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## Background Paper 4

# Scientific assessment of biofuels from a sustainable management perspective

Background Paper 4 for the meeting of the International Panel for Sustainable Resource Management, Budapest, Hungary, 8-9 November 2007

## Introduction

**This paper points to some social, economic, and ecological sustainability issues due to the rapid development of biofuels. It considers the entire biofuels value chain, in a sustainable resource management perspective from production to use. The paper is based upon the most recent UN publication on bioenergy and includes excerpts from the document (UN-Energy (2007).**

**The paper focuses on modern biofuels, principally in the form of liquid and gaseous fuels. However, in order to sketch the whole picture, other bioenergy systems are also referred to (such as solid biomass use for electricity and heat generation).**

The issues that stem from biofuels development are complex and highly dependent on local circumstances (climatic, agronomic, economic, and social). This paper is intended to give an overview of some principal trade-offs involved in biofuels development, and identify some questions that the Panel might wish to consider.

## Recent and expected future developments of biofuels in the energy sector

### *Increased biofuels technologies*

Modern biofuels technologies that produce transport fuel, in particular ethanol and biodiesel, are advancing rapidly. Biofuels has become one of the most dynamic and rapidly changing sectors of the global energy economy. The United States and Brazil are global players in the global biofuels industry, and many other governments are considering the appropriate role for biofuels in their future energy portfolios.

### *Biofuels production is on the rise*

Global production of biofuels alone has doubled in the last five years and will likely double again in the next four years. Among countries that have enacted new biofuel policies in recent years are Argentina, Australia, Canada, China, Colombia, Ecuador, India, Indonesia, Malaysia, Malawi, Mexico, Mozambique, the Philippines, Senegal, South Africa, Thailand, and Zambia.

> *"The gradual move away from oil has begun. Over the next 15 to 20 years we may see biofuels providing a full 25 percent of the world's energy needs."*
>
> **Alexander Müller, Assistant Director-General for the Sustainable Development Department, FAO**

### *Oil demands and pressures*

In the past three decades, oil-dependent economies have been affected by three dramatic oil price increases—in the mid-1970s, the early 1980s, and the current period (2004–07). Unstable and unpredictable oil prices have complicated economic planning around the world, and market analysts expect this pattern to persist. Oil production has already peaked in long list of major oil producing countries such as Indonesia, Mexico, Norway, the UK and the US.

Oil imports now consume a large share of the foreign exchange earnings of many developing countries, in some cases offsetting gains from foreign debt elimination agreements. Recent oil price increases have had important effects on many of the world's developing countries, some of which now spend six times as much on fuel as they do on health.

> *Senegalese President Abdoulaye Wade has described Africa's current oil crisis as "an unfolding catastrophe that could set back efforts to reduce poverty and promote economic development for years."*
>
> **Source: UN Energy, 2007**

For countries that obtain 50–100 percent of their energy demand from an increasingly unstable world oil market, the arguments for supply diversification are strong. Many of these nations lie in tropical zones where relatively low-cost biofuel crops, such as sugar cane and oil palm, grow. In this context, 12 African countries joined Senegal in forming the Pan-African Non-Petroleum Producers Association, aimed in part at developing a robust biofuels industry in Africa. The idea behind such efforts is to divert a portion of the money now being spent abroad on oil to local agricultural and manufacturing sectors, where it would strengthen economies and generate employment.

## Limited experience with associated economic, environmental and social impacts

The rapid development of biofuels worldwide clearly presents a broad range of opportunities, but it also entails many trade-offs and risks. Experience with the associated economic, environmental, and social impacts is limited, and the types of impacts will depend largely on local conditions and on policy frameworks implemented to support biofuels development. Agricultural policy, including the availability of rural infrastructure, credit, and land tenure, will determine the scale and distribution of economic benefits. At the international level, efforts to reduce agricultural subsidies in developed countries and to allow free trade in agricultural commodities are inextricably linked to the development of first-generation [6] biofuels which have become the fastest growing segment of the world agriculture market. Trade reform efforts will both have powerful effects on and be subject to sizable impacts from biofuels expansion.

