Chair of Energy Research : Biofuels

South Africa Biofuels

IEA Taskgroup 39 Progress Report

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1. BACKGROUND

The South African Department of Minerals and Energy (DME) announced the 5-year Industrial Biofuels Strategy on 5 December 2007, with the primary objective to create jobs in the energy-crop and biofuels value chain in the former homelands, and to act as a bridge between the 1st and 2nd economies. The biofuels target for 2008-2013 is a 2% penetration level of biofuels in the national liquid fuel supply, thus 400 million litres per annum. To date, investments in biofuels in South Africa have been very modest. Yet, the development of a biofuels industry in South Africa has great potential to stimulate rural economic development, thus to help realize the second economy envisaged by the Accelerated and Shared Growth Initiative of South Africa (ASGI-SA). South Africa has much more to offer when considering the capacity to grow total plant biomass (all lignocellulosic plant biomass) and not only produce sugarcane or sugarbeet streams for ethanol or sunflower, canola and soya oil for biodiesel production.

South Africa also has a rich history as technology developers in the larger lignocellulosic conversion technologies. In the 1970s, the CSIR began funding a comprehensive research programme focused on utilization of lignocellulose through the Cooperative Scientific Programmes (CSP) involving research institutes and universities. This research was consolidated in 1979 into a goal-oriented cooperative programme focused on a single feedstock (bagasse), a single product (ethanol), and a single approach to overcoming the recalcitrance of cellulose (enzymatic hydrolysis). Valuable outcomes were (i) the discovery and characterization of new yeasts, such as *Candida shehatae* able to convert the pentose sugars derived from the hemicellulose fraction of bagasse to ethanol, and (ii) the development of the consolidated bioprocessing (CBP) concept that offers the largest potential cost reduction of any potential research-driven improvement in biomass to bioethanol processes analyzed to date. The Stellenbosch/ Dartmouth groups are recognized as the world leaders in this field.

In a similar manner, South Africans also made significant contributions in the development of biodiesel technologies. Mr. Frans Hugo led a research team of the division of Agricultural Engineering that developed the sunflower-to-biodiesel technology in South Africa. The breakthrough eventually came when Louwrens du Plessis at the CSIR suggested a chemical process (trans-esterification with methanol and alkali) for the sunflower oil diesel, which proved successful. The engine ran perfectly as long as the crude biodiesel was further extensively refined to fuel standards. South African ingenuity thus also played a leading role at establishing biodiesel technology.

Built on government commitment and clear vision, Sasol provides a model for initiating a commercial biomass conversion industry and still could play an important role in such initiatives in the future. With the country's vast reserves of low-grade (high ash) coal led to establishment in the 1950s of modest scale coal-to-synthetic fuel facilities at Sasolburg. Following the first oil crisis in the early 1970s, a commitment was made for significantly larger commercial facilities – with Sasol II being commissioned at Secunda in 1980 at 10-fold scale-up from the Sasolburg facility. Sasol's technology for gasification, synthesis, and separation technology developed for coal can readily be applied to biomass feedstocks, either on a stand-alone basis or in combination with biological processing.

This report will highlight the current state of biofuels, recent development and the potential of biofuels production when 2nd generation biochemical and thermo-chemical processes are developed for the conversion of lignocellulosics to biofuels.

2. CURRENT STATUS OF BIOFUELS IN SOUTH AFRICA

The 5-year Industrial Biofuels Strategy announced on 5 December 2007 with a 2% penetration target in the national liquid fuel supply, however with no obligatory blending, has not stimulated a vibrant biofuels industry yet. The only real activity to date has been a 3.2 Bn Rand (€327 M /US$437 M) investment by the South Africa's Industrial Development Corporation (IDC) and Energy Development Corporation (EDC) have in 2 biofuels projects that collectively should produce 190 ML bioethanol from sugarcane and sugarbeet, with erection of the plant set for 2009. However, in the meantime the Mozambican government has approved a US$ 280 M biofuel project by Principle Energy to start producing 210 ML/annum bioethanol from the 2.5 Mt of sugar cane. This should create at least 2,650 direct jobs. Within the beginning of 2009, projects by ProCana and Groun Resources in Mozambique were also approved, bringing the total investment in bioethanol to US$ 710 M in total with a projected 440 ML/annum bioethanol production capacity. The additional projects will bring the number of new job creation in Mozambique to 7 000 – 10 000 persons. Although South Africa is technologically the most advanced, Mozambique and other neighbouring countries preferentially attract private investments because of more favourable leasing contracts and tax exemptions, as well as good agricultural soils.

