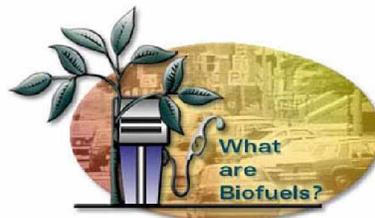


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14 December 2007
ORIGINAL: ENGLISH



**IMPLICATIONS FOR THE USE OF BIOFUELS WITH SPECIAL REFERENCE TO
THE CARIBBEAN**

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IMPLICATIONS FOR THE USE OF BIOFUELS WITH SPECIAL REFERENCE TO THE CARIBBEAN

I. WHAT ARE BIOFUELS?

Biofuels are derived as any solid, gaseous or liquid fuel obtained from biomass mainly of agricultural origin. Biomass comprises recently living organisms such as plants and animals or their metabolic byproducts - such as faeces from cows. It has an important role to play as a feedstock material for renewable energy generation, whether for electricity, heating and cooling or for transport fuels. Bio-energy is the energy derived from biomass, and includes biofuels¹. Biofuels are sources of renewable energy unlike other natural resources such as petroleum, coal and nuclear fuels and are generally in the form of alcohols, esters and ethers. These feedstocks all contain carbon that can be replenished rapidly through photosynthesis and which are sources of energy.

At present, three biofuels account for almost all consumption in the transport sector globally. These are:

- Bioethanol, mainly produced by fermentation of crops such as sugarcane, sweet sorghum and sugar beet, as well as from starch-rich crops such as maize, barley, wheat and cassava. Sugarcane is the most efficient plant in terms of biomass production and Caribbean countries have considerable experience in making use of even the plant's leftover fibre, known as bagasse, after processing. Corn and soybean are primarily used in the United States; flaxseed and rapeseed primarily in Europe; sugar cane in Brazil and the Caribbean; palm oil in South-East Asia; and jatropha (though not an agricultural product) in India². BioGel is made from low-grade ethanol and mixed with a gelling agent and has the potential to replace wood for cooking, lighting and heating. Its solid form makes it easy and safe to distribute and the widespread use of this fuel will contribute to reduction of forest depletion caused by firewood use.
- Biodiesel, is produced from oilseeds crops such as soya, rapeseed (canola) and sunflower, from used cooking oils and from animal fats.
- Biogas is produced from energy crops and organic wastes but is, so far, less developed. Biodegradable outputs from industry, agriculture, forestry and households can also be used; examples include straw, timber, manure, rice husks, sewage, and food leftovers that can be converted to biogas through anaerobic digestion. The gas obtained can be used for cooking, heating both for households and light industrial applications and power generation. This requires cultural sensitivity analysis to ascertain its acceptability for use in the local context.

¹ http://ec.europa.eu/agriculture/biomass/biofuel/index_en.htm

² <http://www.sustainable.org.za/transit/transit-project/what-are-biofuels.html>

First-generation biofuels can be used in low percentage blends with conventional fuels in most vehicles and can be distributed through existing infrastructure. For example, ethanol may be included in a mixture up to 10 per cent of petroleum gasoline (E-10) without requiring any structural adaptation in vehicles. E-85 (an alternative fuel blend containing 83 per cent ethanol in the summer and 70 per cent ethanol in the winter) and used in flexible fuel vehicles (FFVs) have corrosion-resistant fuel systems and other modest modifications to accommodate this grade of ethanol. Biodiesel is typically blended at 20 per cent with petroleum diesel. This fuel blend is called B-20. Some vehicles can run on 100 per cent biodiesel and flex-fuel vehicles are already available in many countries.

Second-generation biofuels require advanced conversion technologies. This technology would use a wider range of biomass resources – agriculture, forestry and waste materials. One of the most promising second-generation biofuel technologies - ligno-cellulosic processing (e.g from forest materials) is already well established.

