BIOENERGY

For thousands of years, humans have burned wood and other plant material for light, warmth and cooking, but such plant-derived 'biomass' can also be used to generate electricity and other forms of energy.

Sappi

South Africa's first biomass power plant to be constructed under the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) will soon become operational at Sappi's Ngodwana Mill in Mpumalanga.

Biopower

Construction of the first biomass power plant dedicated to supplying electricity for Eskom has recently been completed at Sappi's Ngodwana Mill in Mpumalanga. This follows the selection in 2015 of the Ngodwana Energy Project as a preferred bidder in the fourth bid window of the government's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). Once fully operational, the 25 MW power plant will burn biomass waste from the surrounding forestry plantations and from the mill production process in a boiler to generate steam. The steam will drive a turbine to generate electricity, which will be fed into the national grid and purchased by Eskom according to a long-term power purchase agreement.

The concept is not new. Sappi had already been generating electricity in this way to run the mill, which produces pulp and paper products, and was selling surplus energy to Eskom. In fact, as early as 1939 a similar power station was built on Thesen Island in Knysna to provide electricity for the sawmill there, and later – until the 1970s – the towns of Knysna and Plettenberg Bay too. The sawmill ceased operation in 2001, and in 2010 the power station building was relaunched as the Turbine Hotel & Spa, with much of the old machinery incorporated into the design.

Many of the sugarcane mills in KwaZulu-Natal and Mpumalanga also have their own power stations to provide electricity for processing operations. In this case they burn bagasse, the crushed sugarcane stalks left behind after the juice has been extracted. But the country's sugarcane industry is in decline, so it is keen to diversify into the production of biofuels.

Sweeter Alternative, CC BY-ND 2.0

Sugarcane is used in other parts of the world, notably Brazil, for bioethanol production, and the South African industry is keen to do the same.

Bioethanol

For example, bioethanol can be produced by fermenting sugarcane juice, bagasse as well as the residue left in the fields after harvesting. During fermentation, yeast and bacteria metabolise the plant sugars and produce ethanol, which can be blended with other fuels or converted into Sustainable Aviation Fuel (SAF). There is a huge demand for SAF, because the aviation industry is well aware that many long-distance travellers and 'frequent flyers' feel guilty about their carbon footprint. The member airlines of the International Air Transport Association (IATA) have committed to achieving net-zero carbon emissions from their operations by 2050, anticipating that SAF production will increase to 65% of the industry's total fuel requirement by then, up from an expected 2% in 2025.

In Brazil, the sugarcane sector made the transition to bioethanol some years ago and is now the second largest producer after the United States, which mainly uses maize (known there as corn) for its bioethanol production.

Development of a South African bioethanol industry has been hindered by the regulatory environment, although government published a Biofuels Industrial Strategy as far back as 2007. In August 2012, the Regulations Regarding the Mandatory Blending of Biofuels with Petrol and Diesel were gazetted, and these were meant to come into effect from October 2015. They stipulated a minimum blending of 2% bioethanol into petrol and 5% biodiesel into diesel, but they were never enforced. This was largely because there was no local supply of biofuels, and no financial incentive for fuel manufacturers to source them, given that biofuels are more expensive to produce than conventional fuels.

More recently, in February 2020, the South African Biofuels Regulatory Framework and National Biofuels Feedstock Protocol was gazetted, and in September 2021

South Africa's recently amended 'mandatory blending regulations' stipulate that petrol should contain a minimum of 2% bioethanol. Overseas, blends of 10% are common and can be used in any vehicle without modification, while special flexible-fuel vehicles (FFV) can use blends of up to 85%.

an amendment of the 'mandatory blending regulations' was published. The regulatory framework now provides for a subsidy mechanism to support the development of a biofuels industry, while the feedstock protocol prohibits the use of maize for biofuel production to ensure that food security won't be compromised. It also prioritises rain-fed feedstock production to protect South Africa's scarce water resources, and excludes jatropha as a biodiesel feedstock because it is a threat to biodiversity, being an alien plant with toxic leaves and pods.

Biodiesel

Biodiesel can be made from a variety of natural plant oils, as well as animal fats and waste cooking oils. Currently, the dominant feedstocks internationally are soybean in the United States, rapeseed (canola) in Europe and palm oils in South-East Asia, primarily Indonesia. The most common method of making biodiesels is transesterification, which uses an alcohol such as methanol or ethanol in the presence of a catalyst such as potassium hydroxide or sodium hydroxide to break down triglycerides in the oils and fats to fatty acid methyl esters (FAME). Glycerol is released as a by-product, and can be recovered for use in soaps, cosmetics, foods, pharmaceuticals and the broader chemistry industry.

The FAME is sold as biodiesel, but it causes clogging problems if used 'neat', so it is usually blended with normal mineral diesel. Biodiesel made from rapeseed oil is called RME – rapeseed methyl ester – rather than FAME, and its lower proportion of saturated fatty acids makes it more suitable for cold climates. However, the greenhouse gas lifecycle assessment for these biofuels is not particularly favourable, because the transesterification process generally uses fossil fuel-derived methanol, carbon emissions from vehicles using biofuels are not always significantly lower than those using normal diesel, and massive tracts of natural vegetation (such as tropical forest in Indonesia and Malaysia) are being converted to agricultural land for feedstock crops, resulting in direct and indirect carbon emissions.

Using bioethanol instead of methanol would improve its green credentials, and such biodiesel is known as FAEE, because it produces fatty acid ethyl esters. Other options are to use biomethanol (see page 27) or to increase the use of waste cooking oil as the feedstock, which would reduce concerns about land conversion while also addressing a major source of environmental pollution, given that incorrect disposal of used oil and fat residues by restaurants often results in contamination of watercourses.

There is also increased focus now on 'second-generation biofuels', which use waste biomass such as wood pellets, sugar bagasse, grain straw, maize leaves and stalks (known as corn stover) or even specially grown 'energy grasses', but never food crops, while 'third-generation biofuels' are those produced from algal biomass. The second-generation feedstocks are high in lignocellulose, so thermochemical processing technologies involving gasification or pyrolysis are preferred to convert them into petrol and diesel substitutes.

Biochemical conversion of biomass via anaerobic digestion is also possible but requires more pre-treatment to break down the lignocellulose. Anaerobic digestion is especially important in producing another type of bioenergy, called biogas (see page 22).

Soybean is the dominant feedstock for biodiesel production in the United States.

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