Currently South Africa has more than 200 small entrepreneurs that produce biodiesel on small scale, mostly from waste vegetable oils. Major concerns for these entrepreneurs are feedstock (virgin oils to expensive), uptake (no mandatory blending) and meeting specs required by petrochemical industries. Major concerns for these entrepreneurs are feedstock (virgin oils to expensive), uptake (no mandatory blending) and meeting specifications required by petrochemical industries. The first serious commercial investment in biodiesel production is that of Rainbow Nation Renewable Fuels Ltd in Coega (close to Port Elizabeth), who will erect a 1.1 Mt/annum soybean crushing facility that would produce and distribute 228 ML biodiesel fuel, 19 000 t glycerine and 825 000 t soybean meal for South African and international markets. They just acquired a license and use Australian technologies (Desmet Ballestra). This would mean new Infrastructure Investment of US $250 M. It will also create 350 full-time jobs (200 in transport), 1,500 in construction & related industries and 5,000 to 10,000 in the agricultural sector.

3. RECENT DEVELOPMENTS IN SOUTH AFRICA

Recently the Department of Minerals and Energy (DME) held a Renewable Energy Summit (19+20 March 2009). A little more than 5 years after the publishing of the well-conceived White Paper on Renewable Energy in 2003, DME acknowledged that only 3% of the renewable energy target for 2013 has been reached. Resolutions were taken during the summit that should renew government's commitment to renewable energy. There are hints that a new Department of Energy will be formed post elections (22 April 2009), which hopefully will pay particularly attention to renewable energy targets, as highlighted in the 2003 White Paper on Renewable Energy.

During the 4th African Biofuels conference (30 Mar – 2 Apr 2009) held at the Vodaworld centre, Midrand, delegates suggested a biofuels "indaba" to be held in the first week of August 2009. The objective would be to re-visit the current lack of developments in the biofuels arena and suggesting the road ahead capitalizing on the potential of South Africa as technology provider. Hopefully this will help to put biofuels development in South Africa again on a good footage for local developments, but also for South Africa to live up to her potential as technology provider in the African content.

4. SOUTH AFRICA'S POTENTIAL TO PRODUCE PLANT BIOMASS

South Africa has much more to offer when considering the capacity to grow total plant biomass (all lignocellulosic plant biomass) and not only the production of crops suggested by the Biofuels Industrial Strategy. A study by Lynd *et al*. (2003) found that South Africa produces about 18 million tonnes (Mt) of agricultural and forestry residues, to which can be added more than 8 Mt invasive species that would be available on an annual basis for more than a decade due to abundant seed banks in invested regions. It was furthermore projected by Marrison and Larson (1996) that an additional 67 Mt/annum energy crops can be cultivated on only 10% of available land, excluding cropland, forest land and wilderness areas. The total biomass production capacity of South Africa was estimated at 94 Mt/annum.

It is interesting to note that if about 20% of South Africa's total land mass of 120 Mha are used for biomass production at a moderate yield of 3 t/ha, the required 60+ Mt/ha can be reached readily. Alternatively, if high yield energy crops, such as sugarcane at about 100+ t/ha (Prof. Frikkie Botha – personal communication), less than 1% of land mass is required!

When considering the use of 50-70% of this plant biomass with second generation biochemical and thermo-chemical technologies, South Africa could very well exchange the bulk of its current liquid fossil fuel usage (currently 21.2 BL/annum) with renewable biofuels. Figure 1 compares the potential biofuels production from agricultural and forestry residues, invasive plants and energy crops, in relation to the current fossil fuel and the Industrial Biofuels Strategy's target for 400 ML/annum.