II. WHY BIOFUELS?

Globally, national biofuels programmes were initiated primarily for supply security and to mitigate against massive trade deficits caused by the oil price shocks in 1973. While the extractive industries have a long history in the exploitation of energy resources and while oil and coal continue to play a dominant role, environmental and economic constraints are creating pressure for the introduction of renewable energies. In general, biofuels may be useful in reducing greenhouse gas emissions and increasing energy security by providing an alternative to fossil fuels. Some of the more important factors in promoting the use of biofuels are as follows:

A. Finite reserves

One of the major drivers towards the development of biofuels is the fact that oil reserves are finite. At the end of 2001, the total proven world oil reserve was 143.1 thousand million tonnes (Figure 1).

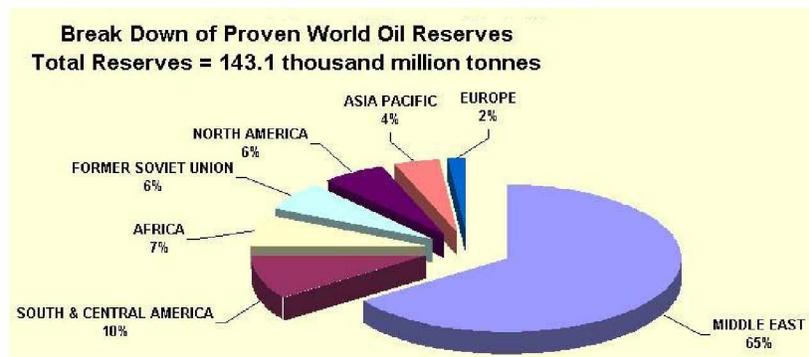


Figure 1: Breakdown of Proven World Reserves³

³ http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/references.htm

Worldwide production of oil from 1991 to 2001 has increased by 13.6 per cent from 3155.5 to 3584.9 million tonnes of oil per year and led to a surplus of 74.3 million tonnes of oil in 2001. Worldwide consumption of oil between 1991 and 2001 has increased by 12 per cent from 3137.6 to 3510.6 million tonnes of oil. Based on total worldwide proven oil reserves of 143.1 thousand million tonnes of oil (end 2001) and a worldwide oil consumption rate of 3510.6 million tonnes, it can be roughly estimated that the world has 40.8 years worth of oil reserves left which could possibly last until 2044. These figures do not include any further oil fields or regions that have so far been unexplored or not fully exploited and therefore may be slightly on the pessimistic side.

B. Environmental pollution

In recent years there has been widespread and increasing concern with regard to reducing global emissions of greenhouse gases. The principal greenhouse gases are chlorofluorocarbons (CFCs), carbon dioxide, methane, nitrous oxides, ozone and sulphur dioxide. These gases trap infrared radiation (heat) emitted from the earth, preventing it from escaping into space (Figure 2). The result of this is an increase in the atmospheric temperature. This heat trapped in the earth's atmosphere has allegedly led to the gradual melting of polar icecaps and subsequent rise in sea levels around the world as well as exaggerating the El Niño effect. With regard to carbon dioxide, biofuels are certainly beneficial. Due to their 'carbon neutrality' these fuels produce no net output of carbon dioxide as when they grow they absorb the same amount of carbon dioxide as when they are burned. However, processes like fertilizer production and transesterification require energy and this invariably results in an output of greenhouse gases. Despite this there are still greenhouse gas savings to be made and so biofuels could help⁴.

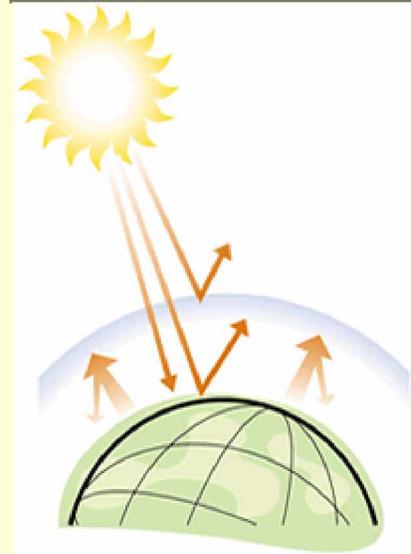


Figure 2. Heat is trapped in the atmosphere

C. Land benefits

Rural communities would experience benefits from involvement in the production of biofuels. Advantages that farmers might experience are as follows:

- Revitalisation of agriculture. Farmers face a variety of problems that can affect their livelihood including cheap imports, increasing pressures to sell, rising demands for high quality healthy produce, and concerns over intensive production on the environment. In addition, if woody fuels such as willow are encouraged then it will not just be farmers with good quality arable land that would benefit but those with poorer land also;

⁴ http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/references.htm

- Rural job creation: by creating a new market for supplying biofuels, new and additional jobs would be created primarily in rural areas. There would possibly be other opportunities created for the secondary processing of crops in which by-products are processed and other markets are created;
- Crop diversification: the inherent problems involved in growing single crops in large quantities have been known for a long time. Growing energy crops as well as food crops would boost farm diversification.

D. Security of supply

Currently oil is the dominant fuel within the transport industry. As imports are relied upon more heavily there remains the concern about the possibility that the Organization of Petroleum Exporting Countries (OPEC) could become an effective cartel once again exerting a huge political and monetary influence on worldwide oil consumers. Also, the increased risks from political or military disturbances elsewhere in the world would become critical for energy users in the world. By substituting at least some fossil fuels for biofuels, the life of remaining domestic reserves would be extended and at the same time a more secure and reliable domestic market for its raw materials would be created.

III. BEYOND BIOFUELS

In addition to the use of biofuels as alternative sources of fuel, many of the by-products of biofuel production are proving to be useful and these, in turn, could help transform the biodiesel industry into something that more closely resembles the petroleum industry, in which fuel is just one of many profitable products. Such products could then be used as feedstock for other industries in a process that may be referred to as “biorefining”.

One of these, glycerol, a syrupy liquid, sometimes referred to as glycerine is a byproduct of biodiesel production. Glycerol is now used in products from food to soap to dynamite. However, as global biodiesel production has escalated, the market for glycerol has become oversaturated. The price of glycerol, currently around 20 to 50 cents a pound, could drop as low as 5 cents a pound as biodiesel production increases. It would therefore be useful to expand the number of valuable uses for the syrupy liquid so that biodiesel makers could sell their glycerol at a more profitable price instead of paying someone to haul it away⁵. One such initiative is the production of propylene glycol, a widely used compound in the pharmaceutical industry and among the scientific community, from glycerol.

Scientists are also looking at profiting from the leftovers in the production of corn ethanol namely distiller’s dry grain and lignin from cellulosic ethanol where materials like switchgrass, corn husks and prairie grass are used as feedstock. To date, lignin shows some promise. Lignin is a natural polymer that helps provide strength and rigidity in plants, and makes up 15 to 25 per

⁵ <http://www.nytimes.com/2007/08/08/business/08biodiesel.html>

cent of most plants. Most plans for cellulosic ethanol processing call for burning the lignin to generate steam and heat to run the process. As a fuel, lignin is worth around \$40 a ton.

At Iowa State, distiller's dry grain, a main byproduct of corn ethanol that is currently largely sold as animal feed, is being used to produce hydrogen and a biopolymer called PHA. It is expected that this product, which is biodegradable, could be used for surgical gowns and gloves that must now be disposed of as medical waste. Other products such as corn-based high-fructose corn syrup, amino acids and sorbitol for use as industrial products are also being produced⁶.

IV. IMPLICATIONS FOR USE OF BIOFUELS

Despite the valuable uses of biofuels and their contribution to addressing the negative impacts of climate change some concerns have arisen in the industry.

A. Global warming?

In October 2007, Nobel Laureate Paul Crutzen⁷ published findings that the release of nitrous oxide (N₂O) among the commonly used biofuels, such as biodiesel from rapeseed and bioethanol from corn (maize), could contribute as much, or more, to global warming than fossil fuel savings due to global cooling. Crops with less nitrogen (N) demand, such as grasses and woody coppice species, have more favourable climate impacts.

