Global Bioenergy Partnership

A media guide to bioenergy
(to be read in conjunction with the GBEP report:
“A Review of Bioenergy Development in G8 +5 Countries”, November 2007)

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About GBEP

The Global Bioenergy Partnership (GBEP) was established to implement the commitments taken by the G8 +5 Countries (Brazil, Canada, China, France, Germany, Japan, India, Italy, Mexico, Russian Federation, South Africa, UK, USA,) in the Gleneagles Plan of Action in 2005. It was invited by the G8 +5 Summit in Heiligendamm, Germany, in June 2007 to "continue its work on biofuel best practices and take forward the successful and sustainable development of bioenergy”.

GBEP builds its activities upon three strategic pillars: Energy Security, Food Security and Sustainable Development.

GBEP promotes high-level, global policy dialogue on bioenergy and facilitates international cooperation on this issue, supporting national and regional bioenergy policy-making and market development. GBEP also favours the efficient and sustainable use of biomass and develops project activities in the bioenergy field; as part of these activities, the partnership fosters an exchange of information, skills and technologies through bilateral and multilateral collaboration.

GBEP partners are the following: all G8 countries, China, Mexico, the Food and Agriculture Organization of the United Nations (FAO), International Energy Agency (IEA), United Nations Development Programme (UNDP), United Nations Conference on Trade and Development (UNCTAD), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), United Nations Department of Economic and Social Affairs (UNDESA), United Nations Foundation, World Council of Renewable Energy (WCRE) and European Biomass Industry Association (EUBIA). Austria, Brazil, India, Indonesia, Kenya, Malaysia, Morocco, Mozambique, the Netherlands, Tanzania, South Africa, Sudan, Sweden, European Commission and the World Bank are participating as observers in view of formally becoming members.

GBEP is chaired by Corrado Clini, Director General of the Italian Ministry for the Environment, Land and Sea.
FAO hosts the GBEP Secretariat at its Rome headquarters, with the support of Italy.

GBEP Programme of Work – current priorities

- Report “A Review of the current state of bioenergy development in G8 +5 Countries”;
- Methodologies to measure GHG emission reduction from the use of biofuels for transport;
- Facilitating collaboration on bioenergy field projects;
- Raising awareness and facilitating information exchange on bioenergy.
Bioenergy basics

Bioenergy is a flexible and sustainable form of renewable energy with strong potential in many regions of the world.

• **What**: Bioenergy is a clean source of energy produced from biomass – wood and energy crops as well as organic waste and residues. Different regions and agro-ecological zones provide different forms of biomass for making bioenergy.

• **How Much**: Bioenergy provided almost 10% of the world's total primary energy supply in 2005, with all forms of biomass accounting for 47.2 exajoules (47.2x10^18 joules) of the global primary energy supply of 479 EJ. Not all of this is used in a sustainable manner, however.

  Most of this bioenergy supply is for use in the home, such as for heating and cooking. In 2005, bioenergy represented 78% of all renewable energy produced. A full 97% of biofuels are made from solid biomass (such as wood or sugar cane) and 71% of this amount is used in the residential sector.

• **Traditional bioenergy**: More than 85% of biomass energy is consumed as solid fuels for cooking, heating and lighting, often with low efficiency. Traditional bioenergy (fuelwood, animal dung and charcoal when it is used to deliver only heat) dominate bioenergy consumption in developing countries, where up to 95% of national energy consumption relies on biomass.

• **Modern bioenergy** relies on efficient conversion technologies for applications at household, small business and industrial scale. Both solid and liquid biomass materials can be processed to make them more efficient. These include solid fuels (e.g. firewood, wood chips, pellets, charcoal, briquets), liquid fuels (e.g. bioethanol, biodiesel, bio-oil) and gaseous fuels (biogas, synthesis gas, hydrogen).

  Utilisation of modern bioenergy is growing in OECD countries. Over recent years, the co-firing of biomass materials in coal-fired boilers has increased in particular and some gasification technologies are nearing commercialisation.

• **Biogas**: The conversion of animal waste and manure into methane/biogas is employed successfully in various countries, and particularly in China and India where it has contributed to energy provision to rural populations, abatement of negative environmental impacts of livestock production and the production of organic fertilizer. Its impact on sanitation, clean cooking and heating and in the creation of small and medium enterprises in rural areas is considered very positive.

• **Liquid biofuels for Transport**: Liquid biofuels account for around 2% of road transport fuels worldwide but growth rates and future potential are significant. Current biofuels are bioethanol (based on sugars and starches) and biodiesel (plant oils and animal fats). The production and consumption of liquid biofuels for transport is currently highly concentrated. The US and Brazil account for 60-70% of world ethanol production. Germany and France account for nearly 60% of biodiesel production and consumption.

• **Second-generation biofuels** (including ethanol and biodiesel based on cellulosic feedstocks) are in the development stage and are expected to become viable over the next 5-10 years.

• **Flexible in use**: Modern bioenergy can produce electricity, gas, liquid biofuels and heat, a great advantage compared to other renewable energy sources.
• **Bioenergy is storable**: Bioenergy is stored and can be used when needed – unlike other renewables including solar, wind, wave and hydro.

• **Key drivers of bioenergy growth**: Bioenergy production and consumption is increasing inexorably all over the world. Although priorities vary from country to country, most nations are turning to these forms of energy for the same reasons:
  ♦ because rising crude oil prices and energy security considerations are forcing consumer countries to look for alternative fuels;
  ♦ because climate change is driving a trend towards replacing fossil fuels and mitigating carbon-dioxide emissions; and
  ♦ because biofuels can play a role in rural development by providing remote communities with access to energy supplies, stimulating demand for agricultural commodities and creating jobs.

