Bioenergy: Facts and Figures

Bioenergy – The 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, energy crops and organic wastes and residues. Different regions and agroecological zones provide different forms of biomass used to make bioenergy.
- ***How Much:*** Biomass accounts for approx. 11% of total primary energy consumed globally and for about 80% of renewable energy, but not all of this is used in a sustainable manner.
- ***Traditional bioenergy:*** Currently, over 85% of biomass energy is consumed as solid fuels for cooking, heating and lighting, often with low efficiency. Traditional bioenergy (fuelwood, charcoal which can only deliver 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 scales. Utilisation of modern bioenergy is growing in OECD countries. Over recent years, especially co-firing of biomass materials in coal fired boilers has increased, and some gasification technologies are nearing commercialisation.
- ***Biogas:*** The conversion of animal wastes and manure to methane/biogas is employed successfully in various countries, and particularly in China and India where is 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:*** The three predominant factors driving recent and projected growth in bioenergy are a) rising energy prices, in particular oil prices; b) a desire in many oil-importing countries to reduce energy dependency on a few oil and gas exporting countries, increasing energy security; and c) commitments to reduce greenhouse gas (GHG) emissions to combat climate change.
- ***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.

Bioenergy – Key Benefits and Challenges	
Key Benefits	**Key Challenges**
• *Sustainability:* a clean and renewable energy source • *Availability*: bioenergy development can increase access to energy in rural areas • *Flexibility*: bioenergy can deliver power, heat and transport • *Energy Security*: bioenergy can contribute to diversifying the energy mix; there are a wide variety of feedstocks (raw material) for bioenergy and all countries can rely on some domestic sources • *Mitigation of climate change* – bioenergy can significantly reduce greenhouse gas (GHG) emissions compared to fossil fuels (see below) • *Diversification of rural livelihoods* – in the energy sector, and utilising newly available energy services - facilitating rural development • *Reduction in land degradation* especially through planting of perennial bioenergy feedstocks	• *Ensuring sustainability* – environmental, social and economic • *Safeguarding food security* – ensuring that increased demand for biofuels does not adversely affect the hungry (see below) • *Protecting biodiversity* - (see below) • *Managing competition for land and water* - (see below) • *Controlling pollution of air, water and soils* - (see below) • *Removing barriers to biomass and bioenergy trade* - (see below)

Bioenergy and Sustainability

GBEP is committed to promoting bioenergy for sustainable development. Bioenergy is a sustainable energy source only if its entire production chain – feedstock production, refining and conversion and end use practices are sustainable. Sustainability includes environmental, social and economic considerations.

Environmental Sustainability:

- ***Main environmental issues:*** the greatest attention has been devoted to environmental sustainability of bioenergy *feedstock production*. This primarily relates to the responsible use of agro-chemicals and fertilisers, waste management, prevention of soil erosion and depletion of soil nutrients, protection of biodiversity, reduction of greenhouse gas emissions, improvement of air quality, and the sustainable management of the quantity and quality of surface and ground water. Environmental issues in *refining, conversion and end use* are predominantly related to GHG emissions, air quality, and water quantity and quality.
- ***Biodiversity:*** Two major crops used in biodiesel production pose a threat rainforests. Soy bean plantations are encroaching on forests in Brazil and palm oil plantations threaten forests in Malaysia and Indonesia. The reduction in forest habitat directly threatens species that inhabit these unique environment and diminishes other important environmental services from forests. Concerns have also been raised that rapid biofuel growth and mono-cropping practices of preferred varieties will lead to a reduction in agricultural biodiversity with negative repercussions on food security. On the other hand, the use of perennial species such as trees for bioenergy may create more favourable habitats for biodiversity compared to conventional crop production.

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 bioenergy:

- ***Rural jobs and rural development:*** Bioenergy is the most labour intensive energy source. Depending on the scale of production (large scale plantations, or medium and small scale operations) and on the degree of mechanisation, new employment 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, 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 in gathering firewood and the danger from indoor air pollution. Bioenergy development and production methods should take into account differential impacts on men, women and children.
- ***Access to land and water:*** poor households in many developing countries do not have formal title over their land and formal 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 policy environments and government 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.

