Bioenergy for Development in Africa

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Author: Peter Lindlein
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Executive Summary

To a great extent the energy sector in Africa reflects the development of the continent, or better said the lack of it: a heavy reliance on traditional resources (mainly unrefined biomass), a low level of energy infrastructure, poor levels of access to modern energy forms, with the exception of a few hotspots of dynamic development, making even more striking the continental, national and regional disparities. All this comes at a high economic cost, not only at the micro level, where poor households spend a significant proportion of their income on inadequate energy, but also at national levels as most of the countries have large and increasing imports of petroleum products. Thus, there are good reasons for action, for major investment for the development of the energy sector in general and for alternatives like bioenergy in particular.

Bioenergy is renewable energy made available from materials derived from biological sources and comprises biomass and biofuels. Biomass refers to the yet unrefined living and recently living biological material. Biofuels are fuels ready for use made available by processing biomass. Due to its wide base of possible raw material and different forms, the bioenergy sector has numerous linkages, making it a rather complex and extremely sensitive topic. Technologies for bioenergy are generally available and are developed further almost continuously. However, there are substantial differences in the costs, yields and results of these technical processes for the different types of biofuels, which make clear, that bioenergy is not a very homogenous sector, and that it is very important to be selective looking for favourable natural conditions as well as for optimization of the yields of techniques. There are substantial differences between the viability and present competitiveness of the different fuels depending on region, crop base, technology of processing and final product. The example of bioethanaol in Brazil suggests, that the potential for biofuels is particularly large in tropical countries, where high crop yields and lower costs for land and labour provide an economic advantage that is hard for countries in temperate regions to match.

Interest in modern bioenergy has been increasing. The demand for biofuels on a global scale will be affected by the energy demand of the global economy, aspects of energy security and prices of fossil fuels. Furthermore, in view of climate change Governments have set targets for the use of biofuels. Bioethanol production is rising rapidly in many parts of the world, especially in the USA. Total production of biodiesel worldwide remains small compared with that of ethanol. Either as inputs for processing plants or as refined biofuels, trade is likely to increase substantially. The production potential of land for biofuel production is theoretically huge, especially in Africa. The demand and supply approach of the IEA in its scenario 2030 makes clear, that even under rather conservative assumptions there will be a substantial increase of biofuels worldwide in the next decades. This is also valid for Sub-Sahara Africa, which however would make use only of a fraction of its theoretical potential, but would nevertheless need already a substantial amount for the corresponding investment.

From the African perspective there are several drivers to look for bioenergy as an alternative fuel: Diversification and substitution of fuel supply, access to energy for rural enterprises and development potential for rural areas and the agriculture sector and environmental aspects. Furthermore tThe increasing motorisation will pressure to look for alternative fuels in the bioenergy sector.

Several African countries currently have, or are planning to introduce, active biofuel policies, some of which date back to the 1970s. Although South Africa and Nigeria are considered among the most active in this field, the map is rapidly changing, as there is some kind of land rush in Africa. Experimental jatropha plantations are now popping up in virtually every corner of the continent. However, so far most ventures are still in the planting and growing stages; at present, the continent is producing almost no jatropha oil, as there is no feedstock available in major quantities due to the time lag between seeding and harvesting, but also due to some scepticism of farmers. Despite this scepticism, there are remarkable activities ongoing in various African countries (Ethanol production in Tanzania, Zambia, Mozambique, Zimbabwe and South Africa). South Africa, as well as the Democratic Republic of Congo, currently export already ethanol to the European Union. Thus, in general the perspectives for the African energy sector are commented with certain optimism, as biofuels are available in varied forms in abundance in almost every part of Africa, and if properly harnessed, can play a significant role in energizing Africa and cannot only help in combating the energy poverty but also assist in reducing the poverty by linking to productive uses.

Beside the usual bottlenecks of the framework conditions, the agricultural sector and the energy sector in the African countries, there are (additional) specific barriers for investment resulting from bioenergy characteristics and needs. On the supply side we find higher operating risks and development costs and the need for longer-term financing at reasonable rates for high initial cost. Further barriers are the competing of inputs uses creating pressure on the quantities and prices and the unclear energy policy in many countries as well a lack of proper financing.

Social and environmental aspects may represent a potential risk for bioenergy development in Africa. Increased food prices for the (urban) poor and decreased food availability, expansion of cropland on to sensitive areas and overstressed water supplies. The real impacts can be positive or negative depending on feedstock, management practices, land use change and process energy, to name just a few factors. This will require individual studies and further attention for each type of biofuel, project and investment. However, in general the competition for land use in terms of food production might be overstated, especially when taking into consideration the large reserve of potential arable land, but on the local level, the situation may be quite different. At the global level, there is clear evidence of sharp increases of prices for sugar and maize in line with the increasing production of biofuels, as well as with the increase in the price for crude oil. Agricultural prices will not rise faster than energy prices as bioenergy feedstock would price themselves out of the energy market. The increase in international agricultural prices through the global demand links will affect food prices in Africa, whether they will plant feedstock for biofuel or not. However, with the own production there would be additional supply for the world market taking away some price pressure. The environmental aspects of each project will require careful planning and assessment, to make sure that the potential benefits from the reduction of CO2 emission will not be offset by negative environmental impacts in the chain from feedstock production to biofuel use. Environmental research of standard feedstock and biofuels and the development of and agreement on environmental standards and minimum requirements would be of help in this matter. Key standards have been proposed as minimum requirements to minimise the impact of risks including: priority for food supply and food security, improvement of labor conditions and worker rights and ensuring a share of proceeds for the local population. The actual enforcement and practical relevance of such standards may have limited chances, if not elaborated and agreed soon, taking into consideration the ongoing dynamic investments in the sector, which are creating facts and actual norms for later entering potentials competitors.

Existing gaps and deficiencies (knowledge, funds, experience, policy) justify and ask for support by development cooperation, despite all the ongoing commercial activities in this field. The goal of the hereby proposed initiative of the G8-member group is to contribute to the creation of such conditions in the bioenergy market, which fulfil environmental and social standards, thus contributing to the sustainable (rural) development. By the supply of financial funds for financing of innovation and investment financing, the G8-member states could take some influence on the development of the market conditions. The political decision makers of the partner countries and regional organizations should be supported to create an appropriate organization and set of rules for the fast developing market of bioenergy (Technical Cooperation).

1 Africa – Energy Overview

To a great extent the **energy sector** in Africa reflects the **development** of the continent, or better said the lack of it. In general it is characterised by

- a heavy reliance on traditional resources, mainly unrefined biomass,
- a low level of energy infrastructure, despite a substantial potential in energy resources,
- poor levels of access to modern energy forms
- with the exception of a few hotspots of dynamic development, making even more striking the continental, national and regional disparities.

as the following indicators illustrate:

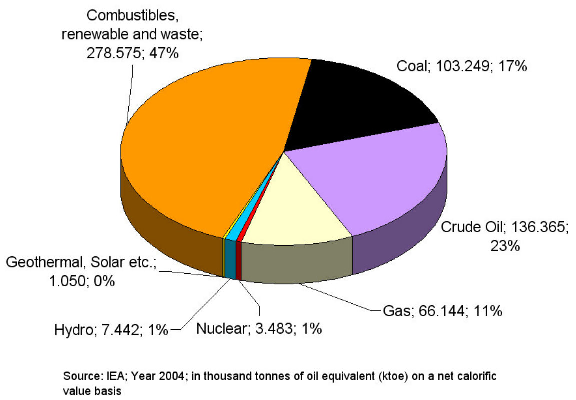
Region	Traditional fuel consumption* (% of total energy requirements)	Electricity consumption per capita (kWh/yr)	GDP per unit of energy use (2000 PPP US$ per kg of oil equivalent)
Developing Countries	26.3	1157	4.7
Sub- Saharan Africa	81.2	522	2.7
OECD	4.6	8777	5.3
World	21.7	2490	4.7

UNDP Human Development Report 2006
* Estimated consumption of fuel wood, charcoal, bagasse (sugar cane waste) and animal and vegetable wastes.

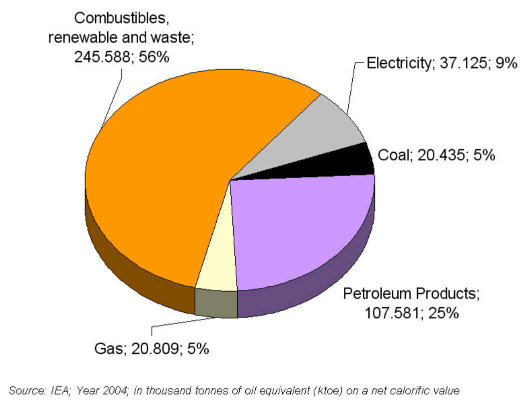
Figures from the continental **energy balance** for Africa underline the heavy reliance on traditional biomass and fossil fuels in the primary energy supply as well as in the total final consumption (Source IEA):

Africa: Supply and Consumption of Energy

Total Primary Energy Supply



Total Final Consumption of Energy

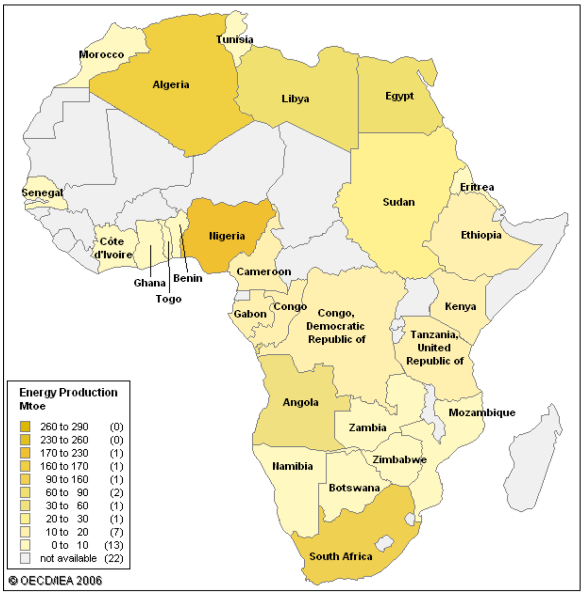


African commercial energy production grew substantially in the last decades, especially in coal and gas. However, African commercial energy production and its growth are distributed very unevenly throughout the continent. North Africa is rich in oil and gas; South Africa has huge coal reserves and but the sub-Saharan Africa is still largely reliant on biomass.