• **Commercial viability**: Only few modern bioenergy technologies are currently viable at market prices, these include Brazilian sugar-based ethanol and wood based heating in Northern Europe, and importantly industrial applications based on residues from production processes, for instance in sugar factories and timber mills. National targets and public incentive systems are key drivers in the development and growth of most modern bioenergy technologies, in particular in liquid biofuels for transport.

• **Alleviating poverty**: The social sustainability of bioenergy expansion will be determined in part by the ability of modern bioenergy markets to extend into poor communities in developing nations in order to revitalize rural economies, which are often hampered by unreliable energy services. It would also reduce indoor air pollution (linked to burning traditional biomass for cooking), which counts among the major causes of ill-health and death in developing countries, and eliminate the time needed to collect supplies.
Bioenergy benefits & challenges

Introduction

Global use of bioenergy is increasing exponentially, driven by four key factors: rising prices for fossil fuels (in particular crude oil), the change to safeguard future energy supplies, the need to reduce emissions of greenhouse gases that are triggering climate change and the possibility to stimulate development in rural areas.

Given the context, bioenergy is here to stay and set to play an increasingly important role in our societies.

Tapping these natural, renewable sources of energy presents a series of clear benefits, but also raises serious challenges. A clear understanding of the full cycle of the bioenergy industry and the side-effects it can have at all stages is needed in order to exploit the benefits on offer to the full while avoiding or mitigating any negative aspects.

The key benefits provided by bioenergy and the main challenges to be confronted can be summarised as follows:

<table>
<thead>
<tr>
<th>Bioenergy – Key Benefits and Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits</td>
</tr>
<tr>
<td>- Sustainability: a clean, renewable energy source</td>
</tr>
<tr>
<td>- Availability: bioenergy development can increase access to energy in rural areas</td>
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<tr>
<td>- Flexibility: bioenergy can deliver power, heat and transport</td>
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<tr>
<td>- Energy Security: bioenergy can contribute to diversifying the energy mix; there is a wide variety of feedstocks (raw materials) for bioenergy and all countries can rely on some domestic sources</td>
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<tr>
<td>- Mitigation of climate change: bioenergy can significantly reduce greenhouse gas (GHG) emissions compared with fossil fuels</td>
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<td>- Diversification of rural livelihoods: as a result of opportunities within the energy sector and those created by wider availability of energy services</td>
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<td>- Reduction in land degradation: through planting of perennial bioenergy feedstocks</td>
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<tr>
<td>Challenges</td>
</tr>
<tr>
<td>- Ensuring sustainability: at an environmental, social and economic level</td>
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<tr>
<td>- Safeguarding food security: – ensuring that increased demand for biofuels does not adversely affect the hungry</td>
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<tr>
<td>- Protecting biodiversity: avoiding an over-reliance on single crops</td>
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<tr>
<td>- Managing competition for land and water: keeping a balance between competing demands for resources</td>
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<tr>
<td>- Controlling pollution of air, water and soils: managing the full bioenergy cycle, from feedstock cultivation to use of fuels, to minimize pollution</td>
</tr>
<tr>
<td>- Removing barriers to biomass and bioenergy trade: harmonising standards and understanding how tariffs can distort the market to maximise the flow of technology, feedstocks and biofuels.</td>
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</table>

The five sections that follow seek to present this dilemma from key perspectives within the bioenergy world. Their aim is to stimulate a balanced and informed discussion about bioenergy that can help all players involved in the industry in ensuring that the great potential on offer doesn’t end up with undesired or unforeseen negative repercussions. A small selection of case histories is provided as a way to offer examples – both positive and negative – of the bioenergy technologies that are emerging.
1. Bioenergy and sustainability

Context

Bioenergy is a sustainable energy source: correctly implemented it offers a long-term solution to increased energy demand that is at the same time both renewable and clean.

Biofuels are potentially an abundant source of energy and demand in almost every country can be satisfied, at least in part, by local feedstocks (thus cutting the pollution and cost associated with transport and at the same time sustaining domestic agriculture).

In some emerging economies, bioenergy offers a potential new source of export revenue. As the example of Brazil has demonstrated, countries that lie in tropical and semi-tropical zones can exploit the potential of certain crops and the fact that the growing season lasts all year. By building on this potential, enterprising countries can build up technological know-how and equipment that can be exported in addition to bioenergy feedstocks or biofuels.

This has the potential to transform the economic role of some developing countries and stimulate rural economies. The rural poor stand to benefit from this increased demand for agricultural commodities but there is also the prospect of jobs being created in the biofuel industry and other businesses that will be attracted to the new energy services on hand nearby.

However, bioenergy is sustainable only if the entire value chain – from feedstock production, refining and conversion to end-use - are sustainable. As bioenergy development starts to take off, many of the negative side effects are coming to public attention. This increased awareness should prompt all stakeholders involved in bioenergy production or use to improve their understanding of how this new energy source can support or threaten sustainability and, as a result, make choices that enhance sustainability.

These considerations can be divided into environmental, social and economic sustainability.

Environmental Sustainability:

The choice of bioenergy feedstock and the manner in which it is used to produce fuel are critical in determining a series of environmental impacts: the level of soil erosion and depletion of nutrients in the ground, how much fertiliser is needed, the production and management of waste, the impact on biodiversity, greenhouse-gas emission levels, the effect on air quality as well as on the quantity and quality of surface and ground water.