B. Meeting transport fuel needs?

If one looked at biofuels more closely, one would conclude that they are not a practical long-term solution to the need for transport fuels. Even if all of the 300 million acres (500,000 square miles) of currently harvested United States cropland produced ethanol, it would not supply all of the gasoline and diesel fuel that is now burnt for transport and it would supply only about half of the needs for the year 2025⁸. Agriculture Department studies of ethanol production from corn, the present United States process for ethanol fuel, find that an acre of corn would yield about 350 gallons of ethanol. However, the fuel value of ethanol is only about two-thirds that of gasoline - 1.5 gallons of ethanol in the tank equals 1 gallon of gasoline in terms of energy output.

C. Biofuel efficiency?

It takes a lot of input energy to produce ethanol for fertilizer, harvesting, transport and corn processing. Some researchers claim that the net energy of ethanol is actually negative when all inputs are included -- it takes more energy to make ethanol than one gets out of it.

⁶ <http://www.nytimes.com/2007/08/08/business/08biodiesel.html>

⁷ http://en.wikipedia.org/wiki/Biofuel#_note-2#_note-2

⁸ <http://www.washingtonpost.com/wp-dyn/content/article/2006/06/30/AR2006063001480.html>

But allowing a net positive energy output of 30,000 British thermal units (Btu) per gallon, it would still take four gallons of ethanol from corn to equal one gallon of gasoline. The United States has 73 million acres of corn cropland. At 350 gallons per acre, the entire United States corn crop would make 25.5 billion gallons, equivalent to about 6.3 billion gallons of gasoline. The United States consumes 170 billion gallons of gasoline and diesel fuel annually. Thus the entire United States corn crop would supply only 3.7 per cent of the auto and truck transport demands. Using the entire 300 million acres of United States cropland for corn-based ethanol production would meet about 15 per cent of the demand. In the Caribbean, where availability of land is limited, this may present an even greater challenge.

D. Efficiency of using agricultural waste?

It is argued that rather than using corn to make ethanol, agricultural wastes from corn (corn stover) and sugar cane (bagasse) may be used. However, the amounts are still a drop in the bucket. Using the crop residues from corn production could provide about 10 billion gallons per year of ethanol, according to a recent study by the United States Energy Information Administration. The net energy available would be greater than with ethanol from corn, about 60,000 Btu per gallon, equivalent to a half-gallon of gasoline. Still, all of the United States corn wastes would produce only the equivalent of 5 billion gallons of gasoline. Also, not plowing wastes back into the land hurts soil fertility⁹.

Similar limitations and problems apply to growing any crop for biofuels, whether switchgrass, hybrid willow, hybrid poplar. Optimistically, assuming that switchgrass or some other crop could produce 1,000 gallons of ethanol per acre, over twice as much as from corn plus stover, and that its net energy was 60,000 Btu per gallon, ethanol from 300 million acres of switchgrass still could not supply our present gasoline and diesel consumption, which is projected to double by 2025. The ethanol would meet less than half of our needs by that date. The same may be true of sugar cane and bagasse.

E. Food vs. fuel

Perhaps more importantly the agricultural effects of large-scale biofuel programmes would be devastating as outlined by the food vs. fuel debate. Considering projected population growth in the world, the humanitarian policy would be to maintain cropland for growing food, not fuel. Every day more than 16,000 children die from hunger-related causes, one child every five seconds, and the situation will only get worse. It would be morally wrong to divert cropland needed for human food supply to powering automobiles. It would also deplete soil fertility and the long-term capability to maintain food production. We would destroy the farmland that our grandchildren and their grandchildren will need to live¹⁰.