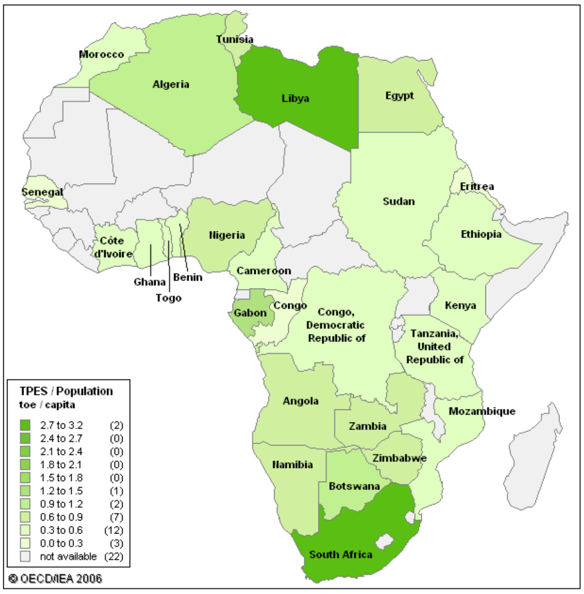
Thus, total and average figures hide much **diversified national realities** in the countries, as the maps of the energy situation illustrate:

Africa – Energy Situation

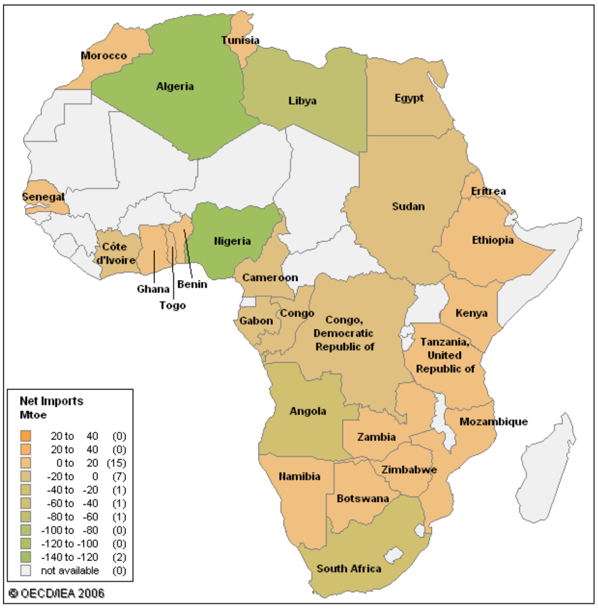
Energy Production



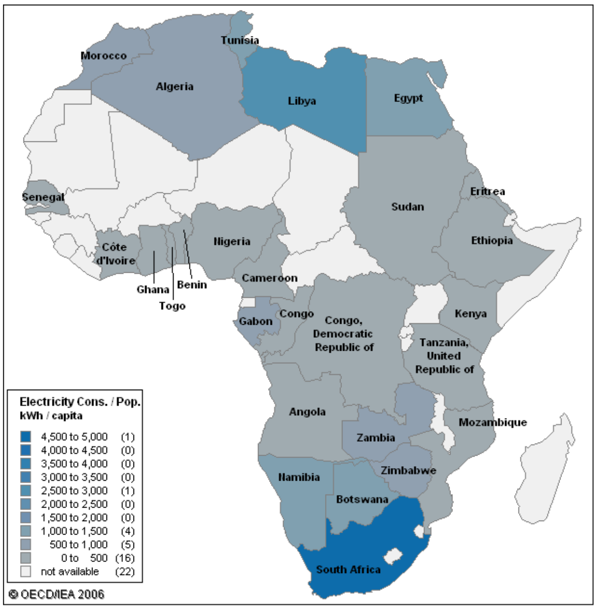
Energy Production per capita



Net Imports of Energy

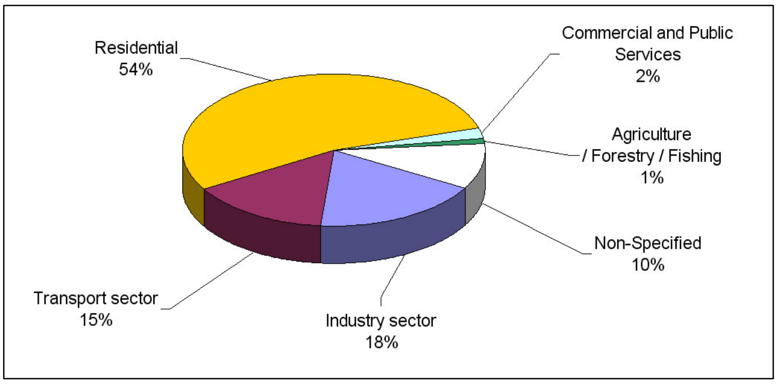


Electricity Consumption per capita



Sources: OECD, IEA 2006

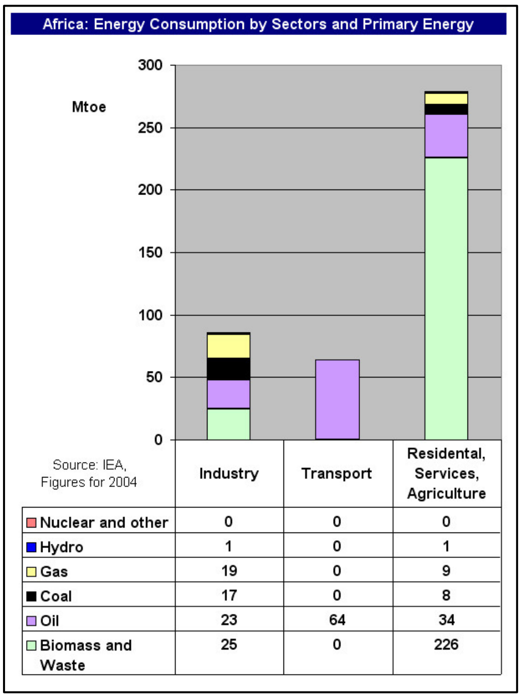
But even within the countries there are substantial regional and sectoral **disparities**, between the urban and the rural regions, the modern and traditional sectors. Thus, even in the oil-rich Nigeria, almost 97% of the household energy needs are met by biomass (IEA, 2001). The power sector in Africa is similar to other industries, being still in the early stages of development, since only 34.3% of Africans have access to electricity and only 16.9% of those who live in rural areas are connected to power grids (IEA 2005). However, the latter is average figure for a wide sample ranging from 0.2% in Ethiopia over 1% in Tanzania to 50% in South Africa and 100% in Mauritius (Source AFREPEN 2002).



Thus, **traditional biomass**, mainly fuelwood and charcoal, is by far the most significant fuel for households in Sub-Saharan Africa. With the exception of South Africa, biomass accounts for over 70% of total primary energy consumption of households. And due to the limited development of the industrial and the transport sector, **households** are the **main energy consumers** in Africa.

This is one of the reasons for the still **low productive use of energy** in Africa, whose energy intensity per unit of GDP (in Purchase power parities) is 40% above the world average.

There are several main reasons for the **gap** in modern energy and the high use of "non-commercial" fuels in Africa. The lack of funds for investment, inadequate framework conditions, incoherent energy policy and widespread poverty considered as the main **reasons**. This gap of reliable and affordable energy still holds back African economic development, in particular for special target groups of development promotional policy like rural population and MSME. The present use of traditional biomass as fuel is neither ecological sound nor healthy and has severe economic and social consequences with casualties from respiratory diseases from indoor pollution.



And even this insufficient level of energy supply comes at a high economic **cost**, not only at the micro level, where poor households spend a significant proportion of their income on inadequate energy, but also at national levels as most of the countries have large and increasing imports of petroleum products, which account for significant proportions of export earnings (an average of 20-40% for non-oil exporting sub-Saharan African countries). The transport sector is the major consumer of oil accounting for 53% of total consumption, putting renewable fuels also on Africa's own agenda. Thus, there are good reasons for action, for major investment for the **development of the energy sector** in general and for alternatives like bioenergy in particular.

After substantial **ODA** for **investment** in the energy sector in Africa with annually more than US-$ 1 billion in the 1970s and 1980, with the change in development policy and priorities ODA funds were reduced drastically in the 1990s. Only in recent years, there is a substantial increase also due to the commitments of China, whose dynamic activities in oil-rich African countries like Sudan, Angola and Nigeria make it now also a major **FDI** player in the African energy sector. And within the recent **rush to Africa's energy resources**, at the end of 2006 the Indian government announced to give US$250 million towards a fund to boost biofuel production in 15 West African countries.

2 Bioenergy – Overview

2.1 Types of Bioenergy

Fossil fuels and biomass, both are store of solar energy. However, there is substantial difference. At present, each year the world consumes the quantities of fossil fuels, which were formed in about a million years. In economic terms this means living of the capital stock, which is a limited approach. In contrast bioenergy would make use of a part of the annually solar energy transformed by plants, i.e. using the energy income of the planet.

However, although being a renewable energy approach, the label 'bio' may be misleading, as plant based energy is not ecological sound per se. The term phytogenic energy may be more correct.

Unfortunately, the terms bioenergy, biomass and biofuels are not uniformly defined, and used for different concepts and forms of energy. For the purpose of this study we use the following concept:

Bioenergy is renewable energy made available from materials derived from biological sources and comprises biomass and biofuels

Biomass refers to the yet unrefined living and recently living biological material, which can be used as fuel or for industrial production. It excludes organic material which has been transformed by geological processes into substances such as coal or petroleum.

Biofuels are fuels ready for use made available by processing biomass, i.e. from materials derived from biological sources. Biofuels come in different aggregate states and forms.

		Bioenergy		
Biomass		➲ being processed to		
⇩	⇩ being processed to	**Biofuels**		
Traditional	**(Co-) generation**	**Gaseous Biofuel**	**Solid Biofuels**	**Liquid Biofuels**
❍ Dung ❍ Wood	❍ (Bio-)heat (Steam) ❍ (Bio-)electricity	❍ Hydrogen ❍ (Domestic) Biogas (Methane)	❍ Charcoal ❍ Pellets ❍ Wood Chips ❍ Saw Mill Dust ❍ Briquettes ❍ Agricultural Residues	❍ Ethanol ❍ Methanol ❍ Biodiesel ❍ Vegetable oils

However, in line with the topic and focus of this study we use the term 'biofuel' as a short term for 'liquid biofuels" if not otherwise specified.

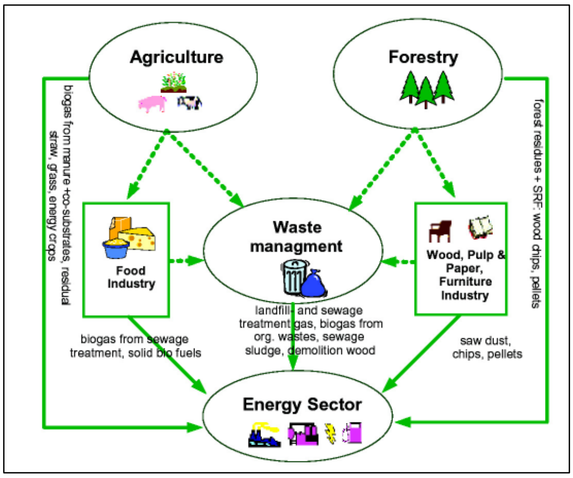
As the technological process has advanced from conventional biofuels to second generation biofuels the variety of biofuels and the corresponding terms has increased further with the different types and more terms. The following table provides an overview of liquid and gaseous biofuels and the feedstock and processes used in their production.