One of the greatest threats posed by expanding energy cultivations arises when natural ecosystems are converted to agricultural use, in particular where this puts increased pressure on forests. Clearing forests for crops causes the obliteration of species and their natural habitats, leading to the irreversible loss of plant, insect and animal varieties, ecosystem functions and services. It also causes a dramatic rise in greenhouse-gas emissions.

Wide-scale destruction of wildlands can additionally affect the hydrologic cycle and impact the climate by reducing regional rainfall and increasing local temperatures. The impact on soil quality largely varies by the type of feedstock, the intensity of cultivation and the length of crop rotation periods.
Heavy use of chemical fertilizers and pesticides are known to cause acidification of soils and surface water. Intensive farming also causes soil erosion, which is especially a problem in areas with long dry periods followed by heavy rains, steep slopes and unstable soil. Erosion leads to a depletion of soil organic matter and the resulting nutrient runoffs can lead to excessive growth in nearby surface water (eutrophication), affecting other plants and wildlife.

Concerns have also been raised that rapid biofuel growth and abandoning crop rotation in favour of only one energy crop (mono-cropping) will lead to a reduction in agricultural biodiversity with negative repercussions on food security.

Environmental issues arise also when refining, converting and consuming biofuels: these are predominantly related to greenhouse-gas emissions, air quality and water quantity and quality.

**Social Sustainability:**

Challenges of traditional bioenergy:

- **Indoor air pollution** linked to traditional biomass use for cooking, counts among the major causes of ill-health and death in developing countries.
- **Time commitment:** Women in least developed countries may spend more than one third of their productive life collecting and transporting wood. Additional help needed from children often prevents them from attending school.

Modern forms of bioenergy present a particular set of benefits and challenges that need to be assessed when a new technology is implemented:

- **Rural jobs and rural development:** Bioenergy is the most labour-intensive energy source. Depending on the scale of production and on the degree of mechanisation, new job opportunities arise for unskilled workers.
- **Labour conditions:** Labour conditions in sustainable bioenergy production should be an improvement on existing standards. Labour issues include child and forced labour, general working conditions, health and safety and adequate remuneration.
- **Gender:** Women are likely to benefit most from improved access to energy where it reduces their burden (and time spent) in gathering firewood and the danger from indoor air pollution (a major cause of ill health and death in developing countries).
- **Access to land and water:** poor households in many developing countries do not have formal title over their land and rights over water. Large scale biofuel plantations can threaten their access to land and water. This also applies to marginal and degraded lands, which some countries, including India, have singled out for bioenergy development. What appears to many to be abandoned land may in fact provide important subsistence functions to the most vulnerable.

**Economic Sustainability:**

Much of current bioenergy growth is driven by government policy and incentives. These incentives should be targeted carefully to encourage development of bioenergy technologies that in the medium to long term are economically and commercially viable.
Case Histories

Brazil and bioethanol:

Although Brazil’s experience with ethanol as a gasoline additive dates back to the 1920s, it was only in 1975, with the launching of the National Ethanol Program (ProAlcool), that the government created the necessary conditions for the sugar and ethanol industry to become, three decades later, one of the most modern in the world.

Over the last 30 years, the use of ethanol as a substitute for gasoline has accounted for savings of over 1 billion barrels of oil equivalent, which corresponds to about 22 months of Brazil’s current oil production. Over the last eight years, the use of ethanol produced savings in oil imports of $61 billion, which is currently the total amount of the Brazilian external public debt.

As a consequence, the Brazilian energy mix is one of the cleanest in the world and currently more than 45 percent of all energy consumed comes from renewable sources, reflecting the combined use of hydroelectricity (14.5%), and biomass (30.1%).

The use of sugar cane in the internal renewable energy supply increased from 31% in 2005 to 32.2% in 2006, representing 14.5% of total internal energy supply. Wood and vegetal coal showed a slight reduction in the internal renewable energy supply, decreasing from 29.2% in 2005 to 28.2% in 2006.

The sugar and ethanol industry is among the productive sectors, creating about 1 million direct jobs (including in family companies and cooperatives) and 6 million indirect jobs. Working conditions on sugar cane farms are, generally speaking, better than in other industrial sectors of the Brazilian economy. The average family income of these employees ranks in the upper 50 percentile. The Brazilian government monitors the industry to ensure that labor laws and regulations are respected. The occurrence of forced labor in sugar plantations is residual and the government has intensified its inspections.

An analysis of the growth sustained by the industry provides evidence to challenge the argument that growing sugar cane for the purpose of producing ethanol is harmful to the environment. On the contrary, biofuels have had positive social and environmental impacts, by recovering previously deforested areas as well as providing crop rotation and aeration of farmlands used for food production. The production of sugar cane uses low levels of pesticides, has the largest program of biological pest control in Brazil, has the lowest level of soil erosion, recycles all its waste, does not undermine the quality of water resources and accounts for the largest area of organic production in the country.

Moreover, the significant increase seen in sugar-cane agriculture in Brazil, which is concentrated mainly in the state of São Paulo (distant from the Amazon region) and occupies only 0.6% of Brazil’s land area, is primarily the result of productivity gains and research efforts. Over the last few decades, productivity gains have surpassed 30%, reducing the need to expand the cultivated farmland.

Indonesia and palm-oil production:

According to research in 2006 by Wetlands International and Delft Hydraulics, the expanding production of palm oil in Indonesia to meet demand for biofuels in Europe was created by draining and burning peat land, as well by razing huge tracts of the Southeast Asian rainforest, in combination with overuse of chemical fertilizers.