The development of new biofuels industries could provide energy services to millions of people who currently lack them, while generating income and creating jobs in poorer areas of the world. But rapid growth in first-generation biofuels production, for example, will raise agricultural commodity prices and could have negative economic and social effects, particularly on the poor who spend a large share of their income on food. In many countries, the current structure of agricultural markets means that the bulk of the profits go to a small portion of the population. Unless ownership is shared more equitably, this could become as true for energy commodities as it is for food commodities today.

Thus, the economic, environmental, and social impacts of biofuels development must be assessed carefully before deciding how rapidly to develop the industry and what technologies, policies, and investment strategies to pursue. Accelerated interest in biofuels in the coming years will place great demands on decision makers to evaluate and guide the development of these new industries. They will need to address structural problems in agriculture, forestry, and the economy as a whole so that the economic benefits to the poor outweigh the losses.

## Key sustainability issues: a short overview

The sustainable bioenergy publication of UN-Energy (2007) identifies the following seven key sustainability issues in addition to the impacts on climate change, biodiversity, human health and resource management:

### *1. Ability of modern bioenergy to provide energy services for the poor*

In many developing countries, small-scale bioenergy projects could face challenges obtaining finance from traditional financing institutions, since such initiatives generally have a less favourable risk rating compared to more well-established energy technologies. Although these projects could be critical in providing modern energy services to populations currently lacking access, they will likely require an effective microcredit delivery mechanism.

### *2. Implications for agro-industrial development and job creation*

[6] Some distinguish between first generation biofuels (fuels made from sugar, starch, vegetable oil, or animal fats using conventional technology) and second generation fuels (made from lignocellulosic biomass feedstock using advanced technical processes).

In the short-to-medium term, bioenergy use will depend heavily on feedstock costs and reliability of supply, the cost and availability of competing energy sources, and government policy decisions. In the long term, the relative economics of bioenergy will improve as agricultural productivity and agro-industrial efficiency improve and carbon markets mature and expand. At the same time, technological advancement will reduce costs and foster the emergence of a variety of new products, including advanced biofuels like cellulosic ethanol.

Successful bioenergy industries bring significant job-creation potential, with positions that include highly skilled science, engineering, and business-related employment; medium-level technical staff; low-skill industrial plant jobs; and unskilled agricultural labour. Because the vast majority of bioenergy employment occurs in farming, transportation, and processing, most of these jobs would be created in rural communities where underemployment is a common problem. The operation of these facilities generates additional rural economic activity, since the weight and volume of most biomass crops usually makes it necessary to locate collection and conversion facilities close to where the feedstock is grown. Jobs are being created in bioenergy agro-industries in rich and poor countries alike.

### *3. Gender implications*

The most significant gender-differentiated and health benefits from modern bioenergy use relate to household applications. Smoke inhalation from cooking with traditional biomass indoors is one of the leading causes of disease and death in the developing world, responsible for more fatalities each year than malaria. The impacts, typically on women and girls, of walking long distances, carrying heavy loads, and collecting fuel in dangerous areas could also all be reduced by increased reliance on biofuels. While biofuels free women from collecting firewood, however, they could also generate additional work if women produce the biomass to make the fuel, such as for biogas.

### *4. Implications for the structure of agriculture*

An important issue that needs to be addressed in the local context, is which crops are most promising. International capacity building is particularly critical at this stage of the bioenergy industry, where the expertise unique to bioenergy cropping practices, such as carbon-cycling cropping considerations, is concentrated in only a few countries (see Annex 3 for example).