Overview of liquid and gaseous biofuels			
First generation (conventional) biofuels			
Biofuel type	**Specific names**	**Biomass feedstock**	**Production process**
Bioethanol	Conventional bioethanol	Sugar beet, grains, corn	Hydrolysis & fermentation
Vegetable oil	Pure plant oil (PPO)	Oil crops (e.g. rape seed)	Cold pressing/extraction
Biodiesel	Biodiesel from energy crops Rape seed methyl ester (RME), fatty acid methyl/ethyl ester (FAME/FAEE)	Oil crops (e.g. rape seed, jatropha)	Cold pressing/extraction & transesterification
Biodiesel	Biodiesel from waste FAME/FAEE	Waste / cooking oil / animal fat	Transesterification
Biogas	Upgraded biogas	(Wet) biomass	Digestion
Bio-ETBE		Bioethanol	Chemical synthesis
Second generation biofuels			
Biofuel type	**Specific names**	**Biomass feedstock**	**Production process**
Bioethanol	Cellulosic bioethanol	Lignocellulosic material	Advanced hydrolysis & fermentation
Synthetic biofuels	Biomass-to-liquids (BTL): ❍ Fischer-Tropsch (FT) diesel ❍ Synthetic (bio)diesel ❍ Biomethanol ❍ Heavier (mixed) alcohols ❍ Biodimethylether (Bio-DME)	Lignocellulosic material	Gasification & synthesis
Biodiesel	Hydro-treated biodiesel	Vegetable oils and animal fat	Hydro-treatment
Biogas	SNG (Synthetic Natural Gas)	Lignocellulosic material	Gasification & synthesis
Biohydrogen		Lignocellulosic material	Gasification & synthesis or Biological process
Source: Biofuels in the European Union, A vision for 2030 and beyond.			

Simplifying the matrix, first generation biofuels use mainly crops, as second generation biofuels can be made of lignocellulosic material, i.e. composed primarily by lignin and cellulose. Examples of lignocellulosic are all types of trees, grasses, agricultural residues such as corn stover, sugarcane bagasse, straw, etc, which uses crop residues and organic waste streams from agriculture and forestry. This would not only widen extremely the feedstock base for biofuels development, but avoid to a great extent resource competition with food production.

2.2 Sectoral Insertion

Due to its wide base of possible raw material and different forms, the bioenergy sector[1] has numerous linkages, making it a rather complex and extremely sensitive topic, with a very broad set of factor to consider for a strategy and a promotional approach. It involves and/or affects agriculture and forestry, various processing industries like food industry, wood, paper and furniture industry, the automobile industry, machine building, the waste management system, the energy sector in almost all its different types and the transport sector.



2.3 Technology

Technologies for bioenergy are generally available and are developed further almost continuously, as they are receiving support in the industrialized countries from the public and private sector for research and innovation. For example[2]:

- Combustion. Has achieved commercial reliability and maturity for a variety of feedstock and sizes of application in the forest products industry and for waste incineration. Work is still needed for small-scale combustion for heating applications.
- Gasification. Significant progress has been made, but further development is needed to reach commercial maturity. Second generation biofuels via the gas synthesis route have provided a new impetus.
- Pyrolysis. Fast progress has been made, but industrial applications and technology reliability are still limited. This could be considered a pre-treatment step for biomass trade.
- Anaerobic digestion. Very successful and commercially viable. Biogas purification to biomethane has opened up new opportunities in the transport sector.

Although, the techniques generally are developed to a technical viability and maturity, there most of it refers to raw material available in industrial countries. They may be substantial room for optimization in techniques to produce bioenergy on the base of other tropical plants than sugar.

In general, the some of most ecologically most interesting types of biofuels are still in their early stages of commercial application and will need further development. Ethanol can be produced through sugar-, starch-, or lignocellulosic-based platforms. Lignocellulosic biomass comprises the bulk of agricultural and forest residues potentially available for bioconversion processes. The conversion of lignocellulosics, i.e. anything from the plant, even what it now considered as waste, is the most challenging, as it requires the hydrolysis and fermentation of polymers derived from five sugars (glucose, galactose, mannose, xylose, arabinose), whereas starch processing requires the hydrolysis and fermentation of a single sugar (glucose). But the status of enzymatic bioconversion of lignocellulosics to sugars is only slightly short of active commercialization. Utilizing lignocellulosics ensures that future operations can expand to areas not currently serviced by existing, starch-dependent facilities. This will increase the potential of bio-based ethanol to improve security of future fuel supplies.

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[1] Source of graphic: Fritsche, Uwe R. – Sustainable Biofuels: Environmental Considerations, 2006

[2] Source: 'Bioenergy: a complex matrix, full of opportunities and dependent on policy instruments' by the Chairman of IEA Bioenergy, Dr Kyriakos Maniatis. Paris, 2005

Furthermore, there are substantial differences in the costs, yields and results of these technical processes for the different types of biofuels, which make clear, that **bioenergy is not a very homogenous sector**, and that it is very important to be **selective l**ooking for favourable natural conditions as well as for optimization of the yields of techniques.

2.4 Key Factors, strength and weaknesses

The wide range of the result of the use of the current technology is illustrated in a comparison of the key characteristics and factors of the different biofuels:

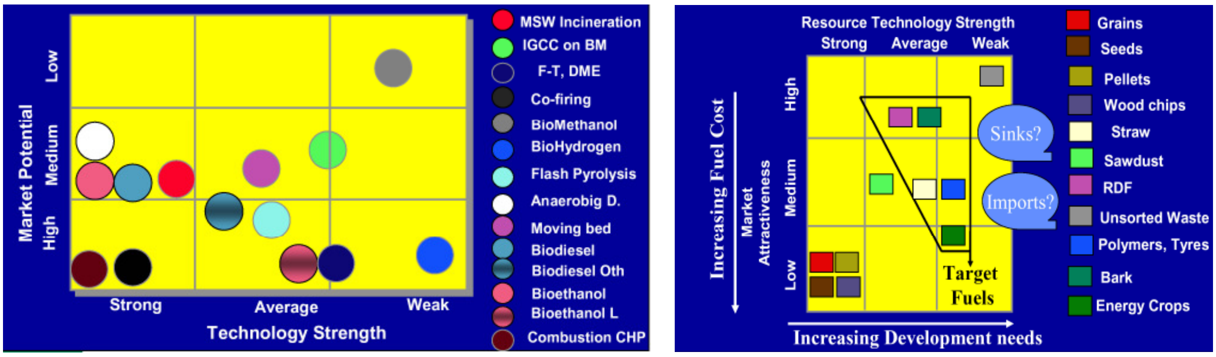
Biofuel: Comparison of key factors						
Biofuel	Vegetable Oil	Biodiesel	Bioethanol (Brazil)	Bioethanol (US, EU)	Methane from biogas	Synthetic biofuels (BtL)
Raw materials:	Rapeseed oil (and other non-drying vegetable oils)	Rapeseed oil (and other non-drying vegetable oils)	Sugar	Grain	Maize and other energy-producing plants, manure and organic waste	Energy-producing plants and wood
Annual yield per hectare (litre Fuel equivalent)	1420	1408	4054	1660	4977	3907
Cost Price (EUR/litre fuel equivalent)	0.51	0.69	0.31	0.72	0.74	1.03
Cost difference to fossil fuels (EUR/l)*	+0.19	+0.37	-0.10	+0.51	+0.44	+0.70
CO2-reduction**	> 80 %	Approx. 70 %	70%	30 %	Not specified	> 90 %
Technical information	can also be used in native, unchanged form in specially refitted diesel engines	Biodiesel in pure form: manufacturer's approval required; mixtures up to 5 % without refitting the engine	Can be used mixed or for special engines up to 100%	Can be mixed with fuel by up to 5 %	Biomethane can be used in natural gas vehicles without adjustments	Can be used in pure form or in mixtures without adjustment of the engine
Technical Status	Niche; Technical Problems	Standard; Mature Processing Technique	Standard; Mature Processing Technique	Standard; Mature Processing Technique		No commercial production and utilisation yet

Compiled from: FNR – Biokraftstoffe – Eine vergleichende Analyse, 2006; FNR – Biofuels: Plants, Raw Materials Products, 2006, meo consulting team and other sources

** based on 50$ barrel oil; ** in % of the substituted fossil fuel*

An overview of the market potential and technological strength illustrate the wide range actual conditions, the market potential and the development needs of the bioenergy sector.

Biofuels: Market Potential, Technology Strength and Development Needs



Source: Maniatis, Kyriakos - Bioenergy: a complex matrix, full of opportunities – and dependent on policy instruments, EC DGET

Obviously there are some substantial difference between the **viability** and present **competitiveness** of the different fuels depending on region, crop base, technology of processing and final product. Although first generation biofuels had rather mixed results in the northern regions, the case of Bioethanol production on the base of sugar with its high yield and low cost demonstrates that certain types of biofuels can be commercially viable under favourable production conditions, which are given in tropic zones already at an oil price of about US-$ 50 per barrel. Other types of biofuels are not yet competitive, but would be so at an oil price of US$/b 90 or beyond. Their already familiar use in the US and Europe is a result of policy mix of subsidies and mandatory mix with fossil fuels, justified with reference to CO2 reduction potential, which at least for the bioethanol production in the US is controversial because of the rather limited net energy balance of its production.

➲ However, the example of bioethanaol in Brazil suggest, that the **potential for biofuels is particularly large in tropical countries**, where high crop yields and lower costs for land and labour—which dominate the cost of these fuels— provide an **economic advantage** that is hard for countries in temperate regions to match.[3]

2.5 Bioenergy in a global economy – Drivers for demand

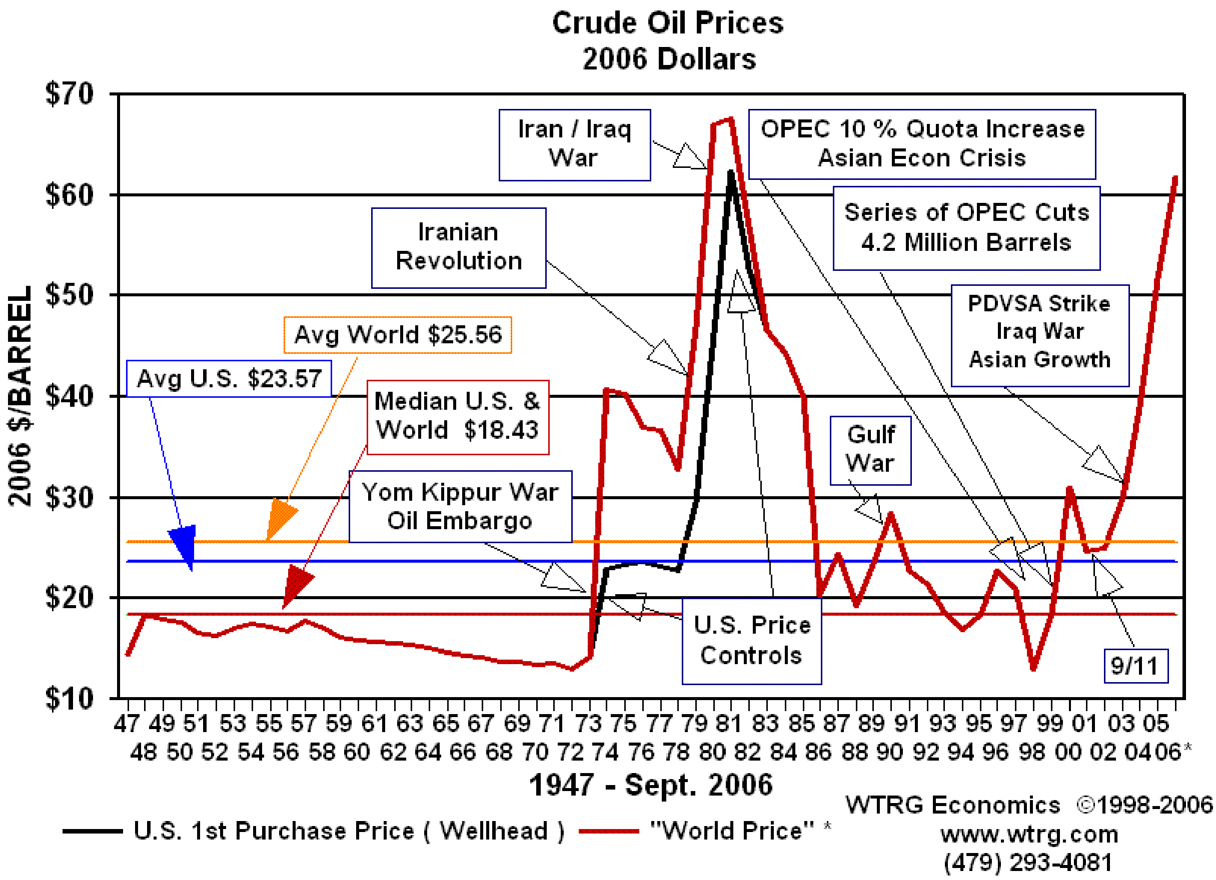
After being dormant for many years, interest in **modern bioenergy** has been increasing worldwide with the increase of the price in fossil fuels like oil and coal in the world market. In many countries, less developed as well as industrialized, it has become a **centrepiece of renewable energy plans** and policies because of its many possible practical, social and economic advantages. Some consider modern bioenergy as an important player in the global transition to a low carbon energy future, which is needed to reduce human induced climate change.