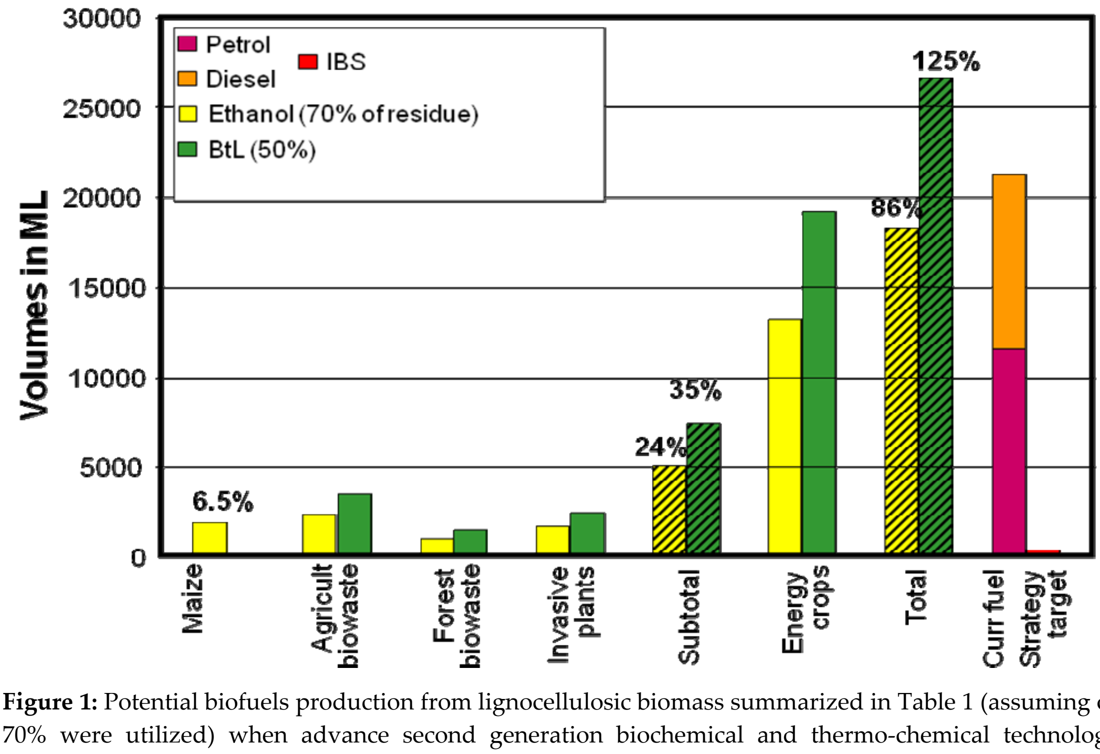

Figure 1: Potential biofuels production from lignocellulosic biomass summarized in Table 1 (assuming only 50-70% were utilized) when advance second generation biochemical and thermo-chemical technologies are available. Optimal biofuels yields estimated when the appropriate technologies are available, include (i) biochemical processing of maize-to-ethanol = 460 L/ton or lignocellulosic-to-ethanol = 280 L/ton (only polysaccharide fraction); and (ii) thermo-chemical biomass-to-liquid (BtL) = 570 L/ton.

The conversion of only 70% of total biomass can already deliver 24% of the liquid fuel needs as bioethanol or 35% via biomass-to-liquids (BtL). When adding the potential production of energy crops, and only 50% usage of this material for biofuel production, a further 62%, and 90% of the total liquid fuel needs can be met by biochemical and thermo-chemical processes, bringing the totals to 86% and 125%, respectively.

Even if the full capacity of second generation biochemical and thermo-chemical technologies cannot not be realized in the next 10 years, biofuels could make a considerable contribution to foreign exchange savings, boosting local agriculture production and providing additional markets and revenue for farmers, help generate employment and local economic development opportunities in rural areas and assist in reducing green house gas emissions and preservation of the quality of atmosphere.

ADVANCED 2nd GENERATION TECHNOLOGIES FOR BIOFUEL PRODUCTION FROM TOTAL BIOMASS

The vision of the CoER : Biofuels R&D programme at Stellenbosch University is to focus on the technological interventions required to develop commercially-viable value chains for 2nd generation lignocellulose conversion to biofuels in South Africa. This will assist South Africa to become a technology- and services-provider to biofuel producers in Africa, where neighbouring countries have substantially better biomass potential than South Africa. The programme builds on existing expertise in feedstock development, biological processing, bioprospecting, yeast biotechnology and non-petroleum hydrocarbon processing. As it is not possible to predict which technology will work better in on different lignocellulosic feedstocks, the CoER will focus on 2nd generation technology development looking at both biochemical and thermo-chemical processes. It is also important to note that biochemical and thermal processes for lignocellulose conversion have comparable efficiencies and economics.

To establish a sustainable biofuels industry in South Africa, the full value chain should be addressed (Figure 2). However, the CoER only focuses on the fourth link of the value chain, which include the following activities: (i) second generation technologies for the one-step fermentation of starch and lignocellulosics to ethanol, (ii) the use of lignocellulose as feedstock for biofuels production by biochemical and (iii) thermo-chemical conversion, (iii) process modelling for integrating biofuels and high-value chemicals production in biorefineries, and (iv) costs and life-cycle analyses to evaluate the environmental and economic impacts of these technologies. All together, valuable inputs will be acquired that can help determine the commercial feasibility of 2nd generation technologies for lignocellulose conversion.

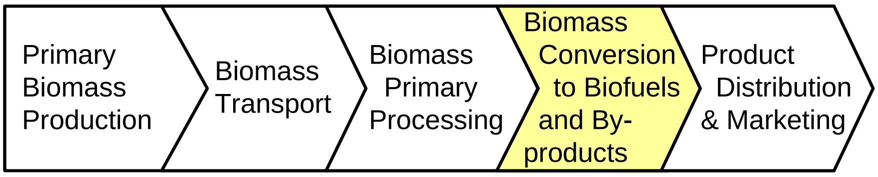

Figure 2: Diagram showing the biofuels value chain. The CoER will focus on the fourth link in the chain, i.e. "Biomass Conversion to Biofuels and By-products"

5. REFERENCES

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