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Bioenergy and Sustainable Development?

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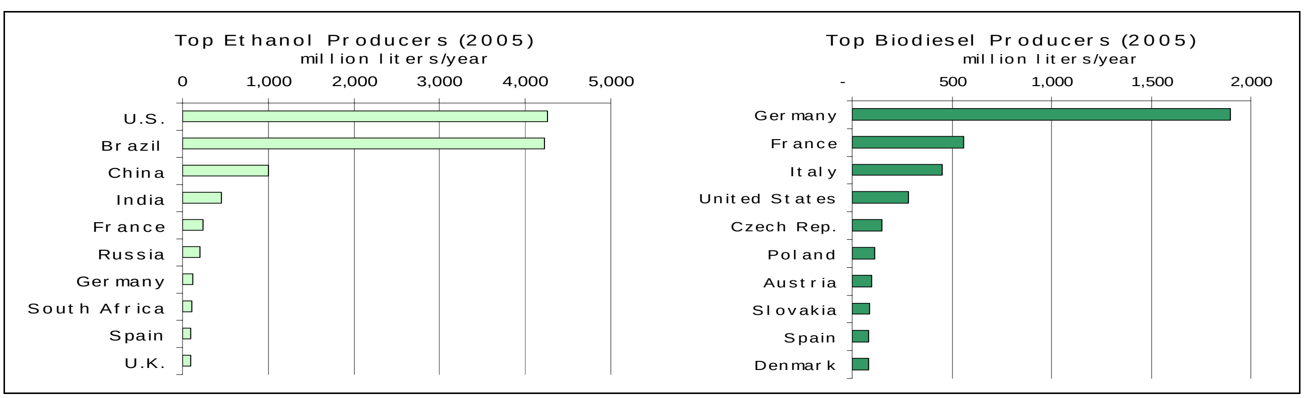
Biomass energy is rapidly expanding as a source of commercial energy with the emphasis being placed on developing biomass-derived fuels for transport. A large-scale expansion of biofuels for transport has the potential to make a significant positive contribution to the climate problem and to provide a source of income to support rural livelihoods. However, large-scale bioenergy, if not done carefully, could lead to a further degradation of land, water bodies, and ecosystems. For the large-scale use of commercial biofuels to be consistent with sustainable development goals will require a concerted move towards sustainable agriculture. It will also require that markets be redesigned to benefit the rural poor in the developing world to provide more employment opportunities and better terms of trade.

Biofuels are already a small but rapidly growing contributor to the transport fuels market. In 2005, global fuel ethanol production was approximately 36,000 million liters [5] and biodiesel approximately 4,000 million liters [6,7]. This is sufficient to displace roughly 2% of global gasoline consumption and 0.3% of global diesel consumption. These amounts are modest but growing rapidly (ethanol at more than 10% per year and biodiesel at more than 25% per year in the period 2000-2004 [1]).

Ethanol can be produced from a variety of biomass crops, including sugar-laden crops (like sugarcane and sugar beet), starch-laden crops (like corn and cassava), or cellulosic feedstocks like wood, grasses, and agricultural residues. In blends with gasoline, ethanol acts as an octane enhancer (an anti-knock agent) and an oxygenate (to reduce emissions of carbon monoxide and unburned hydrocarbons).

The world's top producers of ethanol are Brazil and the United States, each producing approximately 16 billion liters per year in 2005. In the United States, this volume corresponds to less than 2% of transport fuel, whereas in Brazil this amounts to more than one-third of transport fuel. Brazil allocates roughly 3 million hectares to sugar cane for ethanol, a bit more than half of its sugarcane crop. Brazil's program was started in the late 1970s for the purpose of reducing oil imports, and can be credited with major advances in sugarcane ethanol technology. [8-10].



Reference: [5-7].