There are numerous and important activities, which will affect the demand for biofuels on a global scale, particularly:

1. **Energy demand of the global economy**: although the energy intensity of the growth of the industrialized countries is decreasing, the process still requires a lot of energy. But what will contribute especially to the demand for biofuels are the energy needs of the China and India, both having an extremely energy-intensive type of growth, which will further increase the demand for fossil fuels and directly as indirectly also for biofuel.
2. **Energy security and prices of fossil fuels**: The political situation in the last decades, and especially in the last few years, showed, that there may be the risk of difficulties in the access to crude

[3] WWI/GTZ/FNR – Biofuels for transportation, Washington 2006

oil, at least at a certain price level. The extreme volatility of the crude oil price exposed the risk of economic crisis and shocks due to the high dependency on a single fuel. Thus, any proper policy would aim to reduce this risk by developing alternatives already within an approach of diversification if not substitution. Furthermore the price of crude oil and its projections is shifting the level of competitiveness of the biofuels, making them commercially attractive.

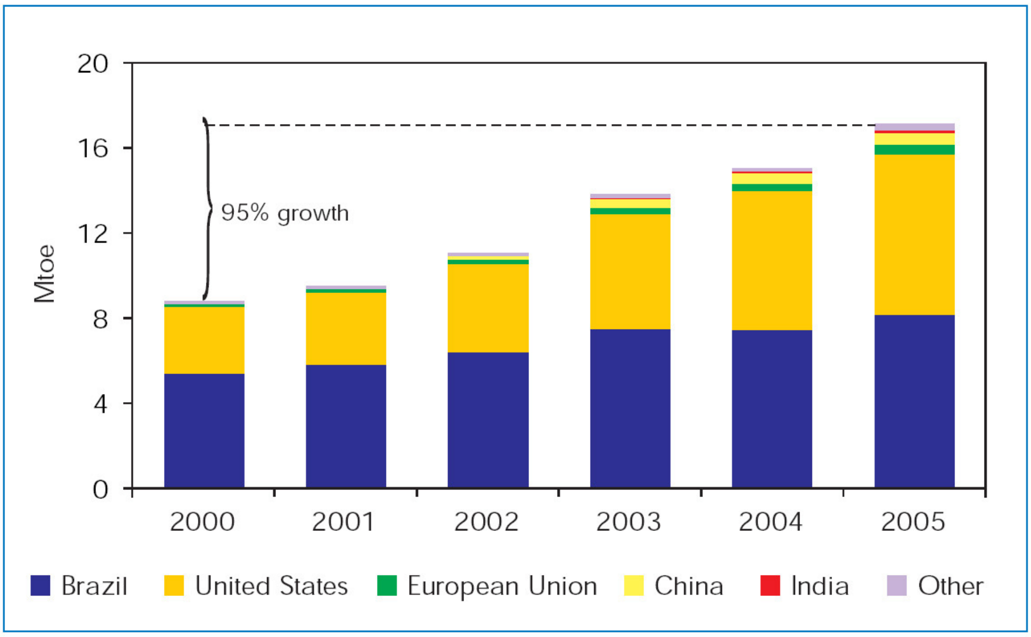


3. **Climate change and ecological aspect -Targets for biofuels**:
   - EU: After targeting 5.75% of motor fuel use by 2010, EU energy ministers have agreed in February 2007 to increase the share of biofuels used in transport to 10% by 2020. The question of whether the renewables target should be mandatory will be decided by EU leaders next month.
   - US: legislation still pending that could increase ethanol use by 2010 to around 5% of gasoline; strong price incentives already in place The Bush plan (Twenty by ten), presented in January 2007, to reduce the country's use of gasoline by 20 percent in the next decade, by promoting alternative fuel sources and increased fuel efficiency standards for automobiles, calls for a 500 percent increase of biofuels by setting a mandatory fuels standard of 132.5 billion litres (35 billion gallons) in 2017.
   - China, already the world's third largest ethanol producer, is planning on a dramatic expansion of its production and use of biofuels for transportation from about 1 million tonnes of ethanol and biodiesel in 2005 to 12 million tonnes in 2020. Twelve million tonnes of biofuels would represent about 15% of the transportation fuel pool in 2020. Probably, it will need to import feedstock at a greater scale.
4. **Technological Change** – The development and market penetration of fuel flex cars could give a boost to the demand for biofuels.

2.6 Global Situation and Perspective

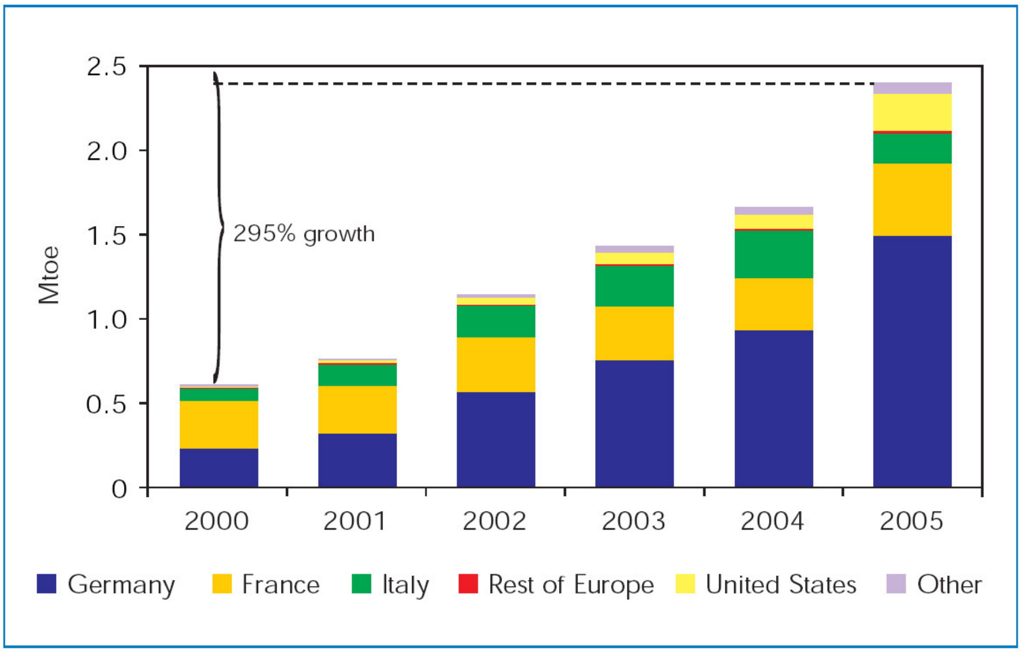
2.6.1 Present Situation

Bioethanol production is rising rapidly in many parts of the world in response to higher oil prices, which are making ethanol more competitive, especially where reinforced by government incentives and rules on fuel specifications. Global production reached 17.1 Mtoe (579 kb/d) in 2005, almost double the level of 2000. (IEA,2006). The United States accounted for much of the increase in output over that period. In most cases, virtually all the ethanol produced is consumed domestically, though trade is growing rapidly.



Source: IEA analysis based on F.O.Lichts (2006).

Total production of **biodiesel** worldwide remains small compared with that of ethanol, amounting to about 2.9 Mtoe (64 kb/d) in 2005. Close to 90% is produced and consumed in Europe. Germany and France are the biggest producers.

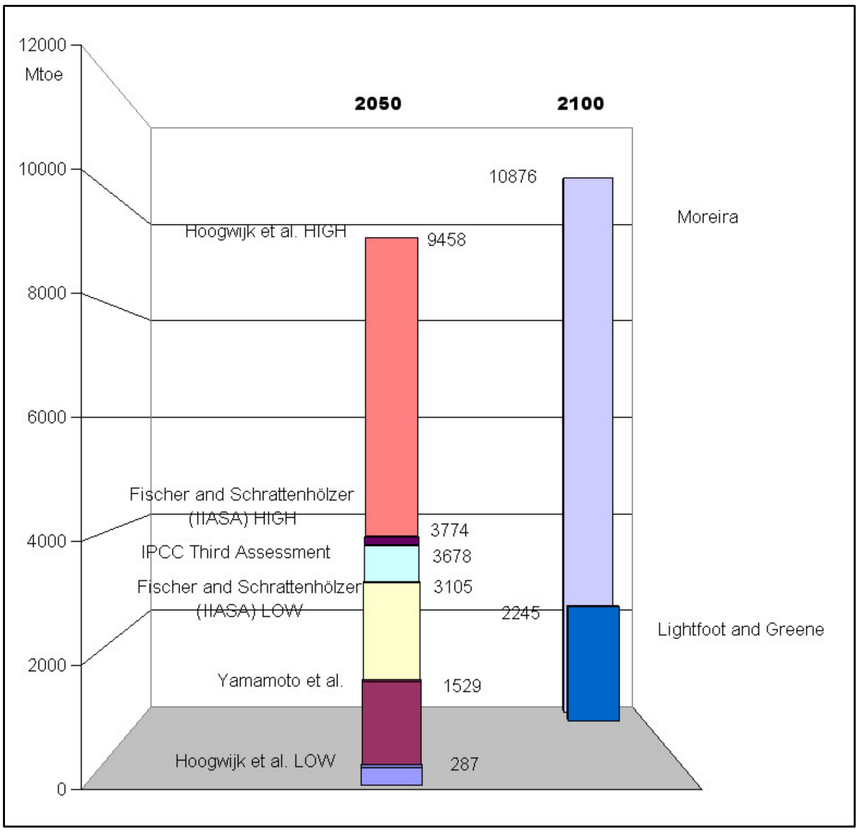


Source: F.O.Licht (2006).