### *5. Implications for food security*

The availability of adequate food supplies could be threatened by biofuel production if land and other productive resources are diverted away from food production. Similarly, if biofuel production drives up commodity prices, as appears to be the case for corn and sugar in 2006 and early 2007, food access could be compromised for low-income net food purchasers. On the other hand, the market for biofuel feedstock offers a new and rapidly growing opportunity for agricultural producers and could contribute significantly to higher farm incomes. Modern bioenergy could make energy services available more widely and cheaply in remote rural areas, supporting productivity growth in agriculture or other sectors with positive implications for food availability and access.

### *6. Implications for Government Budget*

To date, large government subsidies have been provided to biofuels. These subsidies are considerably larger that the benefits of potentially lower greenhouse gas emissions that arise from switching to biofuels. Because the magnitude of the subsidies provided to maintain a domestic biofuel market is very large, governments should examine alternative uses of the budget set aside for subsidizing biofuels to ensure that the objective of welfare maximisation is not seriously compromised. This is especially important in low-income countries where limited government resources compete for basic needs. The economics of bioenergy are situation specific, and each country will produce different results.

### *7. Implications for trade, foreign exchange balances, and energy security*

In the case of energy, a relatively small number of countries dominate exports, while most countries import most of the fuels they consume. Diversifying global fuel supplies could have beneficial efforts on the global oil market. By some estimates, rising production of biofuels could meet most of the growth in liquid fuel demand in the next decades, particularly if second-generation technologies are available and if simultaneous investment in more-efficient transport limits the growth rate.

Agricultural commodities dominate the export earnings of many poor countries, but these earnings are limited by the fact that agricultural subsidies and other protectionist policies in industrial countries have reduced international agricultural prices and limited access to the world's wealthiest markets. Unlike with energy, most agricultural commodity prices today are well below the real price of 20 years ago. The linking of agriculture commodity prices to the vicissitudes of the world oil market clearly presents risks, but it is an essential transition to the development of a biofuels industry that does not rely on major food commodity crops. Rising prices for maize and sugar are a major new incentive to develop second-generation cellulosic technologies for biofuels.

The United States and the European Union have coupled subsidies for biofuels with import tariffs that ensure that these subsidies will benefit domestic farmers rather than those in other countries. This has led to the strange irony of virtually unimpeded trade in oil, while trade in biofuels is greatly restricted. Most experts agree that opening international markets to biofuels would accelerate investment and ensure that production occurs in locations where the production costs are lowest. Poor countries in Central America and sub-Saharan Africa are among those likely to benefit. Realising the full economic benefits of biofuels development, and minimizing the risks, will depend on building the human and infrastructure capacity to support it at the national level (see Annex 3).

## Spotlight on the environment

From an environmental impact and resource management perspective, one of the greatest benefits of using biomass for energy seems to be the potential to significantly reduce the greenhouse gas (GHG) emissions associated with fossil fuels. One of the greatest risks, however, seems to be the potential impact on land used for feedstock production and harvesting (particularly virgin land or land with high conservation value), and the associated effects on habitat, biodiversity, and water, air, and soil quality. Additionally, changes in the carbon content of soils, or in carbon stocks in forests related to biofuels production, might offset some of the GHG benefits.

> *"Bioenergy provides us with an extraordinary opportunity to address several challenges: climate change, energy security and development of rural areas. Investments, however, need to be planned and managed carefully to avoid generating new environmental and social problems, some of which could have irreversible consequences. Measures to ensure sustainability of bioenergy include matching of crops with local conditions, good agricultural management practices and development of local markets that provide the energy poor with modern energy services."*
>
> **Achim Steiner, Executive Director of UNEP from UN Energy, 2007**

A better understanding is needed to fill gaps in knowledge regarding life-cycle GHG emissions (including nitrous oxide emissions) and other heat-trapping emissions associated with biomass production and use. Full life-cycle GHG emissions of bioenergy vary widely based on: land use changes; choice of feedstock; agricultural practices; refining or conversion process; and end use practices.