Bioenergy and Climate Change

Bioenergy offers significant potentials for emission reductions in electricity, heat and transportation. However, potentials 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 and 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:*** biomass combustion replacing coal and oil has significant reduction potentials.
- ***Biogas*** from organic waste not only reduces CO2 emissions compared to fossil fuels but also avoids methane emissions related to the decomposition of organic wastes.
- ***Emission reductions from liquid biofuels:*** the potential of reducing GHG emissions from liquid biofuels vary widely by region and technology. Of currently commercial technologies, Brazilian ethanol produces the largest savings – estimated to be up to 90% of GHG emissions compared to fossil fuels. Maize based ethanol production produces far lower savings, with estimates of

average reductions of around 13%.[1] 2nd generation biofuels, including cellulosic ethanol, are expected to produce significant GHG savings – possibly of up to 80%.

- ***Many opportunities for future GHG savings:*** The 4th Assessment Report of the Intergovernmental Panel on Climate Change presents key mitigation technologies and practices. Bioenergy technologies are highlighted for most sectors:
  - *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:* Current opportunities are biofuels for transport with current technologies; by 2030 second generation biofuels 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
  - *Waste:* Composting of organic waste and methane recovery.
- ***Land conversion from high carbon content land will eliminate GHG reduction potentials:*** Where bioenergy feedstocks replace high carbon storage land, such as virgin forests and peatlands, GHG balances will be negative.
- ***Key factors to ensure GHG emission reductions from bioenergy:*** To ensure emission reductions, the production chain must be managed carefully:
  - no conversion of high carbon content land for feedstock production;
  - use of agricultural practices that increase carbon sequestration below and above ground, minimise fertiliser use, and increase energy efficiency of mechanised operations;
  - energy efficiency in refining and conversion, utilising biomass residues for process heat where possible;
  - efficiency in end use applications – electricity, heat and transport.

Bioenergy and Food Security[2]

854 million people in this world suffer from hunger, and although the proportion of undernourished has declined over recent years, absolute figures have remained constant. Growth in bioenergy has repercussions on food security through two predominant channels: a) price effects in international markets and b) local factors related to specific production methods of bioenergy and the local context.

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 to 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

[1] Farrell et al, 2006: Ethanol Can Contribute to Energy and Environmental Goals, Science, Vol. 311. no. 5760, pp. 506 - 508

[2] based largely on J. Schmidhuber, 2007, Impact of an increased biomass use on agricultural markets, prices and food security: A longer-term perspective, FAO and on Nyberg, J and Raney, T, 2007, Bioenergy and Food Security – A concept Note, FAO, 2007

significant part of their household expenditure – in particular the urban poor and the poorest among the rural poor.

- ***Higher prices create new market opportunities:*** poor rural dwellers, including the food insecure, may benefit from new opportunities in biofuel development, either through increased and profitable own production, new employment opportunities in larger biofuel enterprises in rural areas and ancillary services and businesses, and if biofuel production is coupled with increase availability of local energy services, new business opportunities based upon improved energy infrastructure. The extent of opportunities will also depend upon the type of bioenergy and the production system – 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.

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

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

(-) negative impacts
(+) positive impacts

Bioenergy and Trade[3]

Trade in bioenergy and bioenergy feedstocks is currently low, but is poised to rise with increasing mandates for bioenergy use 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 (Europe, North America) where demand for biofuels is growing most.

- ***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.
- ***Bio-Ethanol*** features today as a very 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 position. International trade in ethanol has undergone strong expansion. Today, Brazil exports some 2.5 billion litres of ethanol and has an approximately 50 per cent 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 – a synthetic fuel produced from vegetable oils, animal fats or recycled cooking grease – 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 deployed 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

[3] based on contributions by Simonetta Zarilli, UNCTAD Biofuels Initiative.

plants and "flexi fuel" engines and vehicles - could be classified as environmental goods. Many 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, have hampered any conclusive result.

Bioenergy and Africa[4]

Africa, in particular Sub-Saharan Africa, depends predominantly on traditional bioenergy for basic energy services. The challenge in Africa is to move away from traditional bioenergy with its limitations and negative impacts. Modern bioenergy provides significant opportunities for sustainable development in Africa.