Peat is an organic carbon storage sponge. Draining and burning the peat land, which is 90% water, releases about 2 billion tons of carbon dioxide a year, equivalent to 8% of annual global emissions from the use of fossil fuels. This has driven Indonesia to become the third-leading emitter of greenhouse gases after China and the USA.
In the case of palm oil from Indonesia, the production of biofuels can produce more harmful emissions than the fossil fuels they replace.

**Jatropha:**

The name Jatropha, a shrub or tree occurring natively in Africa, North America and the Caribbean, is rapidly emerging from relative obscurity because of its potential as a sustainable bioenergy feedstock.

Oil from *Jatropha curcas*, also known as physic nut, can be used to make candles and soap as well as biodiesel. It is a drought-resistant perennial, growing well in poor soils. It is easy to establish, grows relatively quickly with high yields and lives, producing seeds, for 50 years. A major advantage of Jatropha is that it doesn’t necessarily compete with cropland and can be used to stop land degradation and reverse deforestation.

The Chinese government in 2006 launched an $8.58 million project with the United Nations Development Programme to promote jatropha cultivation in poor areas of southwest China. The aim is to plant as much as 270,000 hectares with Jatropha by 2012 to alleviate poverty in the area, where agriculture is afflicted by soil erosion and aridity.

Chinese state media reported in February 2007 that the country intended to plant 13 million hectares, an area the size of England, with Jatropha trees to produce oil amounting to nearly 6 million tons of biodiesel every year. The jatropha trees can also provide wood fuel for a power plant with an installed capacity of 12 million kilowatts, will account for 30% of the country’s renewable energy by 2010.

The plant, which has major potential in Burma/Myanmar, the Philippines, Indonesia, Africa, China and India, has also sparked the interest of corporate players. D1 Oils of the UK and BP Plc in June 2007 announced the formation of a joint venture to invest £80 million ($164 million) in *Jatropha curcas* cultivations (1 million hectares over four years). The partners said Jatropha had the potential to produce low-cost, high-volume supplies of biodiesel without competing for arable land or rainforest while also creating jobs in local communities.

**The Roundtable on Sustainable Biofuels (RSB):**

The RSB is an important international multi-stakeholder initiative to develop sustainability standards for biofuels. The Roundtable is being lead and funded by the Swiss EPFL (École Polytechnique Fédérale de Lausanne) Energy Center. Its first draft principles for sustainable biofuels production are available for review. Examples of draft principles are: “Biomass production should not lead to the destruction or damaging of areas of high biodiversity,” and “biomass production should not degrade or damage soils.”
2. Bioenergy and climate change - Cutting carbon emissions

Context

Bioenergy offers significant potential for reductions in greenhouse-gas (GHG) emissions in electricity, heating and transportation. However, the potential savings vary significantly between different bioenergy technologies and regions.

- **Emission reductions must be assessed considering the full life-cycle**: the life-cycle includes production (choice of feedstock, agricultural practices, land use change, etc.), refining and conversion processes as well as end-use practices.
- **Uncertain estimates**: considerable uncertainty hampers “across the board” estimates of the potential GHG emission reductions from various biofuels. The analysis is complex because of wide variation in the use of by-products, agricultural practices in growing the feedstocks and efficiencies of processes. Reduction potentials must therefore be seen as indicative.
- **Electricity and heat from biomass can generate greater savings than transport fuels**: burning biomass instead of coal and oil products has significant reduction potentials.
- **Extra benefit of biogas**: trapping and burning the gas given off by organic waste not only reduces carbon-dioxide emissions compared with the burning of fossil fuels but also avoids emissions of methane, a powerful greenhouse gas, which is given off in the decomposition of organic waste.
- **Emission reductions from liquid biofuels**: the potential of reducing GHG emissions from liquid biofuels (bioethanol, biodiesel, etc.) vary widely by region and technology. Of those currently in commercial use, Brazilian ethanol produces the largest GHG savings – estimated to be up to 90% when compared with fossil fuels. Maize-based ethanol production produces far lower savings, with estimates of average reductions of around 13%. Second-generation biofuels, including cellulosic ethanol, are expected to produce significant GHG savings – possibly of up to 80%.
- **Land conversion from high-carbon content land will eliminate the potential GHG reduction**: where bioenergy feedstocks replace high-carbon storage land, such as virgin forests and peatlands, GHG balances can end up being negative.

The 4th Assessment Report of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/) presents key technologies and practices for mitigating GHG emissions. Bioenergy features in most of the sectors identified by the IPCC:

- **Energy Supply**: immediate solutions include bioenergy for heat and power with technologies that are currently available; by 2030 new developments should make additional biomass and coal-fired electricity generating facilities as well as advanced bioenergy technologies commercially viable.
- **Transport**: Aside from current technologies available to make biofuels, by 2030 second-generation versions should be commercially viable and make significant contributions;
- **Agriculture**: dedicated energy crops, improved cropping and grazing management and residue management;
- **Forestry**: Use of forestry products to replace fossil fuel use and
- **Waste**: Composting of organic waste and methane recovery.
Case Histories

California’s fuel standard:
California is the fifth-largest economy in the world and is an acknowledged leader in environmental policy, a status enshrined in the U.S. Clean Air Act. Early in 2007 Governor Schwarzenegger established a Low Carbon Fuel Standard (LCFS) for transportation fuels in California, calling for at least a 10% reduction in their carbon intensity by the year 2020.

