Biofuel: A Guide for the Confused

by

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Tables

Figures

1 Preface

> *Why should you read this manual? Why was it written and for whom? How can you use it?*

"Biofuels: A Guide for the Confused" is written primarily for field staff and decision-makers involved in biofuel development. It assumes no previous or specialist knowledge of biofuels in terms of their technical/engineering characteristics or biological/cultivation aspects of biofuel feedstocks.

Biofuel development is a wide area, encompassing natural resource planning, biological and chemical production processes, and macroeconomic policy analysis. This manual, while covering the broad spectrum of bioenergy in the definitions and introductions, focuses on liquid biofuel production from agricultural feedstocks in countries such as Tanzania and Ethiopia. While looking at a number of possible financing scenarios, this study also highlights the particularly sensitive situations where Foreign Direct Investment (FDI) is the financial motor behind biofuel development.

1.1 Methodology

The debate concerning bio-energy is, at the moment, full of confusion. There is a widespread lack of understanding of the spectrum of options in terms of technology and feedstocks. There is also a lack of understanding of the difference between the basic concept of bio-energy (encompassing the use of natural bio-resources such as forests, bio-residues and wastes and biofuel) as opposed to the narrower concept of biofuel: purpose grown energy crops for biodiesel and bio-ethanol. Even within the field of biofuel processing there are a number of complex technological considerations such as co-generation and first and second generation biofuels.

One of the major reasons that so much confusion abounds is that biofuel development has been seen primarily as energy development; the "bio" part of biofuel has been neglected in practice and most of the early discussions have centered on the financial viability of a new fuel source and engineering considerations in processing, transport and use by end consumers. This manual attempts to integrate all of the different areas of expertise and keep them together in a holistic format that is useful for non-technical practitioners.

Many of the decisions made regarding energy inputs into economic development are taken by non-technical practitioners. Even in those cases where those involved do have some kind of technical background, the issues surrounding biofuel development are sufficiently complex so as to require a team of experts to analyze specific situations. This manual has been put together by just such a team, with the ambition to present a broad (if sometimes superficial) overview of all of the relevant concepts and synthesize the latest technological developments and analysis into language which can be understood by most practitioners.

1.2 How to Use this Manual

This manual can function as a reference work, course outline and general support to those who are specialized in one area of biofuel, but not all of the areas which are required to make decisions. (Typically, an appraisal of a biofuel project can include specialists in a variety of engineering and economics specialties, biologists, lawyers, anthropologists and sociologists, so it is no wonder that one person can feel a bit overwhelmed by the prospect of being involved in biofuel decision-making!)

This manual presents a balanced and technical guide to the considerations surrounding biofuel development and, while an attempt is made to use clear language and concrete examples; the topic itself is complex and requires a great deal of mental exertion. Adding values and priorities in addition to technical considerations is the domain of the political decision-maker and is not attempted here.

Your use of this document depends on your own position, your goals, your location and how much time you want to devote to understanding the potential and challenges with biofuels and bioenergy. Ideally, this compendium should serve as a guide for further study and a reference work to return to when complex situations arise. Most people will need to interact with knowledgeable colleagues in order to penetrate the subject in a satisfactory manner.

The report commences with "Implementation and Deployment**"** (chapter 2), which is intended to provide a brief, jargon-free overview on: what are the options, what are the debates, what is the hype, and, assuming FDI is the option for getting projects into production, what are the requirements? Chapter 3 provides an overview and short analysis of the potential stakeholders in a biofuel project and Chapter 4 describes how Foreign Direct Investment (FDI) actually works in practice. Three case studies from Africa are presented to illustrate this.

We then turn, in Chapters 5 and 6, to exploring the underlying scientific information that drives FDI and supports the decision-maker options presented earlier. We look at such questions as what is biofuel and how does it fit into long term natural resource management, socio-economic development and energy scenarios? In Chapter 6 we present some details of the processing of biomass into biofuel, with a degree of technical complexity designed to inform, not confuse, the non-engineer.

Chapter 7 presents an overview of biofuel development policy and how this has impacted biofuel development in different parts of the world.

The three last chapters (8,9 and 10) are devoted to the context within which biofuel development is carried out and the impacts of that development on the environment, on socio-economic development and on land rights.

2 Implementation and Deployment

You know there are potential and pitfalls, described later in the report, but you want to get on with it. Here we look at what can be achieved under typical circumstances and with a minimum of setbacks which might result from choosing unsustainable options. We also take a thematic look at some of the remaining, more diffuse issues.

2.1 Four choices

When considering bio-energy conversion technology in an SSA (sub-Saharan Africa) context, the following issues have been brought to our attention:

- Inclusion of small-scale farmers also in larger scale production
- The scarcity of water and land
- Climate change, where SSA has a potential to assist through producing biofuels and bio-energy which will replace energy from fossil sources.
- Negative trade balance, where SSA actors can potentially assist through producing biofuels and bio-energy which will replace energy from fossil sources.

In view of these issues, the four following options, consisting of a base substrate (i.e. underlying layer, in this case a feedstock input) and a conversion method, should be evaluated for adaptability:

- Bioethanol from rainfed agricultural areas
- Biogas from household and industrial organic waste
- Biodiesel from oil seeds
- Cogeneration from waste and biomass

These alternative production routes are described in their significance as production systems in chapter 6. Technology requirements are reasonably low for small scale production e.g. in the biodiesel case, while a large scale bioethanol production unit and plant would require good infrastructure, access to trained technicians, and capital in the range of a billion USD. It is thus fundamentally important to consider the desirable and feasible scale of operation. A suitable method of development often includes a “model” plant, followed by several satellites or expansion stages. To begin with, the following practices can be recommended regardless of scale, but of course with differences in depth and outside contacts depending on:

1. Development of a project vision
2. Establishing the project vision among stakeholders
3. Developing a pre-feasibility study, shedding light on general issues regarding the new and/or chosen technological route
4. Performing a project and site specific feasibility study
5. Managing project funding, in case of SSA often involving multiple institutions such as donors, banks and DFIs.

6. Setting up and commencing a project plan, including longer term operational planning.

There are several aspects that needs to be investigated further before investing in a given scale solution. There is a system aspect e.g. in that managers of each part of a system need to be up to speed on their component. There are elements of scale – higher blends of ethanol require adapted vehicles, such as those used in Brazil and USA. Biogas requires compression and buses & cars fitted with gas tanks and gas injection equipment to be viable. Such equipment can either be fitted when the vehicle is sold or retrofitted. Biodiesel can usually be blended in up to 20% in existing distribution systems and vehicles. There are other system aspects - the list is also a bit counterintuitive in that biogas is a fuel for cogeneration or combined heat and power (CHP) production. There are also important elements of scale, outlined in Table 3.

Table 3. Quick guide to pros and cons for technology choices

Technology	Large Scale		Small Scale	
	pros	cons	pros	cons
Bioethanol	Large fuel quantities, offsets fossil fuel demand, also cooking fuel	Considerable water requirements, little employment, monoculture	Compatible with existing agricultural structures, Cooking fuel	Inefficiency, manual harvesting requires burning, may cause drinking
Biogas	High CHP efficiency	Logistics, need for heat sink.	Robust local (farm) production units, waste-to-energy	Continuous on-farm operations & maintenance requirement
Biodiesel	Efficiency, offsets fossil fuel demand, employment	monoculture, water req., considerable startup time	community mini-grid potential	risk of lack of continuity in o&m
Cogeneration	Offsets fossil fuel demand, rural energy	Logistics, including transport of feedstock and product	Support for minigrids, co-ops,	lower efficiency, risk of lack of continuity

As a result, cane bioethanol can be an alternative in reasonable size outgrower or estate schemes, where there is enough rainfall to support good yields - without extensive flooding of the cultivated area.

Biogas is an excellent option to reduce waste volumes and manage BOD levels in organic waste, while converting odorous garbage to electricity, heat or vehicle fuel.

Biodiesel is an alternative either on a very small scale from outgrower oil rich seeds such as canola or larger scale jatropha plantations, again where rainfall and competing food crops permit the cultivation of trees for fuel production.

2.2 Bioenergy hypes and scares

During the last decade, the following pattern has repeated itself enough to be identified as such: a biofuel concept, e.g. a “new” type of feedstock, a new fuel based on new organization or production method or an engine with a potential for development of demand has emerged, followed by a rapidly growing interest. Within one or two years, scientific and other follow-up activities have led to revised views of an often initially over-advertised concept. Why is every new feedstock heralded as THE ANSWER? Do we need ONE ANSWER? Can we see through the hype? What will the next trend be?

A new fuel or feedstock, in the right climate and cultural region, may attract the attention of many stakeholders in or around the region itself for a number of reasons. One reason is to attract funding for research or a demonstration project, to develop an area and/or reflect a political ambition. Depending on the stage in the lifecycle in the development of the practice (or hype in the event of overinflated expectancy), a given type of feedstock or fuel could be exposed to a hype or a trough, in the first case leading to overexploitation, market agitation, false hopes, and in the latter to time-consuming investigations, development moratorium, canceled incentives and reduced demand.

In an African context, sugar cane-to-ethanol and jatropha-to-biodiesel have been branded as means to reduce dependence on foreign fossil fuels, and in some cases constitute a source of revenue from export, to receive carbon credits and to develop agriculture and rural livelihoods. Both larger scale plantations, with or without outgrower schemes and community based were planned. A time lag of a year or more has been common between the initiation of the hype, giving fast movers time to start demonstration programs for the unproven promise. Around 50 projects were discussed or under initial development in Tanzania alone in 2008.

While a few projects commenced in SSA, the hype turned into a scare. Reports and articles spoke about the challenges discussed in the following section. Studies (ActionAid, 2009 and others) have suggested that investment in sugar cane ethanol project should be put on hold until adequate regulation and enforcement capability has been put in place. In a similar way, a year after the development of several biodiesel projects involving jatropha cultivation, real water requirements and the time lag from planting to larger scale harvesting became clearer; delaying production and project profitability. Early experiences reduced initial interest and many biodiesel projects have stalled (this is true also for Europe and USA). Biofuel project development in Tanzania, for example, was subjected to an informal moratorium in 2009 as a result of a rising controversy over the long term effects on water and food supply.