In general, crops that require high fossil energy inputs (such as conventional fertilizer) and valuable (farm) land, and that have relatively low energy yields per hectare, should be avoided. It is also critical to reduce if not eliminate the harvesting of non-renewable biomass resources, a problem in much of the developing world. However, even the planting and harvesting of "sustainable" energy crops can have a negative impact if these replace primary forests, resulting in large releases of carbon from the soil and forest biomass that negate any benefits of biofuels for decades.

Research on the net life-cycle GHG emissions associated with biofuels production and use is still under development, and estimates vary widely due to variations in circumstances. Results are highly sensitive to assumptions on land use changes, the effects of fertilizer application, and by-product use. With regard to transport fuels, the vast majority of studies have found that, even when all fossil inputs throughout the life cycle are accounted for, producing and using biofuels from current feedstock result in increased supply security and some reductions in GHG emissions.

In the future, "cascading" biomass over time, that is, using biomass materials for various uses and then recycling the wastes for energy, could maximize the $CO_2$ mitigation potential of biomass resources. It is possible to displace more fossil fuel feedstock, and thus derive a far greater carbon benefit, by first using biomass to produce a material (such as plastic) and subsequently using that material, at the end of its useful life, for energy production. Studies of the climate and economic impacts of cascading biomass have concluded that this practice could provide $CO_2$ benefits up to a factor of five.

Ultimately, the problems associated with land use for biofuels production (particularly virgin land), including deforestation, biodiversity loss, soil erosion and nutrient leaching, seem likely to remain the most complex and deserve the most attention. Depending on the type of crop grown, what it is replacing, and the methods of cultivation and harvest used, biofuels can have negative or positive effects on land use, soil and water quality, and biodiversity.

In the future, second-generation technologies could significantly reduce land requirements for biofuels production. At the same time, it is important to recognize that agricultural and forestry residues are necessary for maintaining soil and ecosystem health and that a certain amount must remain on the ground.

Health risks associated with the production of biomass are similar to those of modern agriculture, including exposure to pesticides (if used) and the operation of hazardous machinery. At the same time, biodiesel has positive health impacts due to reduced particulate emissions as compared to regular diesel, and use of ethanol to increase the octane level of gasoline can help lead phase out. Agricultural water could also be a serious concern especially where water is scarce and highly variable throughout the year.

More research seems necessary to determine which crops and management practices can best minimize impacts and maximize benefits. Unless new policies are enacted to protect threatened lands, secure socially acceptable land use, and steer biofuels development in a sustainable direction overall, the environmental and social damage might in some cases outweigh the benefits.

The Global Bioenergy Partnership (GBEP), which emerged from a commitment made by the G8 at the Gleneagles Summit in 2005, is focusing initially on two main areas: trade and the sustainability of bioenergy. To ensure that bioenergy can achieve its potential benefits, sustainability of the entire life cycle should be assured. Thus, GBEP partners, in particular UNEP, are in the process of defining sustainability criteria and suggestions for decision makers in both industry and government that aim to reduce risks as the bioenergy market develops. Issues for which criteria will be developed include: climate change, local air pollution, biodiversity, water, soil, land use, food security, and labour issues.

The Resource Panel might wish to contribute to this criteria development through its scientific assessment of biofuels from a sustainable resource management perspective.

## Key Questions for the Panel

**1. What are the comments of the Panel on the vision of sustainable bioenergy described in the UN-energy publication?**

**2. What is the current status of knowledge, according to the Panel, on perspectives for the crop production and trade flows for biofuels as well as the sustainability impacts of the production and use of these fuels for a set of global biofuel supply chains?**

**3. Should the Panel contribute to the development of sustainability criteria for biofuels and if so how?**

## List of abbreviations

| | |
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| CO2 | Carbon Dioxide |
| GHG | Greenhouse Gas |
| GBEP | Global Bioenergy Partnership |
| UNEP | United Nations Environment Programme |

## References

UN- Energy (2007), Sustainable Bioenergy: A Framework for Decision Makers, United Nations Publication