At present, most of the produced biofuels are consumed nationally. However, many of the countries that consume large quantities of transportation fuels have limited land available for producing biomass feedstock, which leaves them unable to produce more than a fraction of their transportation fuels from domestic biomass (WWI/GTZ 2006). Thus, already at present some developing countries are producing the vegetable oil for biodiesel processing in the industrial countries, because the yields in industrialized countries are only covering the inputs for a part of the already installed capacities, e.g. in Germany rape yield are only serving 50% of the inputs of 3 Mio for the full installed capacity of bio-diesel plants.

Either as inputs for processing plants or as refined biofuels, **trade** is likely to increase substantially, also as ongoing negotiations at the WTO negotiations aiming at liberalizing trade in agricultural commodities are likely to spur the move to freer trade in biofuels.

2.6.2 Scenarios – A wide range of possibilities



The **potential** of bioenergy is huge. Based on an **agricultural potential approach** various studies made calculations of the bioenergy potential of the world and its regions. However, as such estimates of land use and yield depend on a rather large set of multiplying factors, the estimates of the potential are rather sensitive. The results vary between 287 Mtoe and 10876 Mtoe, depending on the assumptions the potential would be between the double of the current total energy demand and a fraction of it (see graphic[4]). Due to their high hypothetical content in the assumptions, which are going well beyond the bioenergy sector and assume extreme changes in any kind of land management, agriculture and forestry, thee results seem to be more of illustrative use than as elements of a market study.

A similar approach is presented by Smeets et. al. and frequently shown in presentations on biofuels. In their approach, the potential for biofuels would benefit from improvements of food production by best available techniques, which set free agricultural land for bioenergy production. The total bioenergy production from these surplus and other factors areas ranges between 685 Mtoe to 3400 Mtoe. The total potential for bioenergy production (bioenergy from bioenergy crops and agricultural residues) in the different regions within four different scenarios is shown in the following table[5] (units EJ-1).

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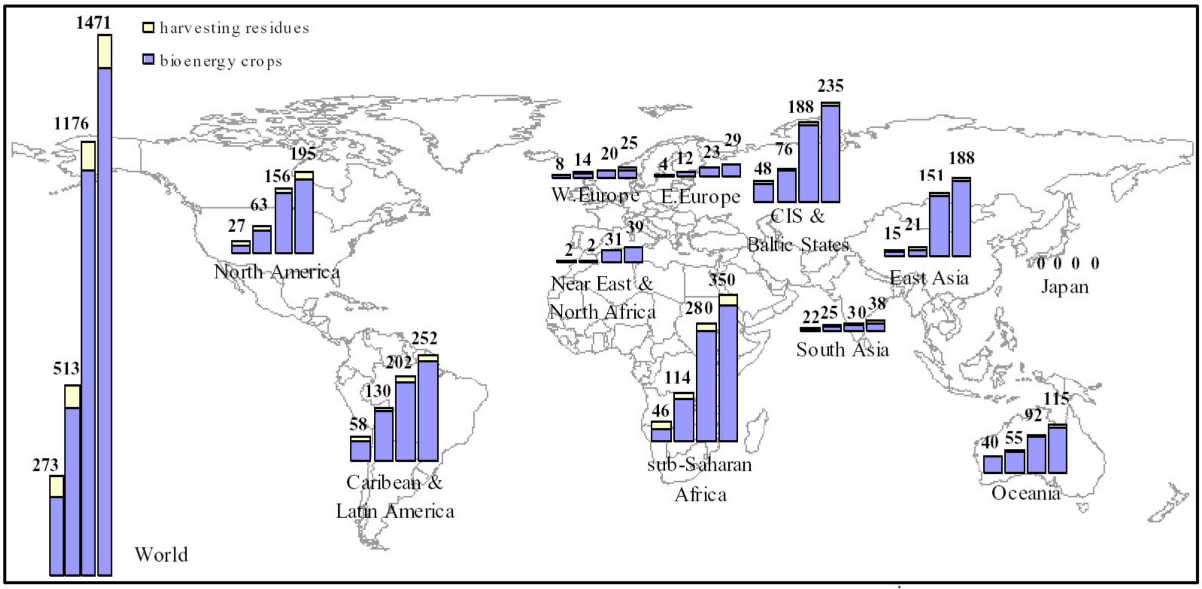
[4] Own calculation and graphic based on compilation in: Fulton, L., Howes, T., and Hardy, J. (2004). Biofuels for Transport: An International Perspective, International Energy Agency, Chirat)

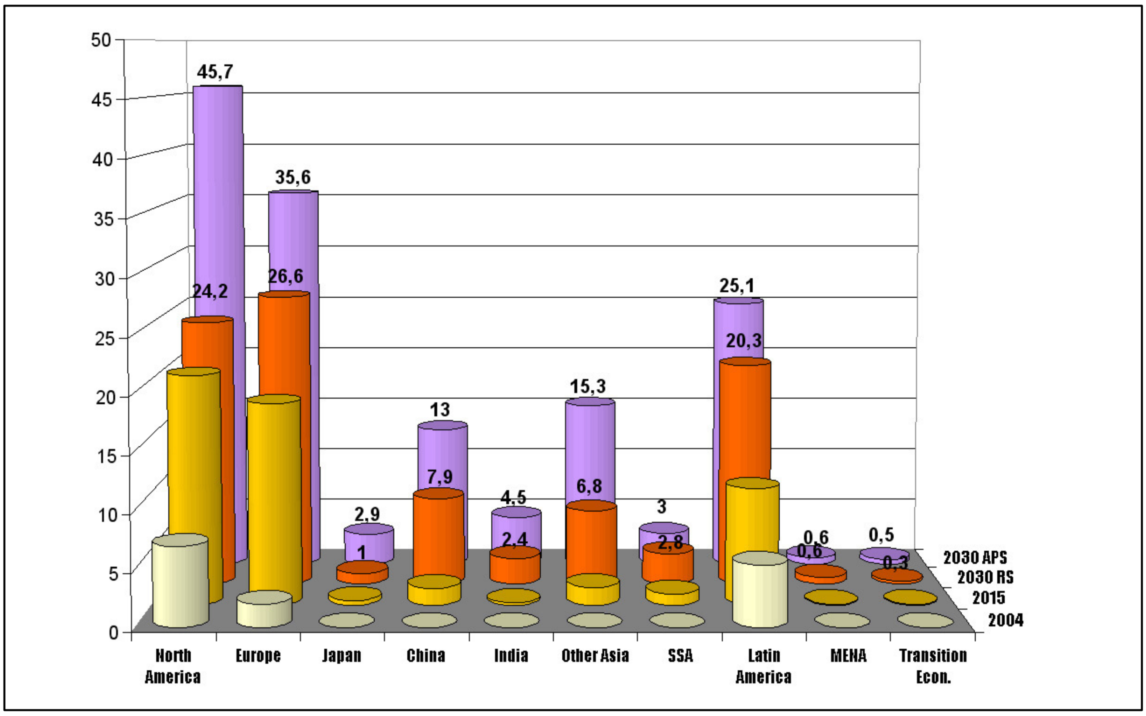
[5] Source: Smeets, Edward et. al . - A quickscan of global bio-energy potentials to 2050 An analysis of the regional availability of biomass resources for export in relation to the underlying factors, March 2004 (units in the original table are in EJ-1 and have been converted for comparison reasons in this text in Mtoe)



According to this scenario **Sub-Sahara Africa** has the **highest potential** for the production of biofuels with an annual additional quantity ranging from 109 Mtoe to 835 Mtoe.

In contrast the IEA is using an **energy-market-approach** in its energy **demand and supply** scenario 2030 presented in the World Energy Outlook 2006, which includes biofuels. The IEA is making rather conservative assumptions (limited technical progress, no second-generation biofuel technologies, such as ligno-cellulosic ethanol or biomass gasification, are assumed not to penetrate the market on a broader base), to calculate the demand and thus production of biofuels:

- In this **Reference Scenario** 2030 of the IEA (2006), existing biofuels policies are assumed to remain in place. Biofuels meet 4% of world road-transport fuel demand by the end of the projection period in 2030, up from 1% today. The total world production of biofuels is projected to climb from 20 Mtoe in 2005 to 54 Mtoe in 2015 and 92 Mtoe in **2030**. This would be only a third of lowest calculated production potential figures for 2050 presented in above in the agricultural based approaches for biofuels (see above under Hoogwijk 287 Mtoe).



- In the IEA scenario the average annual rate of growth is 6.3%. On a global scale biofuel would only account for 4% of transport fuels by 2030. To meet this demand, cumulative **investment** in biorefineries of $160 billion (in year-2005 dollars) over 2005-2030 is needed.
- The bulk of the biofuels consumed in each region will continue to be produced indigenously, as a result of protective farm and trade policies, although biofuels trade is expected to grow significantly. Most exports will probably take the form of ethanol derived from sugar cane, being the most competitive. Some African countries have ethanol production costs close to those of Brazil and may emerge as significant exporters in the coming decades, depending on domestic requirements and trade policies. Within the scenario, total biofuels use in **Africa** is nonetheless expected to remain small on global scale in 2030, reaching 3.4 Mtoe. This would only be the equivalent of 3% of the agricultural production potential of biofuels calculated by Smeets et.al. for 2050. However, according to the IEA calculation biofuels in Africa would contribute only some 2% of the projected total consumption of transport fuels in Africa. However, this modest level would already require some US-$ 7 billion of investment.

In the **Alternative Policy Scenario**, new policy measures to encourage the production and use of biofuels, which are now being considered by governments around the world, are taken into account. In the Alternative Policy Scenario, the share reaches 7% and production rises much faster, at 8.3% per year reaching 73 Mtoe already in 2015 and 147 Mtoe in 2030, i.e. about half of the minimal calculated potential production (Hoogwiik 287 Mtoe). Worldwide cumulative investment would amount to $225 billion over the period. However, this scenario has not taken into consideration the ambitious new biofuel target of the US, EU and China.

What are the **preliminary conclusions** from these scenarios?

- The production **potential** of land for biofuel production is theoretically huge, especially in Africa. To make use of this, a full set of challenging assumptions would to be met, including extremely productive land use and agricultural management, i.e. factors which are not globally spread nowadays.
- However, the size of the calculated scenario values suggest, that **land** itself may **not be the limit** on a global scale.
- The demand and supply approach of the IEA in its scenario 2030 makes clear, that even under rather conservative assumptions there will be a **substantial increase of biofuels worldwide** in the next decades.
- This is also valid for **Sub-Sahara Africa**, which however would make use only of a fraction of its theoretical potential, but would nevertheless need already a substantial amount for the corresponding investment.

3 Role of Bioenergy in Africa – A Market Overview

3.1 Drivers

From the African perspective there are several **drivers to look for bioenergy** as an alternative fuel:

Energy	Economic	Environmental
❍ Diversification/Substitution/ Security of fuel supply ((even in Nigeria, export crude and is said to import refined therefore reliant on imports) ❍ Diversification of domestic energy supply ❍ Access to energy for rural enterprises	❍ High fuel prices (forex, balance of payment) ❍ Export reductions under the EU Preferential Trade Agreement ❍ Development potential for rural areas (Infrastructure, Job-creation, Poverty reduction, Income generation) ❍ Stimulation and diversification of agriculture sector (by creating new markets) ❍ Competitive and volatile sugar markets	❍ Need to take action on climate change and reduction of Green house gases ❍ Africa Dakar Declaration on phasing out lead ❍ Improvements in air quality ❍ CDM?