Africa is most reliant on traditional bioenergy – this poses many problems:

- ***Dependence on traditional bioenergy:*** Sub-Saharan Africa (SSA) depends on biomass to a far greater extent than other regions. Biomass accounts for a full 61% of primary energy consumption, and excluding South Africa this proportion is even higher at 71%. In some countries (for instance the Democratic Republic of Congo) over 95% of household fuel use is biomass from woodfuel or charcoal
- ***Indoor air pollution*** linked to traditional biomass use for cooking, counts among the major causes of death in the region (together with AIDS and malaria).
- ***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.

Africa has significant potential for modern bioenergy production

- ***Biomass productivity*** in tropical and sub-tropical climates is significantly higher (according to some estimates up to five times higher) than in temperate regions (Europe, North America). Sub-Saharan Africa is be the region with the largest bioenergy potential, once food production and resource constraints are accounted for.[5]
- ***Main biofuel crops*** currently developed in Africa are sugarcane, maize and cassava for bioethanol and oil palm, sunflower and soybean for biodiesel. Production is highly concentrated with South Africa the region's dominant producer of sugarcane and maize and DR Congo the dominant producer of cassava. Jatropha is widely regarded as a promising biodiesel feedstock that can grow on poor quality, even degraded, land and reduce erosion as well as produce energy. Trials are under way in several African countries, including Mali and Tanzania, to grow jatropha at commercial scales.
- ***Transition from traditional to modern bio-energy***, including ethanol and ethanol based gel-fuel is necessary and promising. Few countries in Sub-Saharan Africa have made substantial progress in developing modern bioenergy: South Africa passed a national biofuels strategy in early 2007, and is expected to expand production of maize and sugarcane crops to create ethanol and soybeans and sunflower for biodiesel. Malawi has fostered a sugar-based ethanol programme since the 1970s, and Mauritius has developed and employed efficient co-generation technologies linked to its large sugar industry. Ehtiopia has some ethanol production facilities. Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Mozambique, Niger, Senegal, Tanzania, Togo, and Zambia are among the countries that currently explore new opportunities in bioenergy. Use of modern and efficient bioenergy currently limited to industries where residues are available on-site as byproducts of processing – mostly sugar factories and timber mills.

Africa faces many challenges to realise its bioenergy potential

- ***Same old problems:*** The same factors that have held back agricultural growth will also plague bioenergy development: lack and poor quality of infrastructure (roads/transport, energy supply,

[4] Much of this section is based on Johnson, F and Rosillo-Calle, F, 2007, Biomass, Livelihoods and International Trade – Challenges and Opportunities for the EU and Southern Africa.

[5] Smeets et al., 2004, A quickscan of global bio-energy potentials to 2050, Copernicus Institute, The Netherlands.

telecommunications), limited human capital (knowledge and skills), weak institutions (public and private)

- ***Road transport costs*** are several times higher than the world average
- ***Competition for water*** is acute in many countries and regions, and particularly in Sub-Saharan Africa, hence the choice of feedstock is important. Biofuel crops with high water requirements, such as sugar, pose a significant threat to other water use(r)s. Alternative crops, including sweet sorghum, can reduce water needs by about half. Sweet sorghum is also drought resistant and has low nitrogen requirements. Jatropha is promising crop for biodiesel, it is drought resistant, can reduce soil erosion, and fix nitrogen in the soil. Cassava grows on poor soils and is drought resistant.
- ***Land use conflicts***, especially related to large scale feedstock production, could arise as the rural poor in Africa often do not have formal title or other secure tenure of their land and may be threatened by displacement. Further, so called "abandoned" lands that countries wish to reclaim through bioenergy development often provides some livelihood benefits to the most vulnerable living in the area, who may be prevented from continued utilisation if commercial bioenergy plantations are developed.
- ***Price impacts and food security:*** A recent review of South Africa's new biofuels strategy suggests that the envisaged blending targets for ethanol may lead to significant price rises in the main feedstocks, sugar and maize. This may have a significant impact on the food security of the poorest in rural and urban areas, who spend more than half their income on food. It also noted concerns that the strategy to utilise unused or underutilized land for feedstock production may displace those – very poor – who are currently relying on this land for parts of their livelihood.[6]

[6] Wahenga Brief, 2007, Nr 11. Biofuel Production and the Threat to South Africa's Food Security.