Micro-algae’s great potential:
Micro-algae are unicellular aquatic plants that produce vast amounts of plant oil that can be used for the sustainable production of biodiesel. Although categorized currently as a first-generation feedstock due to conventional conversion technologies used for its processing, algae holds great potential as a prolific next-generation feedstock with its long-term economic capacity yet to be tested. Micro-algae can be cultivated in a wide variety of conditions ranging from arid regions with poor soil quality, to salt water and water from polluted aquifers. The per hectare yield is estimated to be many times greater than tropical oil seeds.

The primary necessities of algae production are carbon dioxide and nitrogen oxide, which create the opportunity for the development of integrated systems where micro-algae are ‘fed’ by the emissions of coal, petroleum and natural gas power plants. In recent developments, the Massachusetts Institute of Technology (MIT) has demonstrated new technology for utilizing micro-algae to absorb power-plant emissions. Large enough algal colonies could reduce nitrogen oxide levels by about 80% and carbon dioxide by 30-40%, while simultaneously producing raw plant oil for its use in producing bioenergy. Species of algae that are optimal for such functions, have the capacity to produce 40 to 50% oil by weight.

The economics of algae as an energy feedstock are still challenging, however recent research and innovation are likely to make algae a cost-effective option in the future.

Biogas:
The conversion of animal wastes and manure into methane (biogas) can bring significant environmental and health benefits. Methane is a greenhouse gas that is 22-24 times more potent than carbon dioxide in terms of its effect on climate change. By trapping and utilizing the methane, that negative impact is avoided. In addition, pathogens present in manure are killed by the heat generated in the biodigestion process and the material left over at the end of the process provides a valuable fertilizer.

Biodigestion is employed successfully in various countries, particularly in China and India where it has contributed to bringing energy to rural populations, to the abatement of the negative environmental impacts of livestock farming and to the production of organic fertilizer. Its impact on sanitation, clean cooking and heating and in the creation of small and medium enterprises in rural areas is very positive.

One of the first companies generating biogas on an industrial scale is Nawaro BioEnergie in Germany. Its 20-megawatt biogas park in Pankun, Germany, consists of 40 biogas units, which run on feedstock (corn silage, grain and manure) from large agricultural enterprises and farmers nearby. The gas obtained from the fermentation process is burned to generate electricity that is fed into the national power grid.
3. Bioenergy and food security - Energy crops and food crops

Context

There are 854 million people in the world suffering from hunger. Although the proportion of the world population that is undernourished has diminished in recent years, absolute numbers have remained stable.

Meanwhile, liquid biofuel production from edible crops is booming, contributing to an increase in the price of some staple foods as demand for agricultural commodities rises.

Population growth and over-consumption in the most industrialised economies is putting enormous strain on water, soil and agro-ecosystems while rich countries continue to subsidize domestic agriculture. The subsequent rise in food prices has caused, and will continue to cause, significant debate.

The growth in bioenergy has repercussions on food security through two main channels:

1. price effects in international markets
2. local factors related to production methods for bioenergy in specific contexts.

1. Price effects:

- **Price effects of increase in biofuel demand.** Energy markets are significantly larger than agricultural markets in value terms. Energy prices therefore drive agricultural prices in commodities which can function as energy crops. Rising energy demand for agricultural crops is creating a floor price for agricultural commodities such as sugar, maize and rapeseed. At the same time, energy markets also create ceiling prices for these commodities: if their price rises above a certain threshold, they are no longer competitive energy carriers compared with alternative energy sources and demand for the crops from energy increase. FAO short and medium term projections indicate that these recent trends will most likely lead to a reversal of the long-term decline in real agricultural commodity prices.

- **Impact of rising prices.** Rising prices are beneficial to producers of these commodities, including poor small-scale producers. However, they adversely affect buyers of the commodities, and especially those for whom food and basic commodities including maize and sugar make up a significant part of their household expenditure – in particular the urban poor and the poorest among the rural poor.

- **Higher prices create new market opportunities.** Higher prices, however, create new market opportunities as poor rural dwellers, including the food insecure, benefit from increased and profitable agricultural production, new employment opportunities in the biofuel and associated industries and as economic activity is attracted by improved energy infrastructure. More labour-intensive technologies will bring greater employment opportunities for poor unskilled workers.

The impact of new bioenergy demand and new developments on food security is highly context specific and complex. It is clear, though, that those who are net buyers of both food and energy will be made worse off by a biofuel boom. This includes the urban poor and the land-less rural poor. At the country level this poses particular problems to Low-Income Food Deficit Countries, who are also net energy importers.
2. Local factors:
The specific production methods, regional and social context of biofuel production will have important implications for possible impacts on food security (see also section on bioenergy and sustainability). The various impacts can be analysed by considering how increased biofuel production affects the four dimensions of food security: availability, access, stability and utilization.