The transport sector in Africa is currently consuming Mtoe 64 per year, showing an annual increase of 2,7% which will rise to 2.9% in the future, demonstrating the increasing motorisation of the continent. At present this represents 15% of the total final consumption of energy, but this ratio is likely to increase under prevailing conditions to 21% in 2030. This will increase the pressure to look for alternative fuels in the bioenergy sector.

3.2 Biofuel Production, Projects and Investment in Africa

Several African countries currently have, or are planning to introduce, active biofuel policies, some of which date back to the 1970s. The map shows the African countries with **considerable bioenergy activities** in the form of investments and projects as well as policy and programme at present. Although South Africa and Nigeria are considered among the most active in this field, the map is rapidly changing, as there is some kind of land rush in Africa.

Experimental **jatropha plantations** are now popping up in virtually every corner of the continent, from Kenya, to Ghana, to South Africa. It's difficult to say how much African land is currently being cultivated with jatropha, but there are fields in Benin, Mali, Senegal and Nigeria, and a foreign investor (D1 Oils) has an option for 990,000 hectares in Burkina Faso.

Norwegian, Indian and British companies are racing to buy up or lease enormous swaths of African land for jatropha plantations. U.K.-based D1 Oils has bought 20,000 hectares in Malawi and 15,000 hectares in Zambia. Hemscott.com reports that D1 Oils PLC signed an agreement with the Kingdom of Swaziland for 20,000 hectares of jatropha to be planted to make biofuel. Their agreement plans for up to 50,000 more hectares of jatropha. D1 Oils also signed a memo with World Vision for 3,000 more hectares to be planted in Swaziland. India's IKF Tech has requested government leases for a total of 150,000 hectares of land in Swaziland, Mozambique and South Africa. Worldwide Bio Refineries, a U.K. firm, has 40,000 hectares set aside for production in Nigeria, with planting to begin in May 2007. However, so far most ventures are still in the planting and growing stages; at present, the continent is producing almost no jatropha oil, as there is no feedstock available in major quantities due to the time lag between seeding and harvesting, but also due to some scepticism of farmers.[6]

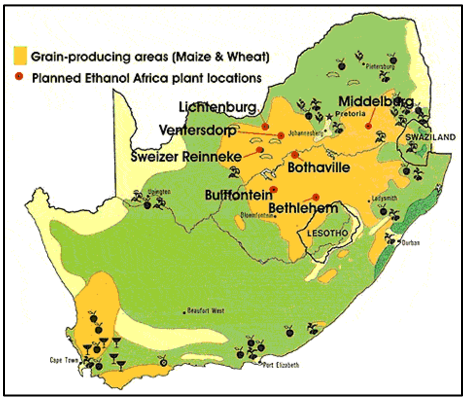
Despite this scepticism, there are remarkable **activities** ongoing in various African countries, as the following list illustrates

- Tanzania, Zambia, Mozambique, Zimbabwe and South Africa are already **active in ethanol** production
- Burkina Faso, Cote d'Ivoire, Mali, Senegal – all have **proposals for ethanol** production
- Angola DRC and Madagascar are revitalizing (small) sugar industries
- Jatropha projects for **biodiesel** are starting in various countries.

To highlight some of the most important activities, their size and impact, we present some country cases.

3.2.1 South Africa

South African has rather favourable conditions for biofuels and costs of supply are similar to the USA, much lower than the EU (using wheat to ethanol as baseline, almost half), but about 50 % higher than for Brazil. In line with its new strategy, in July 2006, South Africa's first **large-scale bioethanol plant** was launched at Bothaville in the Free State by Ethanol Africa, which will be in production by the end of 2007.



Ethanol Africa was set up by a consortium of maize farmers as a solution to grain surpluses. Sterling Waterford, the environmental finance group that listed the world's first carbon-credit product on the JSE last year, recently bought a 50% share in the company. The company delayed the plans to list on the London exchange to raise funds, as pre-production funding will be through private equity. Ethanol Africa plans to build a further 7 **maize ethanol plants** in the next 6 years. Each plant will have the capacity to produce nearly 500 000 litres of bioethanol a day, utilising 1 200 tonnes of maize drawn from 100 000 hectares. Ethanol Africa predicts that, if the planned programme to bring all 8 plants into production within the next 6 years is achieved, the potential 4 million litres of ethanol that the plants would produce each day would **satisfy the demand for a 10% blend** by 2015. Distillers Dry Grains and Solubles (DDGS), CO2 and diesel are valuable by-products. Each plant is expected to have an average turnover of R550-million a year. If this were realised, each plant would add 0.05% to the gross domestic product (GDP.[7]

Another company, Soteria, is to build a $120 million ethanol from corn plant in the Free State province. The plant will use 420 000 tons of corn a year to produce 152 million litres of ethanol and 11 million litres of biodiesel. The South African government's Central Energy Fund through the Energy Development Corporation (EDC) is named as a shareholder.

Expected benefits of the biofuels program are[8]:

- Bringing back into production the 4.5 million hectares maize that were previously cultivated.
- 55 000 additional jobs, or a reduction in unemployment of 1.25 %,
- a net increase of R1 700 million per annum in household income throughout the South African economy.
- A net reduction of the current account deficit to the value of ca. R3 700 million per annum.

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[6] Excerpt from: Palmer, Karen - Green Energy from Africa. Africans used to think jatropha was a worthless bush. Now it may be an important new source of energy. Newsweek International Feb. 19, 2007

[7] Excerpt from: Foster, Gwynne - Biomass Study – Maize from South Africa, Prepared as input to the study of Dutch imports of Biomass, Final Report 2006

[8] An Investigation into the Feasibility of Establishing a Biofuels Industry in the Republic of South Africa, Final Report, Oct. 2006

3.2.2 Tanzania

A feasibility study has been carried out by WWI and GTZ to explore the biofuel for transport potential in Tanzania[9]. As the country is a typical example of the non-oil producing African countries, the studies descriptions and findings may be considered as rather typical for a large part of the bioenergy sector continent, and are therefore presented in some detail:

- As Tanzania does not have own oil reserves, the country is totally dependent on the **import of petroleum products**, which (1.2 million tons in 2003) account for about 40% of all imports to Tanzania, and are thus responsible for a significant fraction of the country's foreign exchange spending. The transport sector consumes more than 40% of the imported refined petroleum products. The Tanzania Petroleum Development Corporation (TPDC) forecasts an annual growth of 5% for petrol and diesel.
- Currently, there is **no commercial biofuels production** in Tanzania. But, several stakeholders are engaged in the development of biofuels, such as FELISA (palm oil), KAKUTE, Diligent and D1 Oils (jatropha oil) in the field of commercial biodiesel production as well as the 4 main sugar companies (Kilombero Sugar Company, Mtibwa Sugar Estates, Kagera Sugar Limited) in the field of sugarcane based bioethanol production.
- Roughly, the current biofuels activities and opportunities in Tanzania can be divided into large-scale and small-scale approaches.
  - Thereby, **large-scale biofuels production**, such as the production of ethanol from sugarcane promoted by the sugar industry as well as the activities of companies such as D1 Oils in the plant oil sector, will have a prime focus on biofuels for transportation and will require supportive policies and regulations in place for start-up in order to secure the rather large investment.
  - On the other hand, **smaller-scale activities** by organisations such as FELISA and KAKUTE are currently mainly concerned with the creation of rural income and revenue opportunities from oil seed crops, either through the production of plant oils (for food and/or fuel) or other commodities such as soap production from jatropha oil. The production of biofuels for transportation in these cases may (or may not) be an objective for the up-scaling of current activities.
- Current (2004/2005) production of C-molasses by the **cane sugar industry** in Tanzania (about 90.000 tons) could be converted into more than 20 million litres of ethanol per year, or enough for an E10 blend. At current petroleum prices, production of ethanol in Tanzania is likely to be competitive with petrol. A more detailed feasibility study would be required to confirm this.
- **Oil palm and Jatropha curcas** are the two **oil crops** most likely to be used as feedstock for biodiesel production in Tanzania.
  - Of the oil crops available, oil palm has the highest potential yield of oil per hectare of land harvested. However, there is currently great demand for **palm oil** for food and other uses, and local production meets less than 5% of this.
  - There is experience in Tanzania of cultivation of **jatropha** for small-scale oil production, and this has been particularly promising. Cultivation of jatropha around the world has tended to be on a small scale, and production and yield data for plantation-scale cultivation is limited. The oil yield from jatropha plantations is reported to be about 1600 kg oil per hectare from the fifth year onwards. On this basis, 19,700 hectares of jatropha would have to be harvested each to produce enough biodiesel for a 5% national blend with petroleum diesel in 2010. For a B20 blend, 78,800 hectares would be required.
- With 4 million ha potentially available for crop production in Tanzania, **land availability** is not likely to be a barrier to biofuel production, However, there is the need of detailed assessment of local land availability (co-operation with farmers).

[9] Jansen, Werner - Opportunities for Biofuels in Tanzania, Presentation Vienna 2006 and excerpt of the study. Liquid Biofuels for Transportation in Tanzania. Potential and Implications for Sustainable Agriculture and Energy in the 21st Century. Aug. 2005

- As currently, Tanzania is not self-sufficient in sugar as well as food oil production (food-biofuels competition), there may be **some risk of competition with food** and feed. On the other hand biofuels may provide stimulus for investment in the agriculture sector.

3.2.3 Nigeria

The **Nigerian Ethanol programme** aims at **blending** ethanol with gasoline to form an E10 blend (10% ethanol and 90% gasoline). Two potential crops have been identified for the fuel ethanol initiative in Nigeria; namely, **sugarcane** and **cassava**, as Nigeria is currently the leading producer of cassava in the world of about 30 million tons annually. The targets are[10]:

- 10-20,000 hectares of sugarcane plantations, 5-10,000 hectares of cassava plantations
- Ethanol production units with capacity of 70-80 million litre annually from sugarcane, 50-60 million litre annually from Cassava
- Ethanol to be commercialized and blend with gasoline up to 10%
- Cogeneration plant to convert waste to electricity

Currently there are three sugarcane **projects** with total ethanol capacity of 225million litre/year and total cultivation area of 60000 hectare and the country is seeking partners for large biofuel project

To make use of other countries experience, partnership MOUs have been signed with Petrobras and COIMEX for technology transfer.

3.2.4 Other countries

Ethanol programmes that produce a blend of ethanol and gasoline (gasohol) for use in existing fleets of motor vehicles had been implemented in the 1990s in Zimbabwe and Kenya. Available evidence indicates that these programmes had registered important economic benefits[11].