The hype and scare scheme reflects a typical process in society for a new element to find its place. Initial knowledge of an opportunity may create a “gold-rush” phase, followed by knowledge building, increased experience and institutional development, all leading to a more balanced role and governmental support for a new technology or practice such as those relevant to the production and use of biofuels. As a project owner, manager or investor, the means to override hypes, troughs and scares are - as with all projects - to ensure that all boxes are ticked regarding social, economic and environmental risks and opportunities. Media training may be prudent in the event of headline hungry journalists. The more profound risks with the swings of hype and media scares include that a project goes live and an area is cleared of vegetation, i.e. producing a carbon deficit, and then the project is stalled, resulting in a more permanent carbon deficit without the replacement of fossil fuel that was planned.

The present hype answer is algae. There is a host of proactive engagement in the practice and theory in this area, ranging from projects to enhance understanding of the technical potential to produce biofuels from aquatic biomass to spectacular production projects in and out of the water. As in the earlier cases described, moving to a more mature view on the potential of algae-to-biofuels is likely to include hypes, scares and troughs.

2.3 Challenges and Strategic Issues

The Contradictions: are they really a problem? How do they relate to biofuel choices?

Biofuel development has been surrounded by controversy. Some of the most important issues are

- biofuel production could compete with production of food e.g. by tapping water resources and use large swaths of land
- foreign companies would acquire the rights to large land areas for monoculture biofuel crop production (this practice is referred to as "land-grabbing"), barring animal migration and inducing the growth of plagues
- biofuels would not contribute to mitigate global warming since cultivation is not carbon neutral
- biofuels, especially new larger scale production schemes, would not contribute to mitigate global warming because of indirect land use changes

On June 3-5, 2008, FAO organized a high-level conference on climate change, bioenergy and food security (FAO, 2008). A five-year moratorium on extending the use of land for biofuels production was discussed, (a similar moratorium was called for recently by a group of Tanzanian researchers in late 2008 and subsequently put in place by the government in mid 2009) but the conference agreed on seeking further scientific evidence and called for sustainability standards for biofuels policies, involving economic, environmental and social sustainability criteria. The protection of land rights for vulnerable smallholders and the promotion of sustainable food models and the Right to Food guiding principles were mentioned. Awareness raising was also highlighted. Further, it is suggested that the wider notion of bio-energy should be favored, and that biofuels should be evaluated within that wider notion.

2.4 Food vs. renewable fuel vs. fossil fuel

Where biofuel feedstocks are cultivated, food production may be hampered because of availability of land or reduced access to water for irrigation. Contrary, some would say, there is not too little food, but many do not have enough money to buy sufficient food and foodstuffs.

A related issue is the market for fuels - if there are abundant and cheap fossil fuels available in a local market, renewable fuels with a higher initial production cost would be barred from entry since the price for these fuels would be higher despite a lower cost to society.

The arguments and evidence underlying this apparent conflict are presented in more detail in section 5.3.2 below.

2.5 Organization and scale

Different scales and types of organizing of feedstock and biofuel production will typically have different corporate economic, socioeconomic and environmental impacts. Ownership structures and organization, according to a report funded by the Swedish Embassy in Tanzania (Mwamila, 2008), must be revised and controlled in order to ensure good development.

A further discussion of smallholders versus industrial or corporate farming is presented in section 10.3 below.

2.6 Policy Options

The main policy options for supporting the development of biofuels and bioenergy are:

- Carbon trading - making biofuel development in sub-Saharan Africa possible through the benefits of Kyoto Protocol instruments “Joint Implementation” and “Clean Development Mechanism”. These are yet to be defined a post-Kyoto context and so far have had little impact on Africa.
- Tax incentives - the exemption of fuel tax for renewable fuels and feed-in tariffs for renewable electricity can be used to stimulate investment in biofuels
- Infrastructure development - development of new infrastructure can focus on the use of domestically produced and/or renewable fuels, promoting “energy independence” in the long run

3 Stakeholders

Who are the actors in biofuel development? Who stands to benefit? Who stands to lose out? Who makes the decisions?

The different stakeholders, including those not involved in the emerging industry but potentially profiting or losing from its social and environmental implications on society, have partly conflicting interests that must be balanced by policy, regulation, enforcement and sorting of issues in ad hoc or organized forums. In view of a mixed scenario of a limited number of larger process industries fed by smallholders, outgrowers and corporate estates, and a large number of rural cooperatives for fuel and energy provision, the following stakeholders can be identified:

3.1 National Government

Promoter of Foreign Investment and Protector of the Environment?

Several, partly conflicting goals may be identified with a national government managing growth in the biofuel sector. The government wants security of supply and increased rural access to electricity, import substitution of vehicle fuels, cleaner and safer alternatives to the present dominating wood fuels for cooking. At the same time, rural employment and empowerment are important goals, often expressed as an interest to develop the competence and efficiency of smallholder farmers. Water use must be balanced over regions and seasons, and productive land use must be prioritized, but not at the cost of displacing or marginalizing large segments of the population.

The national government, through state owned power companies, can also be the country's main electricity producer and distributor. It is responsible for local and national grids, seasonal variations etc. The national Bureau of Standards works, among other things, with fuel standards that must be issued and enforced for imports, export, distribution, blending and use. Emission levels in both fuel production and use are monitored by Environmental Ministries and Agencies at the national level. Investments in the biofuel industry are typically promoted and monitored by national Investment Centers in association with the relevant government ministries, including Ministries of Trade, Transport and Industry and the Ministries of Energy.

Thus the national government, while having an overall function of planning for and regulating economic and infrastructural growth; is also responsible for protecting the environment and the interests of small agricultural producers. Biofuel development, especially that financed by Foreign Direct Investment, puts pressure on governments to perform a delicate balancing act.

3.2 Regional and local government

Protecting local populations from land exploitation?

Regional and local government bodies, including the District/Woreda/Village Councils, etc. often have the major responsibility to manage land use, oversee and enforce water rights and make final decisions on the location of economic and social infrastructure. Thus, while they have a very important role; regional and local policy and implementation priorities are not always in harmony with policies on the national level.

This is especially evident and controversial in the context of land tenure and allocation of land and water resources to foreign investors. It is not uncommon that a number of partially overlapping land tenure systems co-exist and those national decisions to allocate these resources to investors are viewed by the local population as negating perceived traditional rights of access and use (Chapter 10.3 deals with this issue in detail).

Given their physical proximity to the local population, regional and local governments are likely to be under more pressure from the local population, particularly in relatively remote areas, than the national government. Foreign investors may have to deal with local governments directly concerning land issues and this brings with it the range of problems associated with communication and cooperation between two groups of actors so different in background and power.

3.3 Consumers

It is important to realize that biofuel consumers can, at the same time, be a variety of other stakeholders. The national government is a biofuel consumer in the sense that it often has the responsibility for, and always at least some role in, the provision of domestic fuel and power. Urban and rural households typically consume biofuel for transport, cooking and lighting, but can also use it for processing agricultural products. Foreign regions (e.g. Europe and North America) and their inhabitants also affect demand for biofuels through local incentives and regional agreements.

Industries consume large amounts of energy, and are important targets for support to co-generation technology and the use or processing for external consumer use of agricultural and industrial wastes.

3.4 Investors (FDI and Domestic)

While investors for biofuel projects come from many different backgrounds (see section 4.6 for a detailed description of the different constellations of investment capital and organizational arrangements); the arguments for reducing carbon emissions with the use of renewable energy sources carry a great deal of weight in the "developed" countries, while at the same time the production of biofuel feedstocks is much more efficient and cheaper in the "developing" countries. As a result, a spate of large-scale investors from the North (and the emerging economies) have been acquiring large tracts of land in the

South (primarily Africa), with promises of investment, job creation and energy supply that could contribute significantly to economic development in these countries.[1]

The focus for countries such as Tanzania and Ethiopia has thus been on Foreign Direct Investment (FDI). These investors typically come with an industrial perspective (such as that of an energy company) and have a solid understanding of the processing technology, and although many have done business in the region before, they typically are equipped with a minimal understanding of agricultural production conditions for feedstock. Investors expect full support from the government as well as regional/local authorities, and typically look for available grants and other subsidies to strengthen the interest to invest.

Key areas to address include connecting industrial investors to commercial agricultural production possibilities, solving the question of who is responsible for economic infrastructure (many investors are opposed to contributing directly to economic and social infrastructure but the efficiency of using tax transfers for this purpose has been called into question), and how the investors can get security for the longevity/ sustainability of planned operations including (but not limited to); raw material sourcing, off-take, infrastructure maintenance and development and corporate conditions (taxation etc) including political stability.

Domestic investors, while present, often act in consortium with foreign capital. Indeed many countries require or reward some kind of local participation in energy and agricultural sector investments. At the same time, many foreign investors see advantages in associating themselves with local capital and expertise.

It is not uncommon for energy and agricultural sector investments in many African countries to include some degree of donor financing; either funds that have been channelled to the government for use in supporting and regulating investment or in the form of co-financing of economic and social infrastructure. While there is still limited involvement in the actual investment process, there have been wide-spread calls for donor financing to assist in such areas as technology transfer and adaptation and the analysis of environmental and social impact.

3.5 Present industry, including Fuel Distributors

Present industry includes sugar cane based sugar production, and installations such as sisal and forestry plantations, where waste and by-products can be important inputs into cogeneration. Present industry would have advantages in a number of areas regarding biofuel production, and it would thus be important to include them in the planning for investment decisions.

Many agro-industries operating in Africa today could benefit from shifting part of their operations to biofuels and cogeneration. One of the important roles of government is to promote the exchange of experience and information in this area.