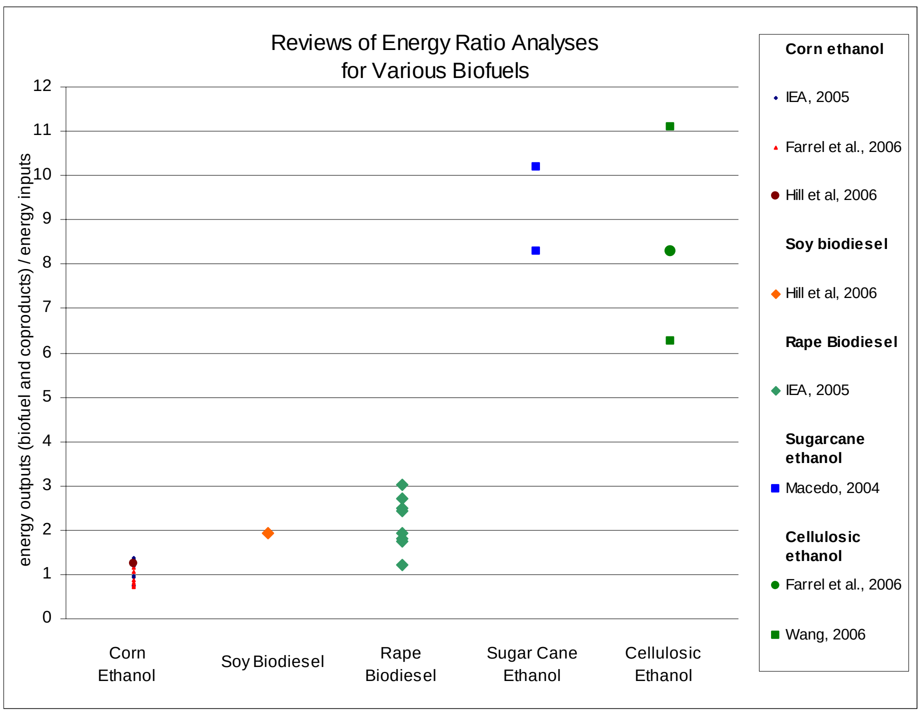
Biodiesel is the common term for a clean-burning diesel fuel and heating oil substitute that can be produced from vegetable oils or animal fat. The most common feedstocks for biodiesel are soy oil and rapeseed oil, and increasingly, palm oil. Its chemical properties and performance characteristics are very similar to petroleum-based diesel fuel. It can readily replace or be blended with diesel fuel or heating oil in standard diesel engines and boilers, requiring very few, if any, equipment modifications. It can be produced fairly inexpensively from a variety of biomass feedstocks in large oil refinery-sized plants or at the village level using simple technology.

At present, several countries have put in place policies to accelerate the expansion of biofuels. The EU plans to have 8% of its transportation fuels coming from biofuels by 2015 [11]. In the USA, the Energy Policy Act (EPACT) of 2005 created a national Renewable Fuels Standard (RFS) that plans to increase national biofuel consumption to 28 billion litres by 2012. India also has an ambitious ethanol policy, requiring 10% blending across the country by the end of 2007, which will be met primarily from domestic sugar cane production.

Energy and environmental aspects of biofuels production and use

Although biomass is frequently labelled a "renewable" source of energy, this term is used loosely, as biomass production requires non-renewable inputs including fossil fuels. Lifecycle inputs include, for example, fuels consumed by farm machinery in land preparation, planting, tending, irrigation, harvesting, storage, and transport; fossil feedstocks used to produce chemical inputs such as herbicides, pesticides, and especially fertilisers (which tend to be energy intensive); and energy required for processing of the biomass feedstock into a biofuel. Energy requirements are generally lower for perennial crops than for annual crops, which involve greater use of machinery and a higher level of chemical inputs.

Figure [***energy ration analysis***] below provides the results of reviews of some recent lifecycle energy studies for biofuels. The variation for a given fuel reflects the range of assumptions regarding factors such as the mix of fossil fuels use for process energy inputs, the energy value of the co-products, and the amount and nature of fertilizer required.



Cellulosic ethanol and sugar cane ethanol are much more effective at displacing GHG emissions than soy or rape biodiesel, which are in turn much more effective at displacing GHG emissions than corn ethanol.

There can also be non-trivial differences in lifecycle emissions of biofuels across countries. This is due primarily to differences in land-use and cultivation practice and fertilizer application and production. The vast majority of lifecycle analyses have been done in industrialized countries, leaving a considerable knowledge gap in energy and GHG impacts in the case of various feedstocks such as jatropha, palm, and cassava.

Biofuels and Sustainable Development?

Agriculture is a land-intensive, environmentally high-impact undertaking. Currently, the predominant biomass crops– sugarcane, maize, rape and soybeans – are grown using the intensive methods of modern agriculture. The main features of modern intensive agriculture are the control of crops (through genetics), of soil fertility via chemical fertilization and irrigation, and of pests (weeds, insects, and pathogens) via chemical pesticides [14]. At the same time, cropping practices have moved towards monocultures and intensive tillage and irrigation. Agriculture accounts for an estimated 70-80% of the global use of water [15], although for many countries the number is even higher. The water requirements associated with large-scale bioenergy crops may increase the water stress in many countries [16].

