PUBLIC UNDERSTANDING OF BIOTECHNOLOGY

BIOFUELS: BENEFITS AND RISKS

Benefits

Security of energy supply

The finite reserves of fossil fuels means that oil supplies will decline after the point of peak supply is reached in the period 2006- 2007 and prices of petroleum products will rise, impacting particularly on energy-poor countries. All countries will need to develop alternative sources of energy and as a renewable energy source, biofuels could decrease dependency on declining fossil fuels (Kerr and Service, 2005; De La Torre Ugarte, 2006).

Lower greenhouse gas emissions

(Katha, 2006)

There is much debate over this issue. Whereas consumption of biofuels themselves produces lower emissions, the processes used to produce the biofuels currently require the input of fossil fuels and may therefore increase greenhouse gas emissions. In theory, efficient production of biofuels and their use could be carbon neutral.

Rural development

Biofuels will provide a new rural industry, increased economic activity in rural areas, more jobs and income generation through labour-intensive agriculture, particularly in Africa (De La Torre Ugarte, 2006; Von Braun and Pachauri, 2006).

Cheaper energy imports

Biofuels could reduce the burden of expense of energy imports for energy-deficient countries and should contribute to addressing imbalances of energy resources in countries over the world (Von Braun and Pachauri, 2006). All countries have the potential of generating their own fuel from biomass and thereby reduce their dependency on fossil fuels.

Renewable feedstock resource

Biomass will not only provide biofuels but it will also provide a renewable feedstock for the chemicals industry, replacing petrochemicals. The use of biomass as a feedstock is already impacting on the chemicals industry, in practical applications such as solvents, plastics, lubricants and fragrances.

Risks and Challenges

Quantities

Biofuel production is insufficient to fully meet the demands for fuel, but can contribute to sustainable renewable energy resources and reduce the demand for fossil fuels (Ruth, 2008). Technological advancement and new generation biofuels can increase output.

"Food vs. fuel" debate

Can agriculture concurrently provide enough food and biofuel to meet the needs of the world?

PRO	CON
It has been predicted that with technological advancements, biofuels may be able to provide up to 30% of fuel demands in an environmentally friendly manner, without affecting food production (Koonin, 2006).	Producing biofuels on a large-scale requires huge areas of land. Many countries cannot afford to divert agricultural land use away from food production, e.g., Malawi, Rwanda, Burundi, South Africa.
2nd generation biofuels relying on non-food sources such as cellulose from switchgrass could largely avert competition for land and water with food production.	Maize and soybeans (1st generation biofuel sources) require fertile land, fertilisers and pesticides.
2nd generation biofuels can be grown on poor agricultural land, and require low input of pesticides and energy. Some crops such as jatropha can be grown on infertile soil.	Food and fuel crops compete for the same resources: land, water, chemicals, skilled farmers, capital, infrastructure.
Other potential biofuel sources such as algae will not require farmland (Williams, 2007).	Higher food prices occur when food crops are used for biofuels.
Food crop residues may be converted to biofuel, e.g., maize husks, sugarcane bagasse.	
Biofuel crops can be rotated with food crops.	
Some biofuel crops such as sweet stem sorghum can simultaneously produce grain for food, sugar for biofuel and bagasse for heat and electrical energy.	

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Net energy balance

Biomass production often involves the consumption of fossil fuels. Is there a net gain in energy output?
Is it efficient enough to warrant the process?
Can biofuel production be developed to the point where zero fossil fuel consumption occurs?

PRO	CON
Bioethanol yields 25% more energy than the energy invested in its production; and biodiesel yields 93% more (Hill *et al.*, 2006). Bioethanol from switchgrass can produce 540% more renewable energy than non-renewable energy consumed (Schmer *et al.*, 2008).	The energy from biofuels will never meet total fuel requirements and are a partial solution to energy problem (Pimentel and Lal, 2007).