Fuel distributors

[1] For a detailed recent discussion, see Joachim von Braun and Ruth Meinzen-Dick, “Land Grabbing” by Foreign Investors in Developing Countries: Risks and Opportunities” IFPRI Policy Brief 13 • April 2009

Fuel distributors play an important role in supplying fuels for the cultivation of biofuels and its transport to processing facilities. Distributors could engage in biofuel distribution – and even production - if this represents a commercial opportunity.

Indeed, the great advantage of ethanol from a commercial point of view is that it can be blended with already existing fossil fuels which use the current distribution network. Investment in non-blended fuels, particularly biodiesel, opens up the possibility of more locally controlled sources of energy but, at the same time, requires new investments in distribution infrastructure.

3.6 Commercial Farmers

Large-scale commercial farming accounts for a small, but increasing segment in the agricultural sector. Often times, although they number less than 5% of the population economically active in agriculture, production from these farms accounts for the lions share of the inputs into agro-industrial processing volumes.

Investors in biofuel processing plants base their financial feasibility calculations on a certain minimum volume of feedstock input. It is clear that a large-scale investor places a high priority on ensuring reliable volumes of feedstock, and that controlling the production process in a large-scale plantation is the most direct way of obtaining that security.

3.7 Smallholders, Cooperatives, Outgrowers

Smallholders typically combine cultivation of crops for subsistence with cash crops. Holding around 1-2 hectares of land, production capacity is limited from the point of view of the industry. It is not surprising that industry views the prospect of receiving a significant amount of feedstock from outgrower schemes with some scepticism, even though these schemes are frequently mentioned as a possibility, especially during the pre-investment phase, when environmental permits and land leases are being sought.

Successful outgrower schemes, primarily in sugar cane and sisal production, have often developed from an original plantation which has either expanded in this form or been taken over and divided up. Several of the potential biofuel feedstock crops indicated in Table 5 (section 6.3), could be suitable for both large and small scale irrigation, and all could be grown under smallholder production systems. Outgrowers may either be aided, e.g. where the seeds are provided for and parts of the cultivation process is carried out by the collaborating industry, and unaided, where the biomass-to-biofuel processing industry simply buys the feedstock from the farmer.

3.8 NGOs/CSOs/PSOs

NGOs play an important role to develop small scale farming in many countries in terms of access to credit, extension information and development of appropriate technological solutions to small-holder needs. They are also important in terms of their potential advocacy role for marginalized groups

NGOs and CSOs are important channels to communicate the needs and requirements of the smallholder sector to the policy process. They are equipped to carry out studies of the effects of different policy measures aimed at or affecting smallholders and they are a cost-effective channel for disseminating information to smallholder agriculture. They may also be effective in an advocacy role and it is important, then, that they be in possession of up to date scientific and empirical information.

Private Sector organizations often represent the larger and more industrial actors; both in the agricultural sector and the energy sector. These are important focal points to involve in dialogue between different interests and thus important reception points for scientific and empirical information.

4 Foreign Direct Investment

Stimulating agricultural productivity and rural economic growth?

4.1 Introduction

Investment is an indispensable element of the realization of any venture. Even building a basic rural house or hut requires investment; use of human resources, land, tools, raw materials etc. Smaller projects may require only the use of locally available resources, made accessible to the project owner by legal rights or barter.

Above a given level of resources needed, especially if a standardized, often imported production unit is involved, capital is usually part of project realization. This capital can come from national sources, foreign sources, grants and loans, or more typically a combination of these. Investors may be the operators/users or industrialists in it for the long haul, or seek entry and exit for the crucial period of cash-intensive project development, e.g. for five to eight years.

Examples of investments in the area of biofuels and bioenergy include developments in Alternative Energy, Forestry, Farming or Agriculture, Micro finance and related Sustainable Business Practices. The demand is huge in terms of power generation alone: US$ 4 billion will be needed in generation, transmission and distribution networks and in off-grid infrastructure to increase electricity access in sub-Saharan Africa to 35% by 2015 and to 47% by 2030. This is in addition to the financing needs for expansion of the electricity networks to maintain economic growth (World Bank 2007 estimates).

FDI inflows into Africa in 2008 were $88 B USD (Source: UNCTAD). FDI into the region has been affected by the financial crisis, particularly the oil-exporting and middle income countries. Ironically, many low income countries have been less affected due to the fact that they tend to be less integrated into the global financial system.

This chapter focuses on FOREIGN direct investment (FDI) regarding biomass based energy. It is assumed that most of the capital requirement for developing renewable energy infrastructure is likely to come from this source.

Due to the capital intensity of bioenergy projects there is a need for “informed” FDI to assist the development of these projects. This means that the allocated FDI in terms of the developed projects will need to respect the local land rights and local food production, the water availability and be built in a way that respects the biodiversity of the region. The projects will need to be built sustainably providing long term carbon and climatic benefits. All of these requirements mean that investments should be preceded by a systematic collection and analysis of the information required for a sustainable project design.

When these biofuel projects are developed correctly they can have enormous benefits to the region in which they are built. The project can provide rural economic development, rural employment, and incomes from a cash crop. Indeed the project can also acts as a stimulus to improve agricultural productivity and capability building within the region. This could be a crucial function as there has been little or no improvement in per hectare agricultural productivity in the Africa region over the last forty years. Two thirds of the labour force is engaged in agriculture and this produces one third of African GDP (World Bank). Agriculture and bioenergy projects could be a significant source of growth in this region.

The development effect of bioenergy projects can equally be a way to transform and develop agriculture. Of course there are other macro-economic benefits to the individual country in terms of increased security of supply, increased availability of foreign reserves and the possibility of exports.

Equally if the sourced FDI does not have a long term view and is not prepared to engage in a socially responsible manner, biofuel development can alienate the local community and not be of underlying benefit to the local and national economy.

Providing financing for this project development is difficult and requires institutional or multi-lateral support. In this sense the development of “Renewable Energy Development Agencies” at the national level is an encouraging sign in the process of supporting the roll out of funding programmes. However, funding is not the only consideration, equally important are the education, information, demonstration programmes. Investors need to adopt a holistic approach and to have a minimum of a five to ten year timeframe in mind.

4.2 Investment fundamentals

A biofuel investment can be looked at from at least three perspectives; For the **project owner** or benefactor perspective, the project realization will bring benefits of one or more kinds such as income, products, employment, or it may solve an environmental problem.

For the **investor**, or group of investors, the project will bring revenue within a given time period. For the **public representative** (national or local government), the project will generate employment, improve health, safety and/or increase economic growth in the administrative region.

These three actors may have diverging ambitions in regards to the investment. Local conditions, regulation, the market situation, the bargaining power of the respective parties and a host of other factors will influence the agreed development plan.

To give a basic understanding of the procedure in an industrial scale project, a relatively simple stylized case is described here. A simplified biofuels investment case may look as follows:

CASE STUDY

A company wants to establish biofuel production in a SSA country. This requires the involvement of a number of smallholders growing a crop on their lands and delivering the crop to a collection hub or to a production unit. Some land is held on long term lease by the company for cultivating part of the biomass input. A standardized production process yields the coveted fuel and a residual cake. Additional biomass used for CHP (Combined Heat and Power) production is trucked in. The produced fuel is stored on the premises until loaded onto tanker trucks and sent to a refinery for blending. The cake is returned to smallholders as a bio-fertilizer.

For the project owner, the objective is to ensure swift construction, leading to steady and high quality production, potentially increasing the yields through learning and adding additional locally grown feedstock overtime. The development of market demand requires ensuring good quality raw materials, good vehicles and reception facilities, a production unit of good quality, well trained staff and management, with a potential for increasing production through new production modules and access to good infrastructure.

The project is funded 50% by a local construction firm, a European DFI and the project owners (the “equity” part), and the other 50% is shared by the African Development Bank and two national commercial banks (the “debt” part). Further, a grant of 10% of needed capital is given by two public donors (World Bank country aid) under certain conditions.

From a domestic financing perspective, the project is overseen by the national investment agency. For the investor (both public and private), the objective is to maximize return on investment under locally acceptable terms. This means trimming the investment as to staff, storage, vehicles, production technology and other necessary items so that the amount of capital needed to commence production is minimized for a given production level.

For the public representatives overseeing the investment, the objectives may be many: employing as many as possible, for the project owner to include housing, schools, hospitals and other amenities for the employees, help with the construction of local infrastructure, income from employment taxes, corporate tax, export tax, sales tax etc.

The different parties negotiate the right level of investment to balance the different perspectives. Contracts are negotiated for supply of feedstock, production technology, construction, sales of fuel and by-products and other required elements of production. Land is leased for the cultivation of energy crops. The allocation of capital is part of what is agreed in the contracts. What is agreed is usually not transparent to the public.

In execution of the project plan, part of the leased land is reserved for the production unit. Permits are sought (if this is not done beforehand) and an environmental impact assessment or study (EIA or EIS) and other studies are carried out as required. This represents a cost and can be part of the investment, or part of the preparation of the investment. The funding of permits and impact assessment must be agreed and secured early in the project, since lack of funding once the project is initiated can cause delay or even stop the project.

Funds are then drawn to contract key staff, procure technology and erect fencing, housing, carry out landscaping and set up storage for feedstock, intermediates, products and by-products. If needed, housing and other amenities for staff and staff families are constructed. More funds are allocated to pay for seeds for outgrowers. The local government is asked to help in developing connecting infrastructure for roads, water, electricity and perhaps a railway or port connection.

As the construction phase is coming to an end, more staff is hired and the company land and outgrowers deliver raw material to the plant. After a test period, sometimes called commissioning, production commences and is gradually increased. Working capital funds are now used to buy feedstock until the first revenue from selling the product comes in.

Production is now underway. Some additional funds may be drawn upon to address increased demand or a call for efficiency increases. After a few years, the investor will typically seek exit by selling its stake in the project, collecting the profits of having supported and established the particular biofuel production project.

For an investment as described above to go ahead, the invested monies would have to be recuperated through the income of the project after a number of years, for larger projects typically seven or eight. This means that those involved in funding the project would have to invest their funds in the project for this period.

4.3 Drivers, inhibitors and support

How does what is happening in the world around us affect the implementation of investment decisions?