<table>
<thead>
<tr>
<th>Availability (The world’s ability to produce sufficient food)</th>
<th>Stability (People’s continuous access to sufficient food – also in situations of crisis)</th>
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<tbody>
<tr>
<td>(+) new demand for agricultural products leads to higher returns for farming and increased production</td>
<td>(+) floor prices for staple food products ensure minimum return to all producers (including poor producers)</td>
</tr>
<tr>
<td>(+) biofuel growth may improve rural energy services, boosting agricultural productivity</td>
<td>(+) biofuels may offer new rural employment opportunities and reduced insecurity compared to subsistence farming</td>
</tr>
<tr>
<td>(-) land, water and other resources are diverted away from food production, (although technological improvements and second generation fuels may reduce competition between food and fuel)</td>
<td>(-) increased volatility of prices between floor and ceiling prices increases risk to poorest consumers</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Access (The ability of households to access food – they can find it in their area, and they can afford it)</th>
<th>Utilisation (People’s ability to absorb nutrients from food – linked to clean water, health and energy access)</th>
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<tbody>
<tr>
<td>(+) new demand for agricultural products leads to higher farm incomes and greater ability to purchase food</td>
<td>(+) increased access to energy offers improved opportunities for food preparation and preservation</td>
</tr>
<tr>
<td>(-) higher food prices reduce affordability and negatively affect poor buyers</td>
<td>(+) rural regeneration related to biofuel growth may improve service provision in rural areas, including healthcare</td>
</tr>
<tr>
<td>(-) displacement of local food production by new biofuel developments may reduce local access to food</td>
<td>(-) competition for water may reduce water access by the poorest for drinking and hygiene</td>
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</table>

(+) negative impacts
(+ ) positive impacts

Case Histories

Price of tortillas in Mexico:
Abengoa Bioenergy, leader in European bioethanol production and fifth in the United States, has sought to quell the debate about the increase in the price of tortillas in Mexico. It pointed out that white corn is a raw food material produced in Mexico with financial support from the government, and accounts for nearly the entire corn production.

Bioethanol, on the other hand, is produced in the US from yellow corn and white corn production accounts for less than 1% of its total corn production. Furthermore, the export of this white corn from the US to Mexico is not only highly limited but is also subject to import tariffs. The drought in Mexico in 2006 has been the determining factor in higher white corn prices.

Brazilian industry’s response:
Leading personalities in the Brazilian bioenergy industry recently defended biofuels from the accusation that their development is exacerbating the plight of the world’s poor.

Expedito Parente, a chemical engineer who patented biodiesel in Brazil 30 years ago, said an expansion of bioenergy combats hunger by creating economic opportunity and jobs in rural areas. Jorio Dauster, chairman of Brasil Ecodiesel, a pioneer in biodiesel production, said the
debate is an “emotional” one: avoiding the use of food crops to make fuels wouldn’t reduce poverty but would boost the price of crude oil, contributing to more wars and hunger.
4. Bioenergy and new technologies

Context

Modern bioenergy applications are key to ensuring greater energy security, reducing dependence on producers of fossil fuels such as crude oil. New technologies that have emerged and continue to be developed demonstrate what a flexible resource bioenergy can be, providing fuels that can be used in electricity generation, the supply of heating and transportation. Here are key current statistics on bioenergy production and consumption:

♦ BIOETHANOL PRODUCTION
   In 2006, world bioethanol production reached 51.3 billion litres, with the United States and Brazil accounting for almost 90% of the total between them.
   The U.S. is currently the largest producer of fuel bioethanol, with corn as its primary feedstock. It made 20 billion litres of bioethanol in 2006 and is expected to produce 26 billion litres by the end of 2007.
   Brazil ranked second in 2006 with production of 17.8 billion litres of bioethanol derived from sugar cane and a projected 20 billion litres for 2007.

♦ BIODIESEL PRODUCTION
   World biodiesel production surpassed 6 billion litres in 2006. Europe led in this field in 2006, producing 3.96 million tons of the fuel from rapeseed, sunflower and other oilseeds. The EU is projected to produce 4.72 million tons for 2007.
   As the top biodiesel producer, Germany made 3.8 million tons (2.5 billion litres) of biodiesel in 2006 and its production capacity is set to rise by 40% to 5.4 million tonnes by the end of 2007.
   The US is currently the second-largest producer of biodiesel and is estimated to produce about 1.8 million tons in 2007, up from 1.3 million in 2006. France, Italy and several small suppliers also grew their biodiesel output. Production rates increased rapidly in Malaysia, China, Colombia and Brazil in 2006, contributing to world biodiesel expansion.

♦ BIOMASS CONSUMPTION
   China is the largest user of biomass as a source of energy with its 9,000 petajoules (PJ) or 9,000x10^{15} joules a year. It is followed by India (6,000 PJ/yr), the U.S. 2,300 PJ/yr and Brazil (2,000 PJ/yr) while the bioenergy contribution in countries such as Canada, France and Germany is around 450 PJ/yr each.

Second-generation biofuels

One of the most interesting fields in bioenergy today is the research and development being carried out into advanced or so-called second-generation biofuels. These rely on the conversion of cellulosic biomass, a vastly abundant category that includes wood, tall grasses and forestry and crop residues. Although it will take a decade or two for second-generation fuels to make a significant contribution to world energy needs, the pilot and demonstration plants that are in operation or being set up around the globe are raising the prospect of an even cleaner, more sustainable future for bioenergy.

A main advantage of using cellulosic biomass crops is that they provide more biomass per hectare than conventional starch and oilseed crops because the entire harvest is available for conversion to fuel, not just one part of the plant.
In addition, second-generation technologies bring substantial sustainability advantages. These are crops that don’t need to be grown on prime agricultural land and don’t compete with its use for food production. Often, waste biomass can be used as a feedstock (something that is readily available from existing forests and cultivations), meaning that in this event no additional land is taken over for energy-crop production.

Importantly, this new generation of biofuels offers the greatest potential for reducing greenhouse-gas emissions. Most studies project they could dramatically cut GHG emissions compared with petroleum fuels. In some cases, this reduction could exceed 100%, meaning more carbon dioxide would be captured during the production process than released during the fuel’s life cycle (especially when fertilizer inputs are minimised and biomass or other renewable energy sources are used in conversion).