Meanwhile, international trade in biofuels is already causing a negative impact on food sovereignty, rural livelihoods, forests and other ecosystems, and these negative impacts are expected to accumulate rapidly. Large-scale, export-oriented production of biofuel requires large-scale monocultures of trees, sugarcane, corn, oil palm, soy and other crops. These

⁹ <http://www.washingtonpost.com/wp-dyn/content/article/2006/06/30/AR2006063001480.html>

¹⁰ <http://www.washingtonpost.com/wp-dyn/content/article/2006/06/30/AR2006063001480.html>

monocultures already form the number one cause of rural depopulation and deforestation worldwide. The rapidly increasing demand for these crops as a source of biofuel will lead to:

- Increased land competition leading to further land concentration, the marginalization of small-scale agriculture and the widespread conversion of forests and other ecosystems. The effects on land use should also be noted in cases where fertile lands are used for housing settlements;
- Arable land that is currently used to grow food being used to grow fuel, leading to staggering food prices and causing hunger, malnutrition and impoverishment amongst the poorest sectors of society;
- Rural unemployment and depopulation;
- The destruction of the traditions, cultures, languages and spiritual values of Indigenous Peoples and rural communities;
- The extensive use of agro-chemicals, which deteriorate human health and ecosystems;
- The destruction of watersheds and the pollution of rivers, lakes and streams;
- Competition for water;
- Droughts and other local and regional climatic extremes; and
- The extensive use of genetically modified organisms leading to unprecedented risks.

These effects will have particularly a negative impact on women and indigenous peoples, who are economically marginalized and more dependent on natural resources like water and forests.

Perhaps of greater significance to the Caribbean is the effect on inflation. As food is diverted to biofuel production, supply would decrease with concomitant price increases thereby fuelling inflation (Table 1).

Table 1: Inflation and Money (M1)

	Inflation Rate ^a			Money Growth (M1)		
	2005	2006	2007 ^p	2005	2006	2007 ^p
Bahamas	2.0	1.8	2.4 ^b	10.0	0.3	-1.6
Barbados	6.1	7.3	5.5	3.9	12.3	9.5
Belize	3.7	4.3	3.5	4.8	19.5	...
Guyana	6.3	7.2	10.4	9.3	27.0	21.9 ^c
Jamaica	12.9	5.8	8.5	19.8	23.6	8.0
Suriname	15.8	4.7	5.6	10.8	21.8	33.7 ^c
Trinidad and Tobago	7.2	9.1	8.0	58.7	12.8	12.0
OECS^c						
Anguilla	4.6	8.4	...	14.4	50.1	23.8
Antigua and Barbuda	2.1	1.8	...	18.1	22.2	18.3
Dominica	1.7	2.6	...	28.6	-3.3	9.5
Grenada	3.5	4.1	...	-7.3	-1.8	0.9
Montserrat	2.7	1.9	...	-11.3	2.3	3.0
St. Kitts and Nevis	3.4	8.5	...	-2.0	12.7	17.6
St. Lucia	3.9	2.3	...	3.7	2.4	4.5
St. Vincent & the Grenadines	3.7	3.1	...	14.1	5.0	4.1

Source: ECLAC on the basis of official data.

p = preliminary figures.

^a January-December.

^b = twelve month variation to September 2007

^c = M1 until June, year on year

... = not available

F. Price competitiveness

Market prices of both agricultural feedstocks and fossil fuel prices are the main determinants of biofuel competitiveness. Given that both these commodities are highly volatile in nature, the very nature of biofuel competitiveness is a risky business and requires investors to look at the long term. Economics of scale in production is crucial for successful implementation of any biofuel development programme in the Caribbean. In this regard, it is important that knowledge and capacity are available to select the appropriate technology and feedstocks to produce biofuels, which are competitive with fossil fuel. For example, lessons can be learned from economic analysis undertaken for selected feedstocks in various countries. On the other hand, biofuels from woody biomass and bagasse are highly competitive with the current price of fossil fuels and are increasingly applied in co-generation of steam and power.

A recent study by Woodruff (2006) showed that while there are economic benefits to import substitution of fossil fuels in Pacific island countries, this reduces exports of copra, coconut oil and sugar and widens the trade deficit. Most African Caribbean Pacific (ACP) countries import more than they export, by replacing about 10 per cent of the imported petrol, 20 per cent of the exported products might have to be used. Therefore, the trade balance actually worsens (Table 2). It is important that countries consider the total impact of a growing biofuel industry on their economies, including economic resilience, job generation, rural-urban drift and support for local agriculture.