There are a number of external factors that could affect an investment. This means that the development of a project could be affected for reasons exogenous to the project, and that the decision to go ahead with a given project must take also these aspects into consideration. A brief overview of examples of such factors is presented below.

- *World economy*

Even if there are sound economics in favor of a project, investors may bail if there is a looming threat of a global or regional economic downturn. World economics may affect production factors such as demand. An example is the recent downturn in the development of the relatively efficient ethanol production in Brazil. Brazil is one of the world's two major ethanol producers, and most of the fuel is consumed domestically. The success years 2007 and 2008 led to development plans of approx. 50 billion USD, much of which has stalled as prices dropped and the financial crisis reduced the possibilities of funding. Since the price and demand for sugar, the alternative product of the industry, has also gone down, pundits believe in strong consolidation of the industry.

The former agricultural minister of Brazil, Roberto Rodrigues, estimates that of the 200 companies in the sugar cane industry today will be reduced to 50 in five years. Only 25 of the planned 40 plants to come on stream in 2009 are now thought to be in a position to go ahead. Also the continuing low price of oil and the contraction by a third of the value of the Brazilian currency, the Real, in relation to the USD, has contributed to the stagnation, as many loans were taken in USD as the value of the Real was increasing. As the production cost of cane ethanol is expected to equal oil at 40 USD per barrel, most new projects are mothballed rather than abandoned. Following the recent large seabottom oilfinds off the coast of Brazil, questions have been raised as to the future of the nations traditionally superior carbon balance.

- *Climate change*

Biofuels projects are favored for their carbon neutrality and ability to promote rural development, but much debate has followed recent announcements of the provisions of large swaths of land in SSA to foreign companies. While the planned use of some of these areas is for growing biofuels, studies earlier published in Nature, *inter alia* , have indicated that there are carbon net increases for decades after a forest is cleared to grow energy related crops. Other issues related to land allocation, discussed in chapter 10, may lead to regulatory inhibition of projects or media scares as discussed in the following section. Carbon reduction-driven measures such as the Clean Development Mechanism (CDM) and Joint Implementation (JI) projects of the Kyoto protocol and its successors may, however, induce the further development of biofuel projects.

- *Media scares*

Recently, a number of reports have surfaced, describing different types of risks especially with large scale biofuel production such as palm oil. In addition to providing useful bases for decisions regarding biofuel projects for decision makers themselves, there has been a trail of media exposure, describing biofuel as a threat rather than an opportunity for domestic production and security of supply for local customers.

Indirect land use change (ILUC) has been flagged as a serious risk associated with biofuel production, given that the required feedstocks for such production would require large space for cultivation. The logic is then that the capital freed up from selling this agricultural land in a less sensitive area would be used to acquire land and exploit more sensitive areas. The end result of the establishment of biofuel production in this case would then be that areas with sensitive environments would be worse off than before the project.

ILUC may occur if swaths of land not previously used for agriculture, or those used for low-intensity agriculture, are bought up at elevated prices, freeing capital for land owners. The now comparatively land poor but cash rich groups would look to re-establish in another location, e.g. a new farm in an area with attractive land prices and suitable soil and rain characteristics. Land prices, growing conditions, grants and other support mechanisms may point to certain areas of the country, in some cases areas worthy of protection, yet lacking such protection due to weak regulatory institutions or control.

ILUC may follow from other development than biofuel, and its mitigation is often difficult due to its indirect nature. Solutions may include more active land management or inclusive development schemes that do not require relocation of land owners.

- *National policies*

National policies as a driver of biofuel development are analyzed in detail in Chapter 7. Suffice it to say here that national policies and incentives are often a determinate factor in shaping biofuel development.

- *Logistics and fuel and energy demand*

Insufficient infrastructure is a common inhibitor of production project development. In the case of rural projects, there may be an advantage in that local demand is enhanced if the region is landlocked and long truck transport is required for any goods.

For fuel production projects, the product can also be exported, which adds demand to the logistic chain. Demand for biofuels is based on alleged reductions of carbon footprint, and both domestically produced and imported biofuels receive benefits in some markets, including the EU and USA. These benefits are both for domestic production on these markets as well as imports. Given the intensive debate on the calculation of benefits of any given type of biomass based fuel, how the projected shortage of fossil fuels (Peak Oil) translates into supply, pricing and demand of conventional fuels, and the difference in aptitude to make changes towards reducing climate change on different markets, incentives and other control measures to foster biofuel development are likely to swing and differ across the globe also in the coming decade.

- *Competition*

When deciding on an investment, the investor should compare the benefits of making the investment on the project in question or somewhere else. If the alternative investment is more profitable, the investor may choose to withdraw from investing. This can happen also when negotiations are advanced, sometimes past the signing point. It is thus important for all actors to ensure that the project in question remains attractive and profitable. For the benefactor-cum-investor, there is no choice since the local connection is strong, but larger foreign investors of different categories often have a wealth of proposals to choose from. The so-called opportunity costs represent the return of the best alternative investment that will be foregone because limited resources are channelled elsewhere.

- *Markets/demand for fuel*

In the case of biofuel projects in Africa, the market demand for the product is a significant project risk. In order to ensure project viability and finance to the project it is almost necessary to ensure that there is a mandated market for the produced biofuel. This is the case in the EU with the gradual introduction of the mandates across the member states. It is possible for biofuel projects to sell into the EU markets, given that African states have favourable market access treatment. This also means that in the short-term, projects on the West coast of Africa, have a greater chance of success given their proximity for shipping to the European market. In the longer term, also India and countries in the Far East may become renewable fuel importers. This policy aspect needs to be developed and implemented locally on a country by country basis.

- *Weak enabling environments*

Very few African countries have the necessary enabling environment in place to promote renewable energy exports to the EU, for example. It is necessary therefore to create an enabling environment by establishing the necessary policy, legal, regulatory and economic frameworks, improve access to knowledge, and strengthen institutional capacities. These steps help reduce risks and transactions costs, and thereby encourage renewable energy investment. The various institutional models including the EU renewable energy directive can be used as a reference case in terms of rolling out policy and legal structures.

- *Lack of access to capital*

There is a funding gap for renewable energy as commercial lenders perceive such investments to be too risky. The high capital costs of renewable energy investments further exacerbates the problem. When there are capital constraints, the tendency is to favor projects that may have lower upfront capital intensity; this is particularly the case in large scale biofuel and bioenergy projects.

- *Need to engage public and private sector.*

The private sector is a critical partner, and it can be most effective in scaling up renewable energy investments if an enabling environment exists. This underscores the important role of the public sector in setting the policy and regulatory framework for private sector interventions and contributing to investments in the early stages of a transformative program.

- *lack of affordability:*

Even with increased access to investment resources, many potential customers may have limited financial resources to make energy purchases at a scale needed to make renewable energy businesses financially viable. Long-term commercial viability is a prerequisite for sustainable and affordable energy services. Ten to twenty year timeframes are the norm when investing in these type of bio-energy projects.

4.4 Investments in the local context

How does the local context shape the design and implementation of investments?

How investments may impact on the local physical or socio-economic environment is discussed in Chapters 8, 9 and 10. How, then, are investments affected by the local or national environments? There are a number of factors which come into play here, they include:

- *Regulations*

Governments may decide to give any given issue priority - e.g. food, infrastructure, energy, tourism etc - which may help or hamper the development of sustainable biofuel production. It is difficult to discuss this topic in specific terms since policy differs widely between countries. However it is important from an investor perspective that regulation is in place to support the development of the bioenergy infrastructure. This can include among other things defined sustainability criteria, established mechanisms for supporting renewable energy production such as feed-in tariffs for renewable electricity (REFIT) and biogas, co-financing in terms of infrastructure development, supportive taxation policy etc. ***One of the key risks to project finance in the bioenergy area is a lack of policy and regulatory clarity.*** This is an area where it is possible to instigate capability building actions between EU partners and African governments.

- *Public Opinion*

Local public opinion may enhance or prohibit the development of a bioenergy project.

An example of this is the moratorium of biofuel development in Tanzania, established as a result of a report (Mwamila et al, 2008) pointing to a lack of knowledge on the effects of larger scale biofuel projects.

As described in the section on outgrower schemes, involving smallholders may be an effective means to involve the local community. In a tentatively more fuel scarce future, developing and operating fuel production projects for local vehicle use may be instrumental for local development. On the other side of the coin, evicting smallholders for larger renewable energy projects without allowing those evicted access to the new amenities may cause unrest[2].

- *Co-development*

Food and fuels may be grown and produced together. There may be a local or regional demand for a type of food, where its cultivation produces not only the raw material for the food type but also an additional amount of “waste” biomass. An example of this is food banana or *matoke*, a popular food in Uganda which peels can be collected as biomass for subsequent use. This biomass could be used to generate electricity and heat and cooling (so-called tri-generation) which may boost profitability and robustness of production. Production of food and energy is then co-developed, sometimes by different industrial entities using the same raw material base. Another aspect of this is intercropping, where e.g. jathropha could be grown together with e.g. banana or matoke to enhance yields of both plants.

- *Natural environment*

The most obvious interaction between the natural environment and a biofuels investment project is regarding impact from changes in climate and the availability of water. African agriculture is plagued with periods of drought and flooding, where both extremes will affect production. Only 5% of the land area is under irrigation. In the case of rainfed sugar cane cultivation and harvesting, rain periods determine the extent of harvests since rain is required for plant growth, but field conditions may inhibit harvesting when road and fields are too wet for trucks and harvesters.

Other changes in the environment due to the establishment of bioenergy production, such as new animal (or human) migration patterns, drought, water use, wildlife, pollution, increased traffic, eutrophication, acidification etc may also inhibit bioenergy projects.

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[2] An example of this is the construction of the Hale dam and power station in Tanga region, Tanzania, where those evicted for the storage dam still do not have access to electricity (Mbonile, 2005).