- At its height, the **Zimbabwe** alcohol programme was capable of producing about 40 million litres and there are plans to increase annual output to 50 million litres. In the Zimbabwe ethanol programme, 60 % of the whole plant was locally produced and significant staff development took place. Currently the National Oil Company of Zimbabwe (NOCZIM) is to embark on a seedling-based jatropha out- grower scheme where the company enters into direct relationships with willing farmers including schools and institutions who have land, infrastructure and capacity to raise seedling for bio-diesel production.
- The total investment cost of **Kenya's** ethanol plant is estimated to be US $ 15 million. At its peak, plant production averaged about 45,000 litres per day (Baraka, 1991). The ethanol was blended with gasoline at a ratio of 1:9. Since it was commissioned, Kenya's ethanol programme has continued to register annual losses mainly due to the prevailing low Government-controlled retail prices (which have since been liberalized); inadequate plant maintenance and operation; resistance from local subsidiaries of multinational oil companies; and, unfavourable exchange rate which has significantly increased the local cost of servicing the loan that financed the establishment of the plant. In an attempt to break even, the plant has had to export 13.3 million litres of crude ethanol. The plant has, however, generated an estimated 1,000 rural jobs.
- In **Zambia**, D1 Oils Africa, a British company, has recently developed 174,000 hectares of crops which it is turning into biodiesel.

3.3 Other bioenergy

Sugar is produced in a number of Eastern and Southern Africa countries. It is a major agricultural export for Ethiopia, Malawi, Mozambique, Madagascar, Swaziland, Zambia and Zimbabwe. The potential

[10] Yusuf, A.O. - The Nigerian Fuel Ethanol Industry, Presentation Nov. 2006

[11] Stephen Karekezi - Renewable Energy in Africa: Prospects and Limits, Dakar 2004

for **electricity generation from bagasse** is high since cogeneration equipment is almost uniformly an integral component of sugar factory designs. Estimates show that up to 16 Sub Saharan African countries can meet significant proportions of their current electricity consumption from bagasse-based cogeneration in the sugar industry.

3.4 Potential

As mentioned before, the theoretical potential for biofuels in Africa is rather large, based on the potential yield of the land. Smeets calculates for 2050 a potential of 109 Mtoe to 835 Mtoe per year. This would be the equivalent of 19% to 143% of the current total primary energy supply of the continent.

However, the IEA in its rather conservative demand-based approach, despite stating that the natural conditions and unused potential are rather favourable, estimates only a biofuel supply of 3 Mtoe in 2030 (about 3% of the theoretical potential of 2050), which would require some 800.000 ha of land, i.e. 0.3% of the arable land of the continent, and some US-$ 7 billion of investment. Looking on the land use figures of ongoing and starting bioenergy projects (see above), this figure has already been passed, indicating that the IEA projection will need some revision and a projection for Africa bioenergy production should after the lead time of the agricultural process rather soon already exceed the projected figure for 2030 only.

It is possible that future policies in Africa will be designed to meet not only domestic needs but also the growing international demand for biofuels. South Africa, as well as the Democratic Republic of Congo, currently export already ethanol to the European Union.

Thus, in general the perspectives for the African energy sector are commented with certain optimism:

- Biofuels are available in varied forms in abundance in almost every part of Africa, and if properly harnessed, can play a significant role in energizing Africa.
- It has large, economic biomass potentials (but needs complex, sustainable, development and a working international market).
- Competitive biomass-technology combinations could by used.
- Bright future; but policy needs to choose and coordinate (agriculture, trade, climate, energy and development are interlinked here).
- Biofuels based rural energy systems can not only help in combating the energy poverty but also assist in reducing the poverty by linking to productive uses.[12]
- New technologies such as bio-gasification can augment rural electrification and process heat applications in SMEs, and liquid biofuels such as bioethanol and biodiesel can meet growing needs of transport sector

3.5 Bottlenecks

As Africa is facing a series of severe problems, such a bright future for bioenergy is not guaranteed at all. Beside the usual bottlenecks of the framework conditions, the agricultural sector and the energy sector in the African countries, there are (additional) specific **barriers for investment** resulting from bioenergy characteristics and needs.

On the supply side we find the following aspects for **Bioenergy:**

- Newer technologies -Higher operating risks
- Longer lead times -Higher development costs
- Initial high capital - Need for longer-term financing at reasonable rates
- Present technologies not yet fully competitive
- Less experienced sponsors - Higher completion and operating risks
- Low level of own funds for investment cost contribution (if not FDI)

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[12] Leuchsenberg, Heinz (UNIDO) – Biofuels and energy security in Africa, Presentation 2006

In the **sector and framework conditions** we find further barriers:

- Competing uses: First generation biofuels are using sugar and vegetable oils, creating pressure on the quantities and prices for the alternative use. This may be reduced, if additional land is used or the improvement in the productivity will set resources free. But demand from the international market can easily offset such effects and lead to extreme increase in food prices (see below). In many countries land is customary (under chiefs), thus difficult to access for a commercial production.
- Energy policy: Many countries do not have a clear and reliable energy policy or rules on mandatory blending, which could create a solid and calculable base for such a long-term investment. Energy Sector Competition and Bias, as low cost of energy from conventional sources as there may be price distortions from existing subsidies and unequal tax burdens between other renewables and energy sources.
- Market barriers, especially lack of reliable information.
- Infrastructure: Production and transport of feedstock and products requires some basic infrastructure as well as the distribution (fuel station), if is not simply mixed with fossil fuel.
- Trade Barriers: There is a lack of International Fuel Quality Standards. The current protectionist policy of the EU and the US gives little room to export biofuels on a major scale to these regions. However, India and China may be more accessible partners.
- Financing: Bioenergy unfamiliar to financiers due to lack of information; Bioenergy may be considered not attractive, because high risk without adequate risk compensation in form of risk coverage instruments or higher returns; financing hardly available for projects and customers due to lack of funds and/or lack of instruments

3.6 Risks

3.6.1 Overview

Bioenergy is not without risks. Social and environmental aspects, which – depending on the actual circumstances in the country and region - may represent a potential risk for bioenergy development in general or a particular project are:

Social Risks	❍ Competition for all production factors and increased pressure on natural resources, particularly land, water and their prices, as well as the risk of land conflicts, water and other resource conflicts ❍ Increased food prices for the (urban) poor and decreased access to food due to increased food prices driven by competition between biomass for energy or food ❍ Decreased food availability due to replacement of subsistence farm land by energy plantations
Ecological risk	❍ Expansion of Cropland on to Sensitive Areas ❍ Overstressed Water Supplies ❍ Soil Degradation ❍ Reduced Biodiversity

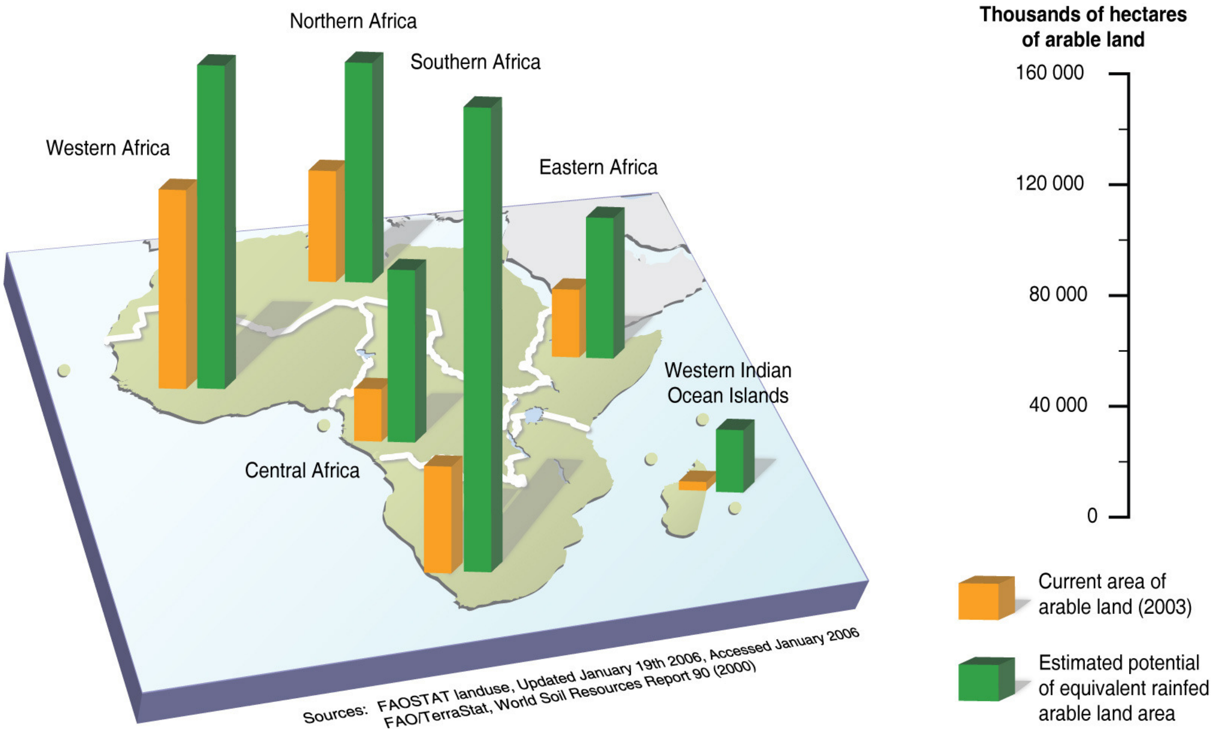
The impacts can be positive or negative depending on feedstock, management practices, land use change and process energy, to name just a few factors. This will require individual studies for each type of biofuel, project and investment. However, some additional observations shall be presented here in reference to major concerns for massive extension of bioenergy in Africa.

3.6.2 Land use and water

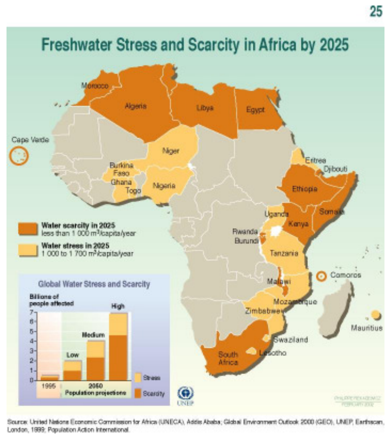
Out of the total land area in Africa, only a fraction is used for arable land. Using soil, land cover and climatic characteristics a FAO study has estimated the potential land area for rain fed crops, excluding built up areas and forests – neither of which would be available for agriculture. According to the study, the potential – if realised – would mean an increase ranging from 150 – 700% percent per region, with a total potential for the whole of Africa in 300 million hectares.

On the other side, there is a severe problem by the state of Africa's soils. In sub-Saharan Africa soil quality is classified as degraded in about 72% of arable land and 31% of pasture land. To convert large areas of pasture to arable land or production would require improvements in the efficiency of livestock-raising practices. Increase in yields would reduce the competition for land use between biofuels and food production. The potential is undoubtedly highest in the poorest developing regions, notably sub-Saharan Africa, where yields are typically well below OECD averages, though water supply could be a major constraint. However, the low ratios of needed arable land for the next 25 years of development of bioenergy according to the IEA scenario, but also on the few available national estimates, suggest that there is no major general conflict for land to be expected.

Thus, although food security and bioenergy systems have complex macro, meso and micro level interaction and regional, national and sub-national analysis are required, in general the competition for land use in terms of food production might be overstated,[13] especially when taking into consideration the large reserve of potential arable land.



