational availability that amounts to below 60 percent a year, says Vogel, a member of the Leipzig-based Institute for Energy and Environment (IE). The reasons for that are rooted in the entire process chain. Inferior treatment of the combustible leads to instable powering of the gasifier and ultimately to a lower quality of the produced raw gas. This, in turn, negatively affects the following gas cleansing process, leading to deposits and an inferior end product. When it is powering motors in the electricity generation process, the inferior final gas leads to control problems and a higher level of toxic emissions.

But as of lately, these problems can be solved, says Christian Aicherning, head of Austria-based Repotec. The company has managed to do so in a biomass heating plant in Wiener Neustadt, Austria, where in 2003, a solid-state gasifier has been put into operation. Initially, fine ash and coal deposits repeatedly clogged the gasifier there; moreover, during the gas cleansing process, the washing facilities were plastered up by the very tar they intended to remove. Every one to two weeks, the whole unit had to be shut down and cleaned. The Austrian experts finally

Kraftwerk Güssing, Photo: Güssing



Updraft gasification

In the updraft gasifier in Harboore, moist biomass fuel is fed at the top and descends through gases rising through the reactor. In the upper zone, a drying process occurs, below which pyrolysis is taking place. Then, the material passes through a reduction zone (gasification), and in the zone above the grate an oxidation process is carried out (combustion). To supply air for the combustion process and steam for the gasification process, moist hot air is supplied at the bottom of the reactor.

Because of the evaporation of moisture in the drying zone, combustible gas at low temperature is discharged at the top of the reactor, and inert ash from the heat-generating combustion process is extracted from the reactor bottom through a water lock.

Source: Babcock & Wilcox Volund ApS

rebuilt the haul off grate and added an air rotator to the gas-cleansing unit that got rid of the ash and coal remnants. To the actual cleansing process, which so far was done with water only, they added bio-diesel. The move proved successful: Aicherning said it removed the weak points in the unit and made non-stop commercial operation of the unit possible.

The industry's showcase is a biomass cogeneration plant in Guessing, Austria, where in 2002, a fluidised bed gasifier was installed. Using leftover wood from forests, it produces syngas that later in a motor generates 2 MW of electricity and 4.5 MW of heat. Its electricity efficiency stands at 25 percent.

The plant's gas made from biomass and its gas cleansing process are marketable products, says IE-head Martin Kaltschmitt. The plant is now being upgraded to be able to generate electricity, heat and fuel at the same time (also called trigeneration). A methanation unit will then make SNG from the syngas. The trigeneration could open up new possibilities for an economical use of the gasifier units. In times of low demand for electricity and heating, the produced syngas could be increasingly used for generating bio-SNG. The SNG could one day power automobiles.

Substituting for natural gas

If the production of bio-SNG and bio-natural gas proved technically and commercially viable, it could – together with the technically more advanced production of bio-natural gas make a significant contribution to the European energy supply. In a study, the IE calculated that today already, Europe's biomass resources could generate up to 300 billion cubic metres of bio-SNG a year. For the year 2020, the IE even forecasts a technical potential of up to 500 billion cubic metres a year. That's a huge number, given that all 27 EU countries together today consume

The Choren Company is building the world's first commercial plant for the production of Biomass-To-Liquid (BTL) fuels in Freiberg. This so-called Beta plant will go into operation in the first half of 2008. Photo: Stefan Schroeter.

an estimated 550 billion cubic metres of natural gas a year.

It still is a long way before these giant potentials can be tapped, however. The production of bio-natural gas is currently the best developed. There are several commercial bio-natural gas production facilities across Europe that provide its operators with valuable experience, and some experience with feeding-in this gas into the existing natural gas grid – one example being the Stawag Stadtwerke Aachen AG. The technology for bio-SNG, however, still is a long way from commercial use. Moreover, without subsidies, bio-natural gas and bio-SNG are only competitive if natural gas prices rise significantly. According to IE calculations, the oil price (which in Europe is tied to the gas price) would need to climb to some $160 a barrel, roughly double today's tag.

One of the institutions researching the production of SNG via gasification is the Energy Research Centre of the Netherlands (ECN) in Petten. After successful laboratory tests, ECN is currently building a pilot unit that is later to be followed up with a larger demonstration plant in Holland. In 2020, SNG from biomass plants will have a heat production capacity of 1 Gigawatt (GW), says ECN-expert Bram van der Drift. 'That's comparable to a small gasfield in Holland.'

