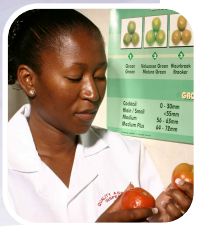
PUBLIC UNDERSTANDING OF BIOTECHNOLOGY

BIOFUELS – THE BASICS



Why do we need biofuels?

In 2007, scientists from collaborating nations around the world finally confirmed the link between increased greenhouse gas (GHG) emissions and climate change (Bernstein *et al*, 2007). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) also showed the link between human activities and GHG emissions, which have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 (Bernstein *et al*, 2007). Since carbon dioxide (and other GHGs) trap heat close to the earth's surface, preventing it from radiating back out into space, this steady increase in GHG has resulted in the rising temperature of the earth – otherwise known as global warming.

With this consensus achieved, combined with the fact that fossil fuels are a finite source for which demand is predicted to increase by more than 50% by 2025 (Ragauskas, *et al*, 2006), action is urgently needed now. Globally, these efforts are formalised in the Kyoto Protocol – an international, legally binding commitment by countries to lower their GHG emission levels to an agreed level by 2012. Developed countries, the worst offenders, have to cut their GHG by 5% against the baseline of 1990 (Kyoto Protocol, 1997). Developing countries, including South Africa, are not legally bound under the Protocol to curb emissions (Van der Merwe, 2007) and rather have to report GHG emission levels. However, with SA being ranked in the top 10 GHG polluters globally (Van der Merwe, 2007), there is pressure to actively reduce emissions.

These are the underlying reasons for the renewed focus on finding and developing alternative, renewable energy resources. As a result, governments around the world, including South Africa, are putting policy and research in place to increase the production and use of biofuels (Ruth, 2008). It is not the first time that alternatives have been sought: the energy crisis in the 1970s (OPEC oil embargo) forced countries to look elsewhere and develop alternative energy strategies, until the oil price dropped, resulting in global consumption tripling in the years that followed (Lovins, *et al*, 2004). Fossil fuels have provided an "easy" energy source and as yet, no renewable alternative can be found that compares economically, with maximum energy output and minimum detrimental effects.

What are biofuels?

1st Generation

Biofuels are energy sources that are produced from biomass – the living matter of plants or organic waste. Biofuel crops recycle carbon dioxide, one of the main GHGs, by absorbing it when they grow and then releasing it back into the atmosphere when they are burned. Theoretically, biofuels should not add to GHG emissions. In practice, the energy balance, i.e., the amount of fossil fuels required to make the crop and convert it into a biofuel versus the energy it produces, varies from crop to crop.

There are many different types of biofuels and the majority used around the world today can be classified as first generation biofuels. These include two main types:

- Plant sugars or starches of biofuel crops, such as sugar cane and maize, are fermented to produce ethanol. Ethanol can be blended with gasoline fuel in quantities of 5-10% for use in normal cars – higher percentages of ethanol need specially adapted cars (Bourne, 2007).
- Biodiesel (or bio-esters) are produced by a chemical reaction between vegetable oil and alcohol, using the oily seeds of rapeseed or soybean. Biodiesel shares similar properties to diesel and so can be easily mixed. Vegetable oils may be burned directly in modified diesel engines, which cuts the cost of processing and eliminates the waste product glycerol from the process (usually produced at a ration of 1:1 with biodiesel).

Essentially, any organic material can be used for biofuels, but the current economics of first generation biofuels is location-specific, meaning that countries will use crops that they can grow domestically that are suited to the specific climate, and influenced by factors such as yield, agricultural practices, environmental considera-

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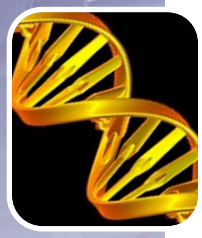
tions, as well as international trade agreements (Ruth, 2008). This explains why countries are currently using food crops – they need to start somewhere in order to reduce their dependency on imported petroleum products in an effort to reduce carbon emissions. Fortunately, new technologies can be developed to replace the use of food crops, such as the use of *jatropha*, a non-edible plant that thrives on marginal lands.

2nd & 3rd Generations

Second generation biofuels involve the conversion and fermentation of cellulose (a carbohydrate found in cell walls of plants) using enzymes (Somerville, 2006; Ruth, 2008). Non-edible plants and plant parts (e.g. grass, wood and agricultural residues) can be used (Ruth, 2008), taking the pressure off of food crops such as maize. However, this will reduce the level of organic matter in crop lands, which may destabilise soil health.

These non-food crops could be tailored into ideal biofuel crops via genetic improvement (Koonin, 2006), combining desirable characteristics including resistance to pests and diseases, and most importantly, increase biomass yields by a factor of two or more (Ragauskas, *et al*, 2006).

Algae are a potentially important biofuel crop. Some strains carry up to 50% oil content; algae have relatively simple requirements to grow; they have a substantial ability to decontaminate the environment (both for GHG and other contaminants); and they can be harvested daily, since their biomass can double within hours (Bourne, 2007). South Africa has many regions with high levels of sunshine, little cloud and land with little or no agricultural potential that would be ideal for algal farms.



Further beyond this, third generation biofuel technology is still in its infancy. This may be defined as new and hybrid-processing technologies that convert organic materials, by converting biomass directly into biofuels (Ruth, 2008).

What are the key issues?

Inadequate current technology: Current technology and agricultural outputs are not sufficient to replace fossil fuels entirely (Ruth, 2008). New technologies and scientific solutions are needed to increase the production of biofuels; minimise the negative impact on the environment or food supply; and to use less energy to grow, extract and burn the fuels than the total energy they supply.

As the technology stands currently:

- **Energy balance:** E.g. production of corn ethanol consumes about the same amount of fossil fuel as the ethanol itself replaces (Bourne, 2007). "If alcohol (ethanol) is now considered a 'clean' fuel, the process of making it is very dirty" (Goulert, In: Bourne, 2008).
- **Impact on global food supply:** The use of food crops to create starch-based ethanol, or the use of edible vegetable oils has already caused major pressure on food supplies, which has driven up food prices (Koonin, 2006), due to the competition for the same crop yields and the limited agricultural land area. However, the tragedy is that if the entire US maize and soybean crops were used solely for biofuels, they would supply only 12% gasoline and 6% diesel of the USA demand (Bourne, 2007).
- **Impact on environment:** Some of the biofuel crops have a high environmental cost, including of the need for high levels of fertiliser, use of pesticides and a high risk of soil erosion. If marginal lands are used for biofuels production, soil and wildlife conservation of these lands will be negated. The outcome may be the release of even more carbon, as well as deforestation (Bourne, 2007).

Extensive research and development investment required: For biofuels to be able to replace fossil fuels entirely, extensive time and money need to be invested in raising the standards of biofuels technology, and the agricultural productivity of biofuels crops (Ruth, 2008).

Biofuels are one tool of many: The production of biofuels is one of a number of energy options that will contribute to future reductions in the ecological footprint of human energy requirements. Other options include nuclear energy, solar energy, and wind power (Hoffert *et al.*, 2002). Fossil fuels, especially coal, will however remain an important part of the energy mix for the foreseeable future.

For detailed information on the status of biofuels in South Africa and on the benefits and risks of biofuels, see other factsheets.

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Kyoto Protocol http://unfccc.int/kyoto_protocol/items/2830.php

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