- *Investment Centre/capacity*

Most developing countries have an institution that coordinates FDI nationally. Organizations such as the Uganda Investment Authority and the Tanzania Investment Centre are established to provide investors with information, licenses, possible joint ventures and land advice. They would also advocate to government if new policies or regulations are required for the investment to advance. These institutions enhance the degree of control of capital entering the country, both to enable taxation and other national benefits, but also to avoid scams that would deter future investment and investors.

4.5 Managing the investment context

To manage FDI in a positive manner, investments can (and should) be guided by local regulation regarding the product, national FDI management as well as certification of the end products and any other interaction between the target country for the FDI and the region where the FDI is sourced.

A number of initiatives have been developed to make investments more sustainable from different perspectives. These range from local regional and international laws, written and unwritten, and Ethical Investment Guidelines, one of which is known as the Equator Principles. Corporate Social Responsibility (CSR) would have implications also regarding worker conditions, the environment and the social context around a workplace. Child labor reduction plays an important role in achieving sustainable investment principles.

There is a "Green Banking" trend emerging which will have a profound effect on capital availability over time. This is the approach adopted by the IFC (International Finance Corporation, www.ifc.org). IFC provides financing in the form of loans and equity to climate-friendly projects.

Increasingly, MDB (Multilateral Development Bank) banking Green Credit Policy encourages local banks to lend less to enterprises with high levels of pollution and energy consumption and more to those favoring energy efficiency and emissions reductions. This is a continuous process. Governments and financial institutions are looking for internationally recognized good practices in environmental policies and implementation standards. The most important reference points are as follows:

- The Equator Principles, a set of principles for social and environmental risk management in project finance that nearly 68 financial institutions have adopted worldwide as of August 2009. This adoption rate accounts for 95% of project finance globally.

- IFC's Performance Standards, defining IFC clients' roles and responsibilities for managing projects and their requirements for receiving and retaining IFC's support

• The World Bank Group's Environmental, Health, and Safety Guidelines, technical documents addressing 63 industry sectors, IFC and the Chinese government

There are now annual awards for sustainable banking. These awards recognize financial institutions for leadership and innovation in integrating environmental, social and governance considerations into their operations. Equity Bank of Kenya was the regional winner for Africa and the Middle East in 2009. Equity Bank was also named as the Micro Finance Bank of the year for Africa in 2008 and 2009 "for assisting local communities and aspiring entrepreneurs to raise finance, ultimately contributing to their growth and development."

Risks for badly managed FDI include sensitivity to the hypes and scares described in section 2.2, which could lead to stalling a project in an environmentally and socially sensitive situation, exposing a region to a monoculture over a large area which in turn could lead to problems with pests, migratory barriers and depletion of habitats and local biodiversity, as discussed in chapters 8, 9 and 10.

4.6 Investor categories

How do stakeholders in the field identify whom they are dealing with in terms of investors?

4.6.1 Introduction

Financial resources are different: there are managed funds, private capital, exchange traded funds and a number of others. The type of funding used by investors depends on the type of project. Renewable energy finance may be segmented by the size of projects and type of debtor:

- consumer and microfinance for off-grid projects
- corporate finance for small on-grid projects, and
- project finance for large scale projects;

Typically, a larger project has different types of funding where FDI plays an important role. The following is a description of different types of funding, describing the rationale of each entity to enable an understanding of the viability of a project to field staff.

4.6.2 Domestic and regional private investors

In this category are wealthy individuals, acting in the capacity either of the individual or representing, for example, a family company. This is not a major source of funding, but this category could invest on other grounds than pure financial if the project aligns with the intentions of the individual or company. This category could potentially act more swiftly than an institutional investor such as a fund. An investment by a private investor would not necessarily be public or susceptible to the normal financial "due diligence" that is norm.

A privately funded project would not necessarily be subject to third-party ethical and environmental evaluation in the same way as is increasingly the case for institutional investors. These characteristics can be both a risk and a possibility regarding public benefit and environmental and financial performance.

There is also the aspect of the local entrepreneur who develops the project planning phase of the bio-energy project. This is a difficult and time consuming task that needs institutional support in the form of feasibility/ technical assistance grants. If the source of FDI can act in concert with a local entrepreneur who is well anchored in the local community; it can provide a framework for sustainable entrepreneurship.

4.6.3 Domestic and regional institutional investors

For a project to go ahead, it may be wise to look to also national sources of funding. Local backers of a project may open doors and give increased operability and credibility, especially if technology is imported and the industrial experience in the area is low.

4.6.4 Private foreign direct investors

Private capital, often channelled through funds, is a normal way to find capital for many types of projects. Unless these funds are highly specialized towards e.g. Africa and/or the environment, many of these would undertake investments in a rather limited geographical area, such as Europe and/or the US.

Such funds normally have an investment lifecycle including exit strategy (time span of 5-10 years). The investment decision is preceded by a comprehensive due diligence of the proposed project including the execution capability and experience of the management team.

Other factors such as industrial technology risk, market risk, political risk, infrastructure risk ownership stability etc. are comprehensively evaluated (see appendix __). In the case of African bio-energy projects the infrastructure risk will receive additional focus. This includes road/rail/port infrastructure, local health and education infrastructure, electricity and water availability. These issues can add significant additional capital expense to a project.

Examples of investment performance measures are: EBITDA[3] (50 to 60%), IRR[4] (30%) & EBIT (25%). A private investor will typically expect these rates of return in a given project.

Investors, either as private individuals, corporations, foundations, or funds, typically manage a portfolio with a number of projects in different stages of the investment development lifecycle. The primary activity of the investor is thus to manage the

[3] The financial term "Earnings before Interest, Taxes, Depreciation and Amortization" represents the profitability of a company without financing and accounting decisions. It is not a standard term in terms of accounting principles and must thus be revised for correctness.

[4] The "Internal Rate of Return" indicates the rate of return on the budgeted cash flows that makes the net present value of these flows equal to zero, i.e. the higher the IRR, the more attractive the project.

portfolio, maximizing profit over the life of a fund. It is important to source capital that has a certain knowledge and experience of Africa. Renewable Energy Investment funds tend to act within very strict investment parameters and if the bio-energy project does not fit within those parameters; then there will be no investment; even if it is an excellent project.

Given that African bio-energy projects have additional risk and investment cost it is necessary to mitigate this risk through soft forms of multilateral financing.

4.6.5 Development finance institutions

Development Finance Institutions (DFIs) are state-owned risk capital investment funds. In order to develop bio-energy projects there is a need for development capital. The DFI's (Development Finance Institutions) have been involved in development capital in the African region for a number of decades.

Development finance aims to bridge the gap between commercial investment finance and state aid. DFI's tend to invest in a partnership approach with a strong local business partner. In addition DFI's work with local commercial banks and investment funds. An example is Swedfund's investment in Africap (www.meceneinvestment.com) which is a $50 million Microfinance Investment Company established in Mauritius.

DFI's are an important third pillar in terms of the international development policies of European countries with aid and multilateral banks being the two other pillars. The Association of European Development Finance Institutions (EDFI) has 16 members. They are state-owned investment funds (except for OeEB and Sifem), mandated by their governments to invest in developing countries and emerging markets. Together they have a consolidated investment portfolio of €16.7 billion with 4,221 projects at the end of 2008. In comparison the International Finance Corporation (IFC) has invested €25.1 billion in 1,560 projects.

The DFIs could be a source of additional investment capital for bioenergy projects. Their business model is supportive of the entrepreneur. DFI's are also prepared to invest in sectors and segments which the private sector may find difficult to finance. For example, a large biofuel project may have a capital spend of $300 M. Some $ 20 MUSD of this may go into project development and planning. This can often be a difficult element to source funding for. An additional part of the DFI business model is to provide expertise and support the commercial development of their projects. This is an area that DFI's are keen to develop.

A key value adding component that DFI's have is their capacity to mobilize other investors (by sharing knowledge, setting corporate investment standards, etc.) This is also due in part to their knowledge of the African markets that they have built up over the years. This gives a sense of security to other investors that may wish to co-invest in the region. It is also possible that the investor may ask the DFI to co-invest in their projects for a period of time. This reduces the risk for the industrial investor and the DFI.

The DFIs have a significant direct and indirect impact on developing countries in which they operate. A recent study indicates that European DFIs together sustained close to two million direct and indirect full time jobs through their investments in 2008. In addition, their investments generated around €2 billion in tax revenue for governments in developing countries.

4.6.6 International finance institutions

The International finance institutions are certainly playing an instrumental role in terms of providing finance to renewable energy projects. The Multilateral Development Banks (African Development Bank, World Bank, IFC) are providing substantial funding programmes to renewable energy projects.

The World Bank has a particular emphasis on investments in climate mitigation measures including renewable energy. In 2009 the WBG financing of renewable energy and energy efficiency projects and programs in developing countries increased by 24 percent to reach US$3.3 billion. The lending is reserved for "new renewables" (solar, wind, geothermal, biomass, and hydro below 10 MW) and energy efficiency projects. In the period 2005 to 2009 the WB in Africa has committed financing of $ 552 M US to energy efficiency projects; $ 444 M US to new renewable energy projects and $ 999 M US to Hydro > 10 MW projects. In 2009 financing in the renewable energy and energy efficiency area represents more than 40 % of the WB total energy lending commitment. Very often these investments are leveraged by a factor of ten at a local implementation level meaning that the FDI can have a significant multiplier effect on local investment capacity.

In January 2004 the AfDB Boards approved the new Bank Group Policy on the Environment, establishing policy on environmentally sustainable development in Africa, followed by an Implementation Plan. The work of the African Development Bank in renewable energy has been operationalized partly through the Dutch-funded Financing Small Scale Energy Users (FINESSE) Program. During 2008, FINESSE resources supported the integration of renewable energy into current Bank activities, as well as the preparation of stand-alone projects through technical and financial support to develop feasibility studies in several regional Member countries. The overall goal of the FINESSE Africa Program is to assist countries in Africa, to work through the Bank in formulating the appropriate policy and regulatory frameworks and developing capacity to generate a pipeline of investment projects in renewable energy and energy efficiency (RE/EE or sustainable energy).