However, on the local level, the situation may be quite different, and without proper standards and framework conditions such situations may lead to social conflicts. Furthermore it must be taken into consideration that about 80% of the land is under traditional land rules. Also water conflicts may be a problem at the local level, and even at the national level as the projection of water stress for several African countries suggest. An area is experiencing water stress when annual water supplies drop below 1700 m3 per person. Water scarcity means that the annual water supply is below 1000 m3 per person. This graphic shows which African nations are expected to be experiencing water



[13] Nyberg, Jennifer (FAO) - Biofuels in Africa - Risks and Opportunities Food, Feed or Fuel?, Presentation 2006

stress, and which are expected to be facing water scarcity, by the year 2025. For these regions, bioenergy strategies should especially consider the water requirements for the production of feedstock for biofuels.

3.6.3 Pressure on Food Supply and Prices

At the global level, there is clear evidence of sharp increases of prices for sugar and maize in line with the increasing production of biofuels, as well as with the increase in the price for crude oil. According to the FAO AG-Commodity Market Effects, energy prices above US$30/ bbl directly affect agricultural prices, as they create a floor price for agricultural production; but agricultural prices will not rise faster than energy prices as bioenergy feedstock would price themselves out of the energy market. Alternative fossil energy sources (like CtL, GtL) limit increases in energy prices, which also limits profitability of bioenergy investments (limits to euphoria) in the long-run.

The increase in international agricultural prices through the global demand links will affect food prices in Africa, whether they will plant feedstock for biofuel or not. However, with the own production there would be additional supply for the world market taking away some price pressure.

Nevertheless, although the current nominal increase of food prices being only a reverse of the sinking real prices in the past, the substantial increases affect considerably the urban poor in developing countries, which spent about 60% of their income for food. Thus, there may be the social risk that urban poor have to spend more of their meagre income, without having the guarantee that the surplus created by higher prices will really increase of the rural poor.

3.6.4 Environmental aspects

First, it should be emphasized that bioenergy could – compared to fossil fuels – drastically reduce greenhousegas emissions if managed appropriately. This is also agreed by institutions, which can be considered as rather sceptic in this matter.[14]

The environmental land-use effects of bioenergy-cropping systems must be considered with reference to current land use (if any): if bioenergy production replaces intensive agriculture, the effects can range from neutral to positive; if it replaces natural ecosystems (forests, wetlands, pasture, etc.) the effects will be mostly negative. Since the share of degraded land which could be used for bioenergy farming systems is (unfortunately) increasing globally, making use of this land for bioenergy production represents a potential of 25 percent of global primary energy use, even when low yields are assumed[15].

Much of the published criticism is concerning environmental aspects of biofuels referring to their production in sub-optimal regions and the high level of inputs of fertilizer and water to generate an only decent net energy benefit by producing feedstock for biofuel. However, depending on the type of feedstock, the land management, the processing and other factors, even in tropical zones, there may be some risk of environmental impacts. The deforestation of the rain forests in Indonesia and Malaysia for the production of palm oil is an extreme example.[16] However, due to the idle resources of arable land in Africa, this may not a major problem in general. A massive production for biofuel feedstock for export however, may – depending on the type of feedstock - increase the risk considerably. In this context it may be interesting to look on some of the environmental aspects of monocropping of sugar cane in large farms in Brazil as an illustrative example:

- The sugarcane crop has expanded to more degraded or poor areas (mainly ex-extensive pastures). It contributes to soil recovery by adding organic matter and chemical-organic fertilizer,

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[14] See: WWF - Sustainability Standards for Bioenergy, Berlin 2006, p.9

[15] See WWF 2006, p.11

[16] The size of some of the new investment is huge: In January 2007, Indonesian Palm oil producer PT SMART Tbk announced a US$5.5bil biofuel deal with China oil major, to be spent in three phases over eight years to develop crude palm oil-based biodiesel and sugarcane or cassava-based bioethanol. This project will be carried out in Papua and Kalimantan where the regional governments have reserves of (about) one million hectares of land. Financial Time, Jan.10, 2007

thus improving the soil's physical and chemical condition and making it possible to use it for Brazilian agriculture again.

- It is recognized in Brazil today that sugarcane causes relatively little soil loss through erosion.
- Since sugarcane is not irrigated in Brazil, environmental problems caused by irrigation to water quality, nutrients in-flow and erosion are low.
- The problem of biodiversity loss is not significant, since sugarcane is cultivated on degraded or poor land, and mainly on “recycled” extensive pasture – but not on new, uncultivated land.
- However, experience gathered in the 1980s shows that rapid expansion of energy source production can lead to the devastation of ecosystems, including deforestation and the degradation of other conservation land. [17]

The environmental aspects of each project will require careful planning and assessment, to make sure that the potential benefits from the reduction of CO2 emission will not be offset by negative environmental impacts in the chain from feedstock production to biofuel use. Environmental research of standard feedstock and biofuels and the development of and agreement on environmental standards and minimum requirements would be of help in this matter.

3.6.5 Social Aspects

As has been stated even in studies specifically to investigate the socio-economic problems and standards, "the multitude of possible social conflicts connected with the cultivation of energy crops precludes the development of a detailed set of standards within the limited scope of this paper".[18] The following key standards have been recently proposed as minimum requirements and are cited in detail[19]:

- Clarification of land ownership: Alongside questions of land use, land-ownership structures – i.e. who controls the property that is to be used for bioenergy crop cultivation – are a fundamental issue. Land ownership should be equitable, and land-tenure conflicts should be avoided. This requires clearly defined, documented and legally established tenure use rights. To avoid leakage effects, poor people should not be excluded from the land. Customary land-use rights and disputes should be identified. A conflict register might be useful in this context.
- Priority for food supply and food security: Although the standard may be difficult to measure, i.e. cultivating energy crops to the disadvantage of food crops for local /or domestic consumption should be avoided.
- Improvement of labour conditions and worker rights: The supply systems for bioenergy must comply with ILO standards on workers‘ safety, workers‘ rights, wage policies, child labour, seasonal workers' conditions, and working hours during harvest time.
- Ensuring a share of proceeds: A standard on income distribution and poverty-reduction issues (share of proceeds) seems necessary, although this can only be discussed in detail with respect to regional and local conditions and project specifics.
- Avoiding human health impacts: Important indicators include medical attendance and regular information about the dangers and risks of the work. They help prevent accidents and provide a safe and healthy work environment.

The actual enforcement and practical relevance of such standards may have limited chances, if not elaborated and agreed soon, taking into consideration the ongoing dynamic investments in the sector, which are creating facts and actual norms for later entering potentials competitors.

[17] Cited from: WWF 2006, p.12

[18] Cited from: WWF 2006, p. 20.

[19] Excerpted from: WWF 2006, p.20ff.

4 Needs, Chances and Approaches for the Promotion of Bioenergy in Africa

4.1 Needs

Although biomass resources and technologies are readily available, the challenges, constraints and shortcomings, have let mature projects in emerging markets like South Africa or investment at an experimental pilot scheme level only. Thus, the fact that players from the global market are exploring the potential of bioenergy in Africa, is a generally positive sign of the general potential, but no reason to inaction for development cooperation, as otherwise benefits may be limited and distributed in a way not compatible with sustainable development of the countries in the region. Although, some of the countries in the region are aware of the chances and the needs for a bioenergy strategy and are making strong efforts, other ridden by a multi-fold of other developmental problems and priorities, are simply lacking the financial and technical resources to master this additional challenge, are in need for support of their part in the bioenergy future. Thus, currently the reality for potential investors for biofuel in Sub-Sahara Africa is described to a great extent by the following **gaps and deficiencies**:

- Lack of **knowledge** at the national, regional and local level about the concrete conditions and potentials of the different types of biofuel and their feedstock.[20]
- Lack of own **funds** and lack of access in the domestic financial and capital markets to finance at adequate conditions.
- Limited **experience** with challenging business models and models to link agricultural production, processing and distribution properly.
- **Uncertainty** about the national **policy** on energy and biofuel in particular, about social and environmental **standards** to observe.

These factors justify and ask for support by development cooperation, despite all the ongoing commercial activities in this field.

4.2 General Approach

In order to improve the chances that bioenergy will meet up its promises of a widely available resource, to contribute to greenhouse gas reductions and other environmental and improve the living in rural livelihoods, support in the shaping of the market conditions and facilitation of the market access would be of utmost importance.

The goal of the hereby proposed initiative of the G8-member group is, to contribute to the creation of such conditions in the bioenergy market, which fulfil environmental and social standards, thus contributing to the sustainable (rural) development.

By the supply of financial funds for financing of innovation and investment financing, the G8-member states could take some influence on the development of the market conditions. Thus they could improve the access of Sub Sahara Africa and the realization of the chances of this future market for the region and at the same time by the participation in the investments set standards for a socially and ecologically compatible organization of the market.

On the other hand the political decision makers of the partner countries and regional organizations should be supported to create an appropriate organization and set of rules for the fast developing market of bioenergy (Technical Cooperation).

Objectives are financially and economically sound projects, which fulfil the principles of development policy and the social and ecological standards. The promotional element should cover some of the investment risk and encourage additional ecological and social measures. Special attention should be given to:

[20] For comparison: Potential producer and investors in the US-biofuel sector have access to a 500 page data book sponsored by the Ministry of Energy full of detailed technical and economic facts to assess the chances and risks.

- Increase of the local creation of value (selection of feedstock, processing and business schemes; promotion of domestic financing);
- Integration of small rural cultivation methods (more outgrower schemes);
- Use of agricultural waste products.

As there are already many and some rather large initiatives for renewables in Africa, including certain bioenergy types like biomass and co-generation, and to give the initiative a **clear profile**, it may be advisable to focus its support to a certain area of bioenergy: **liquid biofuels**. Otherwise there would not be only the risk of overlapping with other schemes, but as well the risk of losing efficiency as well significance by trying to finance everything.

Possible, but not exclusive fields of action would be:

Bioenergy: Fields of support			
Area	**Topic**	**Technical Cooperation**	**Financial Cooperation**
Know-how	Crop Studies and Handbook	Support of research and development (e.g. seeds, cultivation methods, adapted technology); practise oriented analysis of viability and optimization of biofuel feedstock; Dissemination.	
	Outgrower Schemes	Development of models and schemes; Dissemination activities; Support of organization	
	Business Models	Facilitation of cooperation and know-how transfer through regional workshops and trade fairs	
Investment	Feedstock	Development of models and schemes for outgrower schemes	Linking small scale production to large scale processing through outgrower schemes through refinancing of MFIs Support of Guarantee Schemes and other risk-mitigating instruments
	Processing	Know-how transfer through regional workshops and trade fairs	Processing Plants (SME as well as large scale): long-term finance and equity for (partial-) investment funding Support of Guarantee Schemes and other risk-mitigating instruments Refinancing of credit lines of local banks
	Equipment	Know-how transfer through regional workshops and trade fairs	Production of specific equipment for Bioenergy: long-term finance and equity for (partial-) investment funding Support of Guarantee Schemes and other risk-mitigating instruments
	Distribution	Development and dissemination of schemes for commercialisation	
	Funding	Know how transfer on chances and risks of Bioenergy financing	Co-Financing with local/regional banks Support of MFIs
Biofuel Policy	National Bioenergy Plans	Analysis of national potential	
	Blending	Studies, Workshops, High-level Consultations	
	Social and Environmental Standards	Introduction of standards for quality and cultivation (certifying) Studies, Workshops, High-level Consultations Support of Regional Coordination	Standards for quality and cultivation for funding