Table 2: Trade, Current and Capital and Financial Accounts, 2005-2007
(Percentage of GDP)

	Trade balance ^a			Current account			Capital & Financial Account		
	2005	2006	2007p	2005	2006	2007p	2005	2006	2007p
Bahamas	-11.9	-22.7	-8.1	-13.8	-25.4	-9.9	10.7	18.4	6.9
Barbados	-10	-4.2	-3.4	-12.5	-8.3	-7.2	10.3	9.6	15.1
Belize	-8.5	1.6	-0.2	-14.4	-2.0	-3.0	16.0	6.0	4.4
Guyana	-21	-37.8	-38.2	-11.6	-29.6	-27.9	19.1	24.4	21.9
Jamaica	-20.0	-20.5	...	-11.1	-10.6	...	8.7	8.4	...
Suriname	-18.5	-0.3	6.7	-21.5	0.6	2.0	22.8	4.67	5.2
Trinidad and Tobago	29.6	23.8	25.6	20.1	-11.3	-16.5	...
OECS									
Anguilla	-42.8	-59.2	...	-40.3	-52.2	...	31.5	64.1	...
Antigua and Barbuda	-3.2	-13.7	...	-7.9	-18.6	...	11.6	21.7	...
Dominica	-29.3	-24.4	...	-32.7	-29.9	...	34.3	34.3	...
Grenada	-48.1	-37.7	...	-37.0	-33.7	...	43.7	56.2	...
Montserrat	-96.2	-93.5	...	-43	-40.7	...	44.1	41.6	...
St. Kitts and Nevis	-19.5	-28.6	...	-23.1	-31.9	...	6.6	33	...
St. Lucia	-12.8	-17.4	...	-21.3	-26.5	...	16.7	27.1	...
St. Vincent and the Grenadines	-23.8	-30.5	...	-27.2	-34.0	...	21.2	34.9	...

Source: ECLAC on the basis of official data.

p = preliminary figures.

^a Goods and services.

... = not available

V. OPTIMISING BIOFUEL POTENTIAL

It is clear that biofuels are not a total solution to the world's energy problems but they do have the potential to develop a cleaner form of energy that could well contribute to reducing climate change. Therefore, in order to optimize yields and high productivity of biofuels strict management is required. This would necessitate the following:

- Control of fertilizer prices because rapidly increasing fertiliser prices could lead to under-usage;
- Efficient water collection and management are important;
- Development of strategies for managing crop residues as removal of crop residues can harm soil structure, promote erosion and damage the ecosystem;
- The challenge for developing countries is to find resources for large-scale biofuel production by buying into the best technology and processes available;
- Development of partnerships in biofuel production between developed and developing countries to alleviate poverty, speed rural progress and reduce greenhouse gases;
- Bioethanol is made from starch and sugar and biodiesel is made from different kinds of vegetable oils, so it is important that standards are developed for certification even as the world awaits the mass production of ethanol from cellulose material.
- The World Trade Organization (WTO) needs to set rules and standards for biofuel trading, whether as agricultural, industrial or even environmental goods. Scientists in developing countries must be prepared to advise governments and participate in this process;
- Biofuel development will require careful management and support from the public sector;
- The necessary legislation for use of domestically produced biofuel needs to be put in place. This will also give investors the stamp of approval;
- Promotion of integrated agro-energy farming policies in consultation with scientists, engineers and the general public to take into account the interconnectedness of the biofuel industries with livestock, farming, fisheries, and the conservation of forests and watershed areas to ensure maximising national benefits and sustainable development. This integrated approach is also important for coherent and sustainable water and land management;

- In consultation with scientists, engineers, the general public and international partners, governments need to support local and regional research into evaluating and producing suitable feedstocks; process and logistics optimisation; economic analysis for cost effective solutions; adapting and transfer of technologies, such as ligno-cellulosic conversion; searching locally appropriate alternatives to existing biofuels; resource assessment, including the use of Geographic Information Systems (GIS) and support laboratory capacity for the analysis of biofuels produced to ensure compliance with quality standards.