The technologies being studied vary based on the different component of the cellulosic feedstock that is targeted. As cellulosic biomass is more resistant to being broken down when compared to starch, sugar and oils, the difficulty of converting it into liquid fuels inherently makes the conversion technology more expensive even though the cost of the cellulosic feedstock itself is lower than for current, first-generation feedstock.

The most common conversion processes currently being used include gasification and Fischer-Tropsch (F-T) synthesis. In gasification, biomass is converted into synthesis gas, or syngas, which contains carbon monoxide, carbon dioxide, hydrogen and methane. Syngas can be used to make an assortment of fuels such as hydrogen, bioethanol (dimethyl ether, DME) as well as synthetic diesel and synthetic gasoline. Other key techniques include hydrolysis and pyrolysis.

The successful and timely development of these processes will require sustained research funding from public and private sources as well as other forms of government support. High crude oil prices are also necessary to stimulate the search for cost-effective alternatives.

THE “BIOREFINERY” CONCEPT

The key to mass production of biofuels in the future may well lie in the idea of developing biorefineries, taking a leaf out of the book of modern oil refining, which boost efficiency and profitability through the re-use of heat and the making of valuable by-products. Biorefineries would therefore simultaneously produce biofuels and bio-based chemicals, with the former representing the bulk of production and the latter the bulk of the profits. Heat that is released from some processes within the biorefinery could be used to meet the energy requirements for other processes in the system. This is already being done in some bioenergy production facilities.

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Co-firing biomass:
Biomass can be burned with coal in the boiler of a conventional power plant to yield steam and electricity. This so-called co-firing of biomass with coal is currently the most cost-efficient way of incorporating renewable technology into conventional power production because much of the existing power plant infrastructure can be used without major modifications.
The main advantage of this approach is the higher efficiency achieved, meaning that a greater percentage of the energy available in the fuel is converted into electricity or heat. Traditional coal-fired plants run at about 33%, while co-firing can take this to as much as 45% (the figures are around 30%-35% using only dry biomass and 22% for municipal waste). According to the U.S. Department of Energy and the Coal Utilization Research Council (CURC), conventional pulverized coal in modern plants can yield 45 to 50% efficiency and have the potential to achieve 70 to 80% with advances in gasification technologies.

To put this into context, the CURC claims that a 1 percentage point improvement in efficiency at traditional coal-fired power plants would generate an extra 60 billion kilowatt-hours, the same amount of electricity as all non-hydro renewable power in the US in 2005. Raising efficiency by 2 percentage points would produce extra power exceeding all additional renewable power generation that is forecast for the US by the IEA through 2030. Co-firing technology options have been tested in Northern Europe, the US and Australia in approximately 150 installations using woody and agricultural residues.

In Florida, Tampa Electric has been testing such technology at its Polk 1 coal-fired power plant for 10 years. The utility was the first in the US to commercialise such technology, in partnership with the Department of Energy. The company is now seeking permission to build a $2 billion plant that will have the capability to use biomass as a fuel. The projected 632-megawatt plant should start operations in 2013.

**Straight vegetable oil (SVO):**

SVO is a potential fuel for diesel engines that can be produced from a variety of sources. These include oilseed crops such as rapeseed, sunflower, soybean and palm. Used cooking oil from restaurants and animal fat from meat processing industries can also be used as fuel for diesel vehicles. Engine manufacturers are developing software so combustions systems can work with SVO. But, because SVO thickens at colder temperatures, blending it with diesel has been problematic.

People on the Pacific island of Bougainville in Papua New Guinea are developing mini-refineries to produce a coconut oil to replace expensive diesel in vehicles and generators. Their knowledge of this technology derives from the secessionist conflict that afflicted the island in the 1990s and often severed fuel supplies from the mainland.

**Syngas:**

Through a process of gasification, solid biomass can be converted into a gas. Biomass gasifiers operate by heating biomass in an oxygen-free, high temperature environment that breaks it down to release a flammable, energy-rich synthesis gas or syngas.

The first integrated gasification combined cycle (IGCC) plant fuelled 100% by biomass (from straw) was successfully demonstrated in Sweden from 1996-2007. IGCC plants elsewhere could become economically competitive using black liquor from the pulp and paper industry as a feedstock, but further analysis is required.

By treating this biogas it can be suitable for use as a transport fuel. Due to a low methane content (60 to 70%) and a high amount of contaminants, untreated biogas is unsuitable for transportation. Sweden currently leads the world in automotive biogas production, with a fleet of 4,500 vehicles that use biogas for 45% of their fuel supply.

**Airline companies:**

Leading airline companies are now also embracing bioenergy as technological advances raise the prospect of developing biofuels that can be used commercially in the near future. UK-based Virgin Group, owned by billionaire Richard Branson, aims to conduct the world’s test of biofuel in commercial aircraft, using a Boeing 747 and engines from GE Aviation, in early
2008. Virgin, through its $400 million investment in Virgin Fuels, is developing its own biofuels for use in buses, trains and cars in the next three to four years.

Branson is competing with Air New Zealand, which in September 2007 announced its own accord with aircraft manufacturer Boeing and engine-maker Rolls Royce to prepare for the trial of a bio-fuelled aircraft in late 2008 or early 2009. The Boeing 747 is expected to have one engine running on a blend of biofuel and kerosene with the other three powered by regular aviation fuel.