The commercial use of the gasification technology currently works best in small cogeneration plants. Swiss-based Pyroforce Energy Technology is currently building a forest and industry wood-based gasifier cogeneration plant with an installed capacity of 350 Kilowatt (KW) electricity, and 550 KW heat. Pyroforce Managing Director Herbert Gemperle said the plant is about ready to go online. The plant is operated by the Pyrotherm Kraftwerk Guessing, a team-up of Austrian utilities and private investors. Pyroforce is building a much larger unit with a 1,200 KW electricity and 2,200 KW heat generation capacity in Switzerland for a consortium of farmers in the canton of Nidwalden. The plant, which is scheduled to go into operation by December 2007, will burn slightly polluted mature wood and wood from the furniture industry, and draw upon experiences from a similar demonstration unit that was built in 2002 in Spiez, Switzerland.

In Austria, the green electricity produced can be sold benefiting from a feed-in-tariff similar to the one in Germany. In Switzerland, where such government support doesn't exist, the plants' operators have to be more crafty. They certify their electricity as 'green power' and sell it to companies that bank on a green image and are willing to pay its higher price. Because operators need to invest between €4,000 and €4,500 per installed KW, the wood-gasification units from Pyroforce 'are only profitable if the heat can be sold,' says Gemperle. In Guessing and Stans, the projects are working. Gemperle also expects construction costs to drop once more units are built, and his company is pursuing further projects, also in Germany.

Above: the Babcock and Wilcox Vølund biomass gasification demonstration plant at Harboore, Denmark; Below: The biomass plant Bischofferode/Holungen in Germany.

In Denmark, yet another wood gasification concept has proven successful. In Harboore, the Babcock & Wilcox Volund ApS since 1996 operates a 1.4MW cogeneration plant with a wood-gasifier. Babcock is also screening all over Scandinavia, to see if their gasification technology can be post-installed in existing plants. The Danes even sold their technology to Japan. According to Babcock official Kasper Lundtorp, the Tokyo-based plant manufacturer JFE Engineering Corporation has acquired a licence and built a 1.5 MW wood gasification plant in Yamagata. The Japanese are using chips made from cherry trees and plan to build another plant, says Lundtorp, who recently came back from a trip to Japan. Germany-based Relax Environment Technology also banks on the Danish technology. Stephan Ritter, its managing director, said his company is currently building several plants with 2 MW and 3 MW heat production.

The Technical University Bergakademie Freiberg in Saxony is working at a technology that burns straw pellets and wood chips in a pressurised fluidised bed gasifier. The scientists aim to make methanol with the gas that they have thus produced; the methanol can be used to produce synthetic fuels. The Choren company, also from Freiberg, is even one step further. It says it is currently building the world's first commercial plant for the production of Biomass-To-Liquid (BTL) fuels from biomass. The so-called Beta plant, which will go into operation in the first half of 2008, is aimed at producing roughly 18 million litres of synthetic fuels from wood chips, an amount that could power 15,000 to 20,000 cars a year, Choren claims. The generated heat is used to dry the biomass, and the electricity drives the plant. After its finalization, Choren wants to build a larger BTL plant in Lubmin, near the Polish border, or Brunsbuettel, in northern Germany. The plant is planned for a capacity of 230 million litres a year, and is scheduled to go into operation in 2010. The company has four more such projects in the pipeline for the next four years, and they will run not only on wood. 'We will build a large plant only for straw,' says Matthias Rudloff, a Choren manager. 'Technically, that's not a problem.'

Choren together with car makers DaimlerChrysler and Volkswagen has developed a synthetic fuel called SunDiesel, which it currently produces in small quantities in a pilot plant – apparently with great success. DaimlerChrysler tests showed that a motor powered by Sundiesel emits 50 percent less sooty particles and uses up to 5 percent less fuel than a motor run by regular diesel. Moreover, Sundiesel can be easily mixed with regular diesel and thus also drive older automobiles. According to DaimlerChrysler, a diesel car's emission levels are lowered by 80 percent when 30 percent Sundiesel is added. The company has announced it will deliver all its new diesel cars with a tank full of Sundiesel, once there are enough production capacities.

The car maker will then have to negotiate with Royal Dutch Shell, which has acquired the entire production capacity of the Beta plant when it bought a stake in Choren, a company that banks not only on the limited and thus increasingly expensive wood chips, but on a broad range of bio combustibles, including entire plants, corn and energy plants.

IE scientist Vogel sees a great, unexploited potential for straw, industry wood, and black liquor from the paper and pulp industry. Using that potential could not only increase the number of gasification projects, but also lower combustible costs, which often amount to up to 40 percent of a plant's entire costs. The larger the plant, the greater the distance combustibles are coming from, leading to higher transport costs.

Lowering transport costs

The Research Centre Karlsruhe, one of the biggest science and engineering research institutions in Europe, is working together with private companies to produce a high-energy intermediate product from

Together with the German technology company Lurgi the Research Centre Karlsruhe launched this pilot unit in June 2007 for the initial step of the process called pyrolysis. In its testing phase the reactor handles 500 kilogramme of biomass per hour. Eventually a commercial plant should have to digest 50 tons in 60 minutes.
Photo: Forschungszentrum Karlsruhe.