One cannot assume that the expansion of bioenergy would be environmentally benign. As recently seen in the case of palm oil (a biodiesel feedstock), an increase in biodiesel demand was a major contributor to deforestation and drainage of peatlands in South East Asia -- an estimated 40% of the clearing of peatlands is attributable to palm oil plantations. The total annual emissions (through peat oxidation as well as fires) from Southeast Asian peatlands are estimated to be about 2 billion tons of CO_2 which is about 8% of the global CO_2 emissions from fossil-fuel burning [13]. New palm oil plantations were responsible for 87 percent of the deforestation in Malaysia between 1985 to 2000, according to estimates by Friends of the Earth [17].

The following table illustrates that the GHG benefits of biofuels vary substantially and can be quite low.

	source	yield per hectare (liters fuel / ha)	hectares required to fuel one car (ha / car)	GHG reductions relative to gasoline/diesel vehicle
Ethanol (Corn)	Farrell (2006)	3,463	1.08	14%
Ethanol (Cellulosic)	Farrell (2006)	5,135	0.73	88%
Ethanol (Sugarcane)	Macedo (2004)	6,307	0.60	91%
Biodiesel (Soya)	Tilman (2006)	544	4.33	40%
Biodiesel (Rape)	IEA (2005)	1200	1.96	50%

Food Security

Various analysts question whether there will be sufficient land resources for biomass energy at all, after satisfying food demand and requirements for land for natural ecosystem functioning ([18-20]).

For example, displacing one North American passenger vehicle's[1] worth of GHG emissions would require between 0.7 hectares (if fuelled with sugar cane ethanol) to more than 10 hectares (if fuelled with soy biodiesel.) For comparison, the total global arable land of 1.4 billion hectares is 0.22 hectares per person. The land intensity of biofuels production (corn ethanol and soy biodiesel in particular) is reflected in the scale of the current biofuels program in the United States. After Hill et al.[12], one can calculate that the 14.3% of the US corn harvest that was converted to ethanol was able to displace about 0.25% of GHG emissions deriving from US gasoline consumption. Devoting the entire US corn harvest to ethanol and soy harvest to soy biodiesel would allow the US to displace roughly 1.7% of the emissions arising from its gasoline consumption and about 2.4% of the GHG emissions arising from its diesel consumption.

While there have been suggestions that growing bioenergy markets could offer an opportunity for socio-economic development in developing countries [2-4,21], capturing these opportunities will not happen by default. The FAO estimates that there were 815 million chronically undernourished people in developing countries in 2000-02 [22]. About three-quarters of these are extremely poor rural inhabitants, mainly practically landless small farmers living in difficult regions, underemployed agricultural laborers, and other artisans and traders who rely on these groups for a living [23]. Thus it is imperative that any effort to use bioenergy markets to promote sustainable development must find ways to include this group.

[1] The vehicle is a typical North American passenger vehicle assumed to have an annual mileage of 24,000 km and a fuel economy of approximately 10 km/liter or 23 miles per gallon.

There are several factors that make it difficult for the rural poor to profit from the growth in biofuels. The trend towards large-scale, vertically integrated corporations that have greater control over agricultural commodity chains makes it even more difficult for small scale producers to participate in the market for agricultural products [24,25]. Thus, the gains to the growers of the raw commodity – the biomass – might be minimal. Agricultural subsidies in developed countries can enormously distort the global agriculture markets and depress commodity prices [24] -- producer support in OECD countries was estimated be to 280 billion dollars in 2005

Most of the added value in biofuel supply chains will come from converting biomass into fuel. Given the increasing sophistication of biochemical conversion technologies for cellulosic ethanol, many developing countries may not have the technological capacity to build or operate these plants indigenously, making it difficult to move up the value chain in the biofuels market (paralleling the traditional agricultural world, where the lack of agro-processing capabilities severely hobbles the returns farmers able to get from their produce [26].

The diversion of agricultural commodities towards biofuels may also have unanticipated effects in the food markets. The increasing demand for corn for ethanol production in the United States has led to significant increases in its price in Mexico (more than doubling between 2006 and 2007) that led to a tortilla crisis in that country – a serious food security issue since poor Mexicans get more than 40 percent of their protein from tortillas [27].

There is no doubt that biomass is going to remain an important part of the non-commercial energy arena for some years to come, and evolve into a major contributor to the commercial energy arena. Bioenergy can be implemented in a way that will increase farmer's incomes and opportunities for livelihoods and contribute to their food security. Or it can be implemented in a way that shifts land, labor and capital resources away from food production and undermines food security. The resolution to this uncertainty lies not in technical assumptions, but in the policy decisions we ultimately make about how biomass feedstocks are produced and marketed.

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