**Fastest bike burns biodiesel:**

In September 2007, a custom-built biodiesel motorbike set a new world land speed record for diesel motorcycles. The bike, constructed from a BMW R 1150 RT model, was powered by a two-litre engine from a BMW 3 Series car. It reached a speed of 131 mph (210 kmh) travelling across the Bonneville Salt Flats in Utah, US.

The team that developed the bike claimed that it produces 78% less emissions than a standard diesel engine. The engine used can run on vegetable oil, biodiesel or regular diesel.
5. Bioenergy and trade

Context

Trade in bioenergy and its feedstocks is poised to rise from its currently low levels because of regulations imposing a greater use of biofuels in regions with limited production potentials (for instance, the EU). Biomass productivity in tropical and sub-tropical climates is significantly higher (according to some estimates, up to five times higher) than in temperate regions (such as Europe and North America), where demand is growing most.

This imbalance highlights the potential benefit that greater trade can have in ensuring the most cost-effective deployment of bioenergy technologies worldwide.

- **Biofuel trade development**: Biofuels promise new and dynamic export flows of both raw materials and finished products. Today global trade in biofuels, however, remains fairly small relative to both biofuel demand and traditional fossil fuels trade. A truly international market for biofuels will require more producing countries to be in a position to export large surpluses.

- **Bioethanol** features today as a dynamic commodity, with production and international trade recording a strong growth. World production increased from less than 20 billion litres in 2000 to over 40 billion litres in 2005, and is expected to double again by 2010. Brazil is the largest producer, followed by the United States. China and India come in a distant third and fourth. Brazil exports some 2.5 billion litres of ethanol and has an approximately 50% market share of global ethanol exports. Other developing countries have benefited from the dynamism of the sector, including by taking advantage of existing preferential trade arrangements. Conversely, there appears to be little international trade in ethanol feedstocks. Subsidies are likely to contribute to the expansion of domestically produced feedstocks in developed countries.

- **Biodiesel**: The production of biodiesel outside the EU is still limited, which is why there has been no significant international trade. Recent investments in several developed and developing countries indicate that production and international trade are poised to grow. Trade in biodiesel feedstocks is on the rise, indicating that raw agriculture materials, rather than industrialized finished products, are being traded internationally.

- **Distortions in international markets**: International trade in biofuels faces tariff and non-tariff measures. Moreover, the biofuels market is distorted by different kinds of subsidies and incentives. International trade, however, could provide win–win opportunities to all countries: for several importing countries, it is a necessary precondition for meeting self-imposed fuel blending targets; for exporting countries, especially small and medium-sized developing countries, export markets are necessary to initiate their industries. Reducing and eliminating trade barriers and phasing out trade-distorting subsidies would contribute to establishing a level playing field. Investors in prospective biofuels export facilities need to be assured that markets are going to be open and that there will be scope for exports, allowing them to exploit economies of scale.

- **Labelling and certification** of biofuels and related feedstocks may be instrumental to ensure that widespread biofuel production and use will indeed be conducive to environmental improvements. Certification and labelling remain, however, a rather complex issue. Efforts should be made to ensure that the development of sustainability criteria and certification systems contribute to reaching environmental objectives without creating unnecessary barriers to international trade, especially to exports from developing countries.
• **Biofuels in current trade negotiations:** Paragraph 31 (iii) of the Doha Development Agenda has launched negotiations on “the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services.” Negotiations on environmental goods have been carried out by the Committee on Trade and Environment Special Session (CTE-SS) and by the Negotiating Group on Non-Agriculture Market Access (NAMA). Negotiations on environmental services have been conducted within the Special Sessions of the Council for Trade in Services. According to some WTO members, renewable energy products - which could include ethanol and biodiesel and related products, such as parts and components of biodiesel and bioethanol plants and "flexi fuel" engines and vehicles - could be classified as environmental goods. Concrete progress has been hampered by disagreements among countries on the identification of environmental goods, on the scope and approach to take to liberalize trade in such products, and on mechanisms for regularly updating the product list to account for constantly moving targets.

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**Sweden and wood pellets:**

National standards for the trade of pellets have been adopted by a number of EU countries such as Sweden, Austria and Germany, with the establishment of region-wide standards currently underway by the European Committee for Standardization (CEN). Pellet standards have established a common size requirement for pellets to facilitate storage and use as feed for automatic burners, as well as established criteria for pellet quality.

As a result, pellet trade has occurred in several countries in the EU including Sweden, the Netherlands and in the Baltic area. The major trade flows over the last few years have occurred from Estonia, Latvia, Lithuania and Poland to Sweden, Denmark, Germany and the Netherlands. Austria remains the strongest trader in Central Europe.

Sweden features among a key player in this respect because of the priority it has given to bioenergy development: thanks to its forests, 25% of Swedish energy supply is derived from biofuels and the government has decided that the country should be independent from fossil fuels by 2020.

Swedish imports of biomass in 2003 were estimated to be between 18 and 34 petajoules. Sweden imported tall oil and pellets from North America and the Baltic states, pellets and logging residues from Belarus and household rubbish and recovered wood from continental Europe. Additionally, Canada and Finland exported approximately 350,000 tons of pellets to Sweden in 2003.

**Brazilian exports:**

Brazil is the only major country to have built up an exportable surplus in ethanol. The volume of bioethanol traded worldwide grew to around 7.8 billion litres in 2006, compared with 5.9 billion in 2005 and 3.2 billion in 2002. The rise was mostly attributed to Brazil, whose exports reached 3.5 billion litres in 2006, a gain of 0.9 billion litres from 2005 and a threefold increase over 2002.