Greenhouse gas (GHG) emissions

There is currently a debate as to whether substituting biofuels for petroleum may increase rather than decreases greenhouse gas emissions.

PRO	CON
Relative to fossil fuels, the use of bioethanol and biodiesel reduces greenhouse gas emissions by 12% - 125%, depending on biomass sources and their processing (Hill *et al.*, 2006; Adler *et al.*, 2007).	Two recent studies have considered the greenhouse gas expense of converting forests and grassland to crop lands to provide for both food and fuel.
Ethanol derived from maize reduces greenhouse gases by an average of 13% (Farrell *et al.*, 2006).	One study estimated greenhouse gas emissions will be doubled for 30 years and increased for 167 years (Searchinger *et al.*, 2008).
Improved environmental performance depends on reducing the GHG emissions and petroleum inputs of agricultural practices.	The other predicted that the conversion of rainforests, savannas and grasslands to cropland would create a C debt by releasing significantly more C emissions (CO_2) in the process than the equivalent fossil fuels they would displace (Fargione *et al.*, 2008).
Evolving technologies of 2nd generation biofuels, of cellulose-derived ethanol, show large reduction in GHG can be achieved (Farrell *et al.*, 2006), such as 94% reduction when switchgrass bioethanol replaces gasoline (Schmer *et al.*, 2008).	Use of environmentally sensitive sites, such as the tundra and tropical peat marshes for growing biofuel crops will release vast quantities of carbon that is currently locked up in the soil.
Biofuels made from waste biomass or from biomass grown on abandoned agricultural land will offer sustained greenhouse gas advantages.	It is predicted that there will be a net increase in nitrous oxide emission due to increased use of fertilizers for biofuels (Crutzen *et al.*, 2007).

Soil health (Katha, 2006)

PRO	CON
2nd generation biofuels can be grown on land with a low agricultural value, having less impact on soil quality.	High quality, rich land will be overused.
Farmers can reduce nutrient depletion of soil by allowing nutrient rich portions of the plant to decompose into the soil.	Marginal lands are extremely vulnerable to erosion and the loss of soil health, especially under intensive culture of one crop only, i.e. biofuel crops.
Harvesting can be timed so that the portion of the plant that is harvested has relatively low nutritional content.	A focus on cellulosic biofuels will remove crop "wastes" which are essential to maintain soil health.
Rotation of crops and good management will prevent soil depletion.	Complete harvest of the plant also increases soil erosion by leaving soil barren (Pimentel and Lal, 2007).

Loss in biodiversity

As with any agricultural practice, the risks associated with the exclusive culture (monoculture) of biofuel sources exist, but can be avoided by good management practices. The use of 2nd generation biofuel sources such as native grasses in mixed plantations can improve biodiversity (Katha, 2006).

Water quality and shortages

Future increases in the cultivation and use of maize for bioethanol may harm water quality due to excessive use of fertiliser. Other rapidly growing bioenergy crops consume more water than natural vegetation or other food crops and consequently water shortages may occur (Schnoor *et al.*, 2007).

Economic sustainability (Ruth, 2008)

The production and use of biofuels still require financial incentives such as subsidies and tax credits for both producers and consumers to be economically viable and competitive with petroleum-based fuels. The competitiveness of biofuels currently depends on the relative prices of oil and of agricultural feedstock for biofuels.

Technological advances needed to improve the benefits of biofuels (Ragauskas *et al*, 2006)

- Increase biomass of plants. Increase yield of plants.
- Lower agricultural input, i.e., water, fertiliser, agrochemicals.
- Improve management of soil health under intensive agriculture
- Improve ethanol yield of fermentation processes
- Develop viable large-scale processes for the production of biodiesel from algae
- Develop efficient compression combustion engines to use plant oils directly, avoiding the esterification step of biodiesel.
- Improved processing, requiring less energy input from fossil fuel.
- Improved vehicle efficiency.

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