In addition there has been the establishment of the Climate Investment Funds (www.climateinvestmentfunds.org) which channels finance through the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, Inter-American Development Bank and the World Bank Group. Over $ 6.1 B US has been committed to these funds. The funds will be disbursed as grants, highly concessional loans, and/or risk mitigation instruments in the period up to 2012 through the Multilateral Development Banks.

The Clean Technology Fund has a more country specific approach and to date country investment plans have been approved for Egypt, Morocco and South Africa in the case of African states. In addition to the CTF there is a Strategic Climate Fund (STF) which has established a programme, "Scaling Up Renewable Energy Program In Low Income

Countries" (SREP). This programme has committed funds of $ 250 M; the Norwegian government being one of the significant programme supporters.

The SREP aims to help low-income countries use new economic opportunities to increase energy access through renewable energy use. The full text of the design document is contained in appendix 3. The need to increase modern energy use in low income countries, coupled with the availability of exceptional renewable energy resources, provides a fertile opportunity to help countries develop a renewable energy base that will allow them to leap-frog into a new pattern of energy generation and use.

The SREP is permitted to use a variety of financial instruments. They can include, among others:

a. Investment financing using equity and debt financing, capital cost buy-down, production incentives or other financial instruments to make renewable energy investments and related transmission and distribution investments financially viable.

b. Credit enhancement or risk mitigation that leverages trade finance and short term working capital finance to renewable energy suppliers provides partial risk coverage to investors that lack adequate credit history, and limited collateral for securitizing the renewable energy loans or other risks.

c. Grants and loans that can be lent-on through domestic financial institutions, including micro-finance institutions for renewable energy investments.

d. Feed-in tariffs and other performance-based incentives. These incentives will be based on actual production of energy from renewable, time bound and transparently sourced and targeted so they lead to commercially viable renewable energy applications that would not be dependent on such incentive payments over the longer term. This is a particularly important policy input.

e. Grants for technical assistance, program and project preparation and implementation, and capacity building related to policies and legislation conducive to the renewable energy sector and knowledge management. It can often take three to five years to build institutional capability that is replicable and encourages best-practice. The importance of this instrument should not be underestimated.

The SREP programme is indeed multi-faceted in its approach and allows for institution capability building as well financing of individual renewable projects. This will also allow sharing of knowledge between the African states over time.

Institutions such as the African Development Bank (AfDB) may facilitate lending by arranging roundtables and bringing different actors in to reduce insecurity.

In order to instigate change we can also see that there is a "Green Banking" trend emerging which will have a profound effect on capital availability over time. This is the approach adopted by the IFC (International Finance Corporation, www.ifc.org). IFC provides financing in the form of loans and equity to climate-friendly projects.

A special type of fund is the African Biofuel & Renewable Energy fund (ABREF, www.faber-abref.org), also working based on CERs (Certified Emission Reductions). Focusing on West Africa, the fund works with a number of partners to contribute to the development of a biofuels and renewable energy industry.

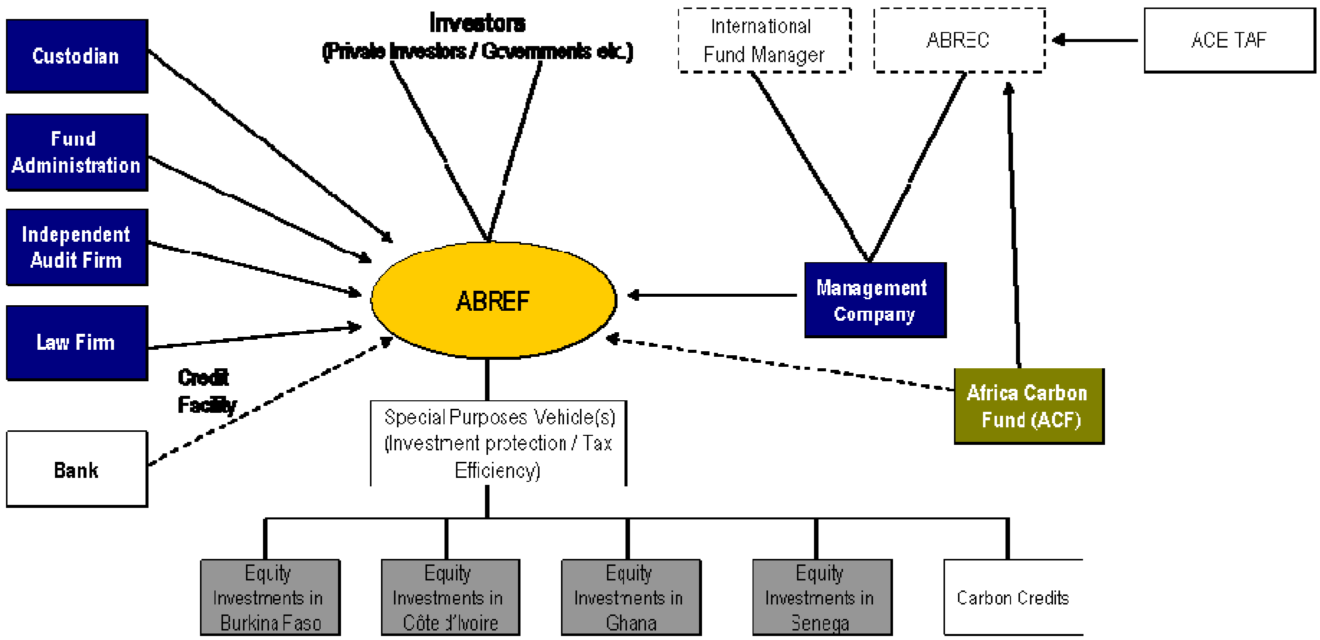


Figure 3. ABREF fund structure and partner outline

4.6.7 Debt financing

As mentioned, an investment typically includes a fraction of bank loans or debt in addition to equity. To give a loan that would match or surpass the equity stake, commercial banks would typically need to and want to reduce investment insecurity to a minimum and fence in the profitability and performance of the plant. Commercial banks would thus undertake detailed client screening procedures and will require substantial collateral as security against failure to replay the loan. Conditions (rates) are subject to negotiation.

4.6.8 Aid organizations and donors

Aid organizations can help in many ways to facilitate biofuel investments where project plans align with development goals. Donors can complement more commercial investment to form a sustainable system for a given region. It has been suggested that rather than contributing to the investment directly with donor money, different types of training, infrastructure and equipment can be provided. By providing training in sustainable technologies for young businessmen, aid can interact with entrepreneurship.

Additionally there can be deficits in terms of health, education and road infrastructure in the communities where these projects are developed. Here the aid agencies can facilitate development in the local community. While the biofuel project can act as a substantial local stimulus, involvement of the aid organization can provide support in terms of improving the social and community environment.

There is also the specialist form of aid organization which is focused on reducing poverty through the development of renewable energy. An example of this is the Koru foundation of the United Kingdom (www.korufoundation.org). A series of European industrialists, involved in the renewable energy industry in Europe, are keen to assist communities that are energy poor and exposed to the specifics of climate change. This is an interesting form of project aid where project expertise is supplied to enhance the project. In the case of the Koru foundation it is sponsored by the European Wind Energy Association. From viewing the Koru corporate sponsors there are indeed elements of corporate social responsibility being exhibited and played out.

4.6.9 Other factors/methods

If a project in SSA includes imported goods, one way to ease the procurement process is through an **export credit agency (ECA),** when a private or quasi-governmental agency, typically from the country of the technology provider, takes the risk of the payment from the customer. ECA finance may offer competitive commercial terms, enhanced bankability, and political risk cover for biofuels projects in Africa.

Carbon Finance
The carbon finance market is another aspect of finance. This market now provides $6.5 billion a year for emission reductions, directly to projects in developing countries. **Carbon credits** under the Kyoto protocol[5] can be a source of funding for a project which includes reducing greenhouse gas emissions. Companies such as Tricorona in Sweden and Climate Interchange AG in Germany develop projects that reduce carbon emissions and transfer technology from Annex 1 countries to non-annex 1 countries. Certified Emission Reductions (CER's) are transferred to the Annex 1 country, which then reduces the amount of carbon reduction needed domestically to meet requirements under Kyoto.

National governments in developing countries can also co-invest in rural projects that will address development issues such as housing, schools, hospitals, infrastructure etc. Such investment can be direct and indirect, in the form of grants and soft loans. Through legislation, governments can also give incentives to others to provide funding

For small-scale projects, different types of micro-loan schemes have developed through organizations such as Grameen bank and Kiva.

[5] CDM, the Clean Development Mechanism, is one of the Kyoto Protocol financing mechanisms which can be used to finance renewable energy. However Africa hardly benefits from CDM and is the region with the least number of CDM projects, 2.6% of the global total.

4.7 Case studies

4.7.1 Sugarcane ethanol in Sierra Leone

Addax Bioenergy is a division of Addax & Oryx, a Swiss based energy group. AOG was created in 1987 and has become a leading petroleum and mining company in Africa. Addax Bioenergy was established in 2008 to develop renewable energy projects.

The petroleum company Addax Oryx decided in 2008 to perform a feasibility study on the production of ethanol based on sugar cane. Based on the study, the company established Addax Bioenergy with the intention to establish an integrated sugarcane plantation and ethanol distillery in the Makeni region in Sierra Leone producing ethanol, electricity, biogas and food and have acquired 26,000 hectares of land for sugarcane cultivation. Project cost was estimated to about USD300 million with planned production commencing in 2011. The project is co-funded by several entities in addition to Addax Bioenergy. The plant will be capable of producing up to 170'000 m3 of ethanol per annum, primarily for export to the European market. The biomass-fuelled power plant will achieve an excess capacity of up to 30 MW available to industry and consumers. Addax is working together with seven Development Financing Institutions (DFIs) to realise and develop this project: EU-EFP-EIB, the UK Emerging Africa Infrastructural Fund (EAIF-UK), *Deutsche Investitions- und Entwicklungsgesellshaft* (DEG) which translates into the German Investment Corporation, FMO-Holland, OEB-Austria, Swedfund-Sweden, as well as the AfDB-Africa. The project will adhere to the EU sustainability standards in terms of the protection of the environment, greenhouse gas emissions and social responsibilities and also the IFC Performance Standards (World Bank).

4.7.2 Sugarcane ethanol in Tanzania

Another example of sugarcane ethanol development is the now paused project developed by the Swedish company SEKAB in Tanzania. SEKAB, a company owned by a number of municipalities in Sweden, in the first years of the new century had investigated the potential of cane ethanol for export from a number of African countries, and settled for Tanzania and Mozambique. Plans for a pilot processing plant and surrounding approx 20 000 ha sugar cane plantation were drawn up north of Dar es Salaam, as a first step towards the expressed vision of 400 000 ha. Funding came initially from the owners, with plans of funding the later phases of the project through FDI. The development of the pilot plant coincided the establishment of a National Biofuels Taskforce in 2006, and subsequent capacity building of the responsible branch of government, the Ministry of Energy and Minerals, funded by the Swedish state. Permits, leases and additional FDI proved difficult, partly due to limited water availability, and the project stalled in 2008 when the owners refused to continue funding the Tanzanian branch of SEKAB operations. In 2009 the Tanzanian branch of SEKAB was sold to Per Carstedt, former CEO of SEKAB.

SEKAB had similar but less advanced plans for Mocambique, through the majority owned subsidiary, Ecoenergia de Mozambique Lda.

Several projects were underway in 2007 in Tanzania. Biopact[6] tells of a 20 MUSD jatropha-to-biodiesel project launced in the Kisarawe coastal region. 8000 ha of degraded land was leased for 99 years. Since then, clearing of the land has commenced, followed by planting of around 600 ha[7].

4.7.3 Jatropha based power generation in Mali

The following case study is cited from PAC (2009): To develop a local electricity grid in the Garalo Commune in Mali in West Africa an overall budget of 756,000 USD was amassed jointly by AMADER, a parastatal company managing rural electrification, Mali Folkecenter, a local branch of a Danish NGO, and two other NGOs. The Mali Folkecenter (MFC) is the initiator of the project. AMADER provided a grant of almost 380,000 USD. The supply chain or production system is developed by the Garalo Jatropha Producers Co-operative and ACCESS, a local power company. The vision includes 10,000 ha of jatropha plantation, out of which 600 is already under cultivation. Agricultural methods such as intercropping are employed. A seed press and a hybrid power plant complete the system. The power plant will run on 5% locally produced oil in 2009, increasing to almost 100% by 2013. The balance is supplied by fossil diesel oil. Through the project, electricity is already available to villagers, and key conditions such as the press and local and national support are in place to reach the target of local power generation. MFC played an important role in initial fundraising.

[6] http://news.mongabay.com/bioenergy/2007/08/sun-biofuels-invests-20-million-in.html
[7] www.sunbiofuels.com

5 Background on Biomass, Bioenergy and Biofuels

What are the choices for investing in Bioenergy? Is Bioenergy really a new development?

5.1 Introduction

Biofuels have been used in the transport sector for over a hundred years, and have historically been quite important in times of conflict when oil supplies were reduced. More recently—in the past few decades—it has been recognised that they are not only valuable in terms of energy security but also that they can make a significant contribution to reducing greenhouse gases and addressing other environmental impacts of fossil fuels. Biofuels are also linked to the emerging bio-economy, since various co-products can find useful markets and further substitute for non-renewable resources, thereby making an additional contribution to the overall sustainability transition. Biomass resources can provide food, feed, fuel, fibre and many other types of products and services.

The role envisioned for liquid biofuels for transport has come under increased scrutiny in the past few years, due to the potential social and environmental impacts associated with scaling up ***biofuels production*** and use from its low level—***currently representing about 1% of transport fuels globally.*** At such low levels, the amount of land and resources required is relatively low, but if biofuels were to be expanded to ten times that amount or more, there are legitimate concerns about the impacts on the food supply, deforestation, socio-economic changes, and other impacts that are associated with large-scale use of land resources.

5.2 Biomass, Bioenergy, and Biofuels

5.2.1 Biomass Resources

Biomass is living matter derived from plants and animals. Energy sources from biomass are often divided into two main categories: wastes or residues, and energy crops. Biomass wastes or residues refer to the remaining biomass after harvesting and/or processing. The two categories differ significantly in the economics of utilisation as well as in biophysical terms.

Biomass residues include forest and agricultural residues (e.g. straw); urban organic wastes; and animal wastes. They normally offer the most widely available and least-cost biomass resource options. The principal challenge is to develop or adapt reliable and cost-effective handling methods and conversion technologies.

Dedicated energy crops refer to plantations of trees, grasses, oilseed crops and other crops that are optimised for energy production; the harvested biomass is used directly or serves as feedstock for further production of specialised fuels. The principal challenges centre on lowering biomass production costs and reducing the risks for biomass growers (stable prices) and energy producers (guaranteed biomass supply).

Like other renewable sources, bioenergy can make valuable contributions in climate mitigation and in the overall transition towards sustainable energy, but it also has two decisive advantages over other renewables. First, *biomass is stored energy*; like fossil fuels, it can be drawn on at any time, in sharp contrast to daily or seasonally intermittent solar, wind, wave and small hydro sources, whose contributions are all constrained by the high costs of energy storage. Second, *biomass can produce all forms or carriers of energy for modern economies*: electricity, gas, liquid fuels, and heat. Solar, wind, wave and hydro are limited to electricity and in some cases heat. Indeed, biomass energy systems can often produce energy in several different carriers from the same facility or implementation platform, thereby enhancing economic feasibility and reducing environmental impacts (Leach and Johnson, 1999).

Modern bioenergy systems have several other advantages over other energy resources, providing economic development benefits in addition to improving energy services. Bioenergy provides rural jobs and income to people who grow or harvest the bioenergy resources, as bioenergy is more labour-intensive than other energy resources. Bioenergy can increase profitability in the agriculture, food-processing and forestry sectors. Biomass residues and wastes—often with substantial disposal costs—can instead be converted to energy for sale or for internal use to reduce energy bills. Biomass plantations in some cases can help to restore degraded lands. Growing trees, shrubs or grasses can reverse damage to soils, with energy production and sales as a valuable bonus.

Bioenergy is inherently land-intensive (except for wastes, residues and aquatic biomass) *and the associated environmental impacts* (both positive and negative) *are more significant, relative to the energy produced, than those of other energy systems*. A comprehensive list of environmental impacts is difficult to summarise, but some key concerns relate to loss of ecosystem habitat, deforestation, loss of biodiversity, depletion of soil nutrients, and excessive use of water. In addition to provision of a renewable energy source, some positive environmental impacts include restoration of degraded land, creation of complementary land use options, and synergies in the provision of fibre and other non-energy products. The modern concept of a biorefinery is an integrated and highly efficient agro-industrial complex that uses multiple feedstocks and creates multiple products—food, feed, fuel, fibre and more—thus maximising the value of land resources and bio-based materials.

5.3 Land availability

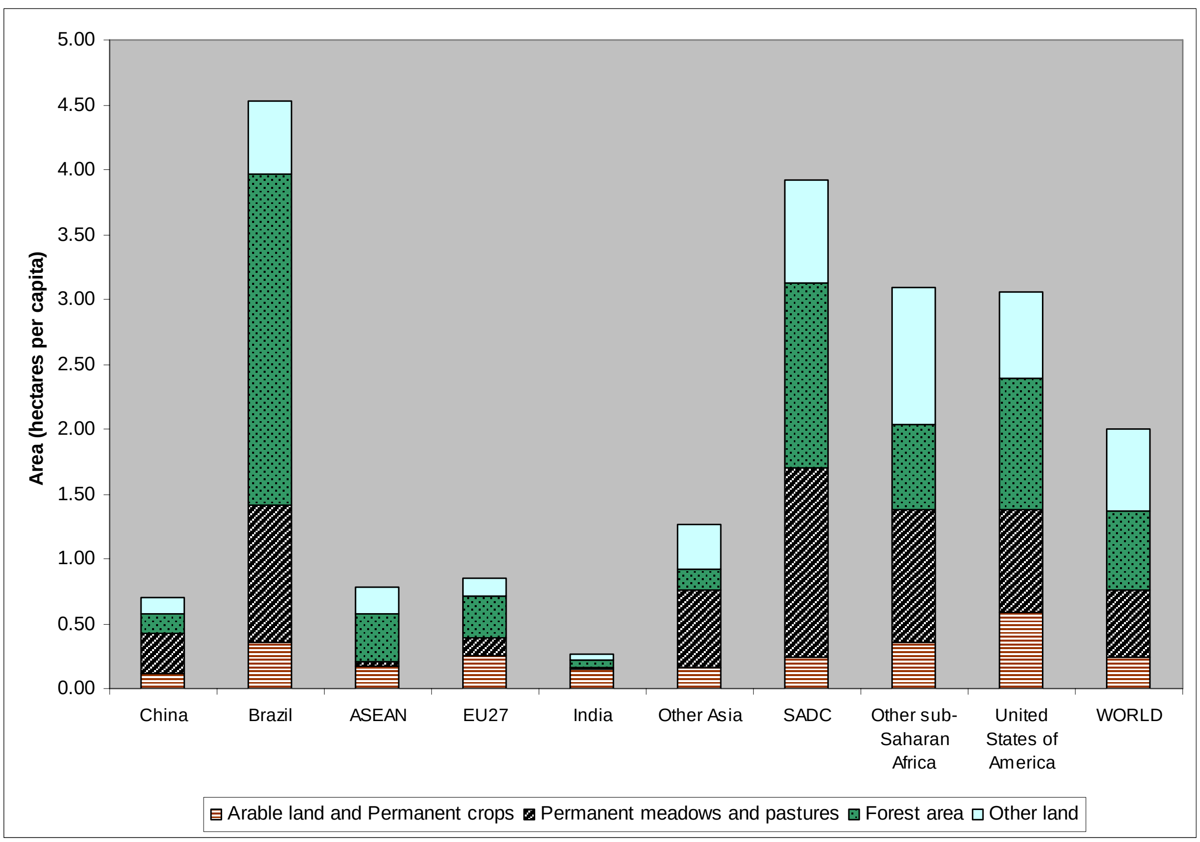
Agricultural reform, climate change and energy security have been central drivers in renewed enthusiasm for biofuels, which have also been seen as providing new opportunities for economic revitalisation in rural areas, in developing and developed countries alike. At the same time, growing demand is raising concerns about food security and environmental impacts. Balancing these concerns has become more difficult in the face of media coverage that tends to polarise the issues.

Currently, land devoted to growing biofuels is only 25 million hectares, or about 0.5% of 1% of the 5 billion hectares of global agricultural land (Faaij, 2008). Land conflicts have therefore not yet reached significant proportions, although of course it is important to improve scientific analysis before it reaches major proportions so that the potential impacts are better understood.

Biofuels have not been a major contributor to increasing food prices or to land degradation, but that does not preclude them causing such problems in the future should biofuels production reach much higher levels and/or move into sensitive regions. Furthermore, as the world faces dwindling and/or more costly supplies of fossil fuels in combination with increasing population, there will inevitably be more land pressures, since renewable resources require more land than the non-renewable fossil fuels they replace.

The distribution of available land is rather uneven with respect to population. Figure 1 shows per capita land by type for various regions and countries. Some developing regions, such as sub-Saharan Africa and Brazil, are well above the world average; by contrast, many regions in Asia are below the world average. On average, one expects that there will be more land pressures and more constrained options for biofuels in many regions of Asia. Even in some parts of Asia, however, there are sparsely populated regions that have significant potential. Yet in terms of regions and bioenergy trade, it seems likely that *only Latin America and sub-Saharan Africa could become major exporters.*

Figure 4: Land use per capita by type for selected regions or countries



Source for land use data: FAOSTAT database, www.fao.org

[1]SADC includes the 14 countries of the Southern African Development Community

[2]Arable land and permanent crops indicate current cultivation, but do not determine how much land is potentially cultivable.

5.3.1 The marginal lands debate

Biofuel proponents often point to abandoned cropland and other “marginal lands” that can be made available for feedstock production, including uncultivated or low-grade lands that can potentially be used for non-grain cropping and afforestation.

Much of the public discussion is focused upon notions of land resources “available” for bio-energy crops, but this discussion does not take into account either informal/traditional land use systems or the fact that in many African countries the limiting factor is water, rather than arable land per se. (more detailed discussion on these topics is provided in Chapter 10 below)

5.3.2 Food vs Fuel

The most advertised risk with increasing biofuel production is that of reducing accessible land and water resources for food production, thereby adding to the high and increasing prices for basic foodstuffs such as rice, wheat and maize. This would severely affect the already serious situation for Africa’s poor, and in addition cause public dissent for biofuel initiatives, both public and private. This, to some extent, is already taking place.

There are several possible explanations for the perceived shortage of land for food production, and biofuel is but one of these. The FAO representation in Tanzania roughly estimates the role of biofuels for the present food price increases to being 10-20%[8], along with growing demand in Asian countries, increased meat production and other factors. It is likely that a balanced, policy driven production of biofuels with appropriate mitigation measures, would not interfere with food production, but could increase the incomes of many smallholders.

Care must however be taken that analysis and policy differ when addressing large, industrial projects, compared to measures aimed at smallholders entering biofuel feedstock production. In Mozambique, Chinese investors have attempted to bring Chinese workers to acquired land, which would limit the involvement of local labor (von Braun and Meinzen-Dick, 2009).Larger projects and regional development plans should probably include support to subsistence for local inhabitants, especially those displaced by corporate cultivation schemes.

5.4 Biofuel as a driver of agricultural development

A number of developing countries, including many of the LDCs of sub-Saharan Africa have a major comparative advantage in biofuels and in agriculture more generally, but have been impacted negatively by competition from heavily-subsidised agricultural sectors in OECD countries.

Another issue relates to use economic incentives to promote bio-energy on degraded lands, which could put Least Developed Countries (LDCs) in Africa at a disadvantage

[8] Interview with FAO representative in Dar Es Salaam

since they have not yet reached an economic level where they have many degraded lands that could benefit from such incentives

Agricultural reform could offer some opportunities for them to modernise their agricultural sectors, using biofuels as a driver. Whether or not such increased market access and economic competitiveness brings poverty reduction and sustainable development will nevertheless depend on many other factors, including land tenure, property rights, resource allocation, credit access, and distribution and transport infrastructure. As with many other economic development issues, there are many different strategies for expanding biofuels production, some being much more sustainable and equitable than others.

5.5 Energy Crops

Use of wastes and residues for bio-energy is important for minimising environmental impacts and land use conflicts, as residues will generally require no additional land. However, use of residues is constrained by collection costs and the fact that they are not optimised for energy purposes. Scenarios for large-scale bio-energy expansion therefore assume that dedicated energy crops of some type will be grown in agricultural areas in order to maximise returns.

In assessing availability of agricultural land for energy crops, it is generally assumed that food and feed requirements should be met first. In some cases energy crops can grow on degraded lands, thereby minimising land use conflicts. In other cases, the same crop may result in multiple products—including food, feed, fuel, fibre and other categories; such multiple-use scenarios will depend on the particular markets that develop. Provision of economic incentives for bio-energy crops should therefore be concentrated on degraded, abandoned, or marginal lands where possible, and should aim to encourage multiple products.

Woody biomass from residues and improved management in natural forests, even with fairly stringent ecological constraints, can provide a significant amount of bio-energy resources. However, use of woody biomass in some regions, is likely to be considerably constrained by factors such as the demand for industrial roundwood, use of woodfuel for cooking and the important ecological roles of natural forests (Smeets and Faiij, 2007).

5.6 Global Bioenergy Potential

Global bio-energy potential has been assessed from a top-down perspective in major world regions in the long-term (2050) after accounting for food and feed production, using four scenarios under which the intensity of cultivation, level of technology, and amount of irrigation (starting from zero or rain-fed) were successively increased (Smeets et al, 2004). A summary of the estimated potentials for the four scenarios is given in Table 4.

Table 4. Estimated biomass potential for four scenarios and various world regions in 2050

	Potential (Exajoules)				*Share of world total*			
Region/Scenario:	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
North America	27	63	156	186	10%	12%	13%	14%
Oceania	40	55	92	106	15%	11%	8%	8%
East and West Europe	12	26	43	62	4%	5%	4%	5%
C.I.S. and Baltic States	48	76	188	203	18%	15%	16%	15%
sub-Saharan Africa (SSA)	46	114	280	335	17%	22%	24%	25%
Latin America & Caribbean (LAC)	58	130	202	232	21%	25%	17%	17%
Near East & North Africa	2	2	31	33	1%	0%	3%	2%
East and South Asia	37	46	181	188	14%	9%	15%	14%
World	***270***	***512***	***1173***	***1345***				
SSA+LAC	*104*	*244*	*482*	*567*	*39%*	*48%*	*41%*	*42%*

Source: Smeets et al, 2004

Overall, the global potentials range from 30% to over 200% of projected global energy consumption in 2050. Other sources of bio-energy that are not included in these potentials include animal wastes, organic wastes, and bio-energy from natural growth forests. Inclusion of such sources would increase the potentials by an additional 10 to 50%, depending on the assumptions (Smeets et al, 2007). Nor is aquatic bio-energy production included, the potential for which could be quite large, such as in the case of algae-oils for bio-diesel (Briggs, 2004).

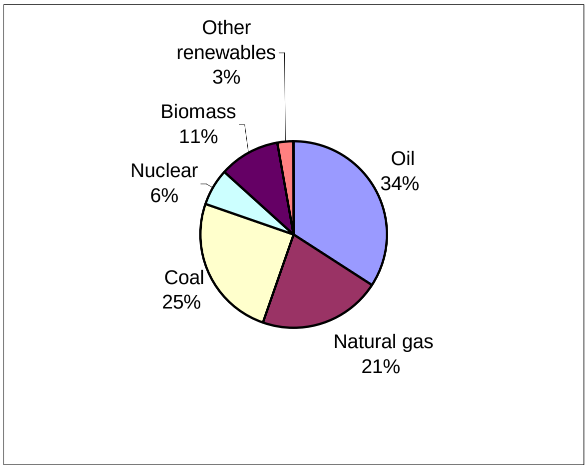
The bio-energy potential of Latin America and sub-Saharan Africa together accounted for 39% to 48% of global potential. The high potential results from the large areas of suitable cropland, large areas of pasture land and the low productivity of existing agricultural production systems. Since these regions together account for less than 20% of global population, they seem to be the most likely regions to become major exporters of biomass and bio-energy.

Highly productive crops such as sugar cane could contribute significantly to global bio-energy supply as well as supporting sustainable development in Africa (Johnson and Matsika, 2006).

It is important to note that these are technical potentials; the economic potential would be lower, as would the potential in the case when strict ecological criteria are applied. The application of strict ecological criteria and economic criteria for forest-based biomass resulted in reductions of availability by more than half in many world regions (Smeets and Faiij, 2007). Such restrictions would tend to have less effect on availability of agricultural lands for bio-energy, since there is more flexibility and more options available than for forests.

5.6.1 Traditional and Modern Biomass used for Energy

Biomass accounts for about 11% of total primary energy consumed globally, more than other renewables and nuclear power together. Fossil fuels continue to account for the overwhelming share of global primary energy consumption, together accounting for nearly 80% of the total. Other renewables, including hydro, account for less 3% of all primary energy consumption. (see Figure 1a below). Biomass is also by far the most significant among renewable energy sources, accounting for about 80% of renewables used (Figure 1b). Modern bio-energy could potentially surpass large hydro in the coming years, given the significant rate of growth in liquid and solid biomass use and the increasing reluctance in many regions of the world to accept the environmental impacts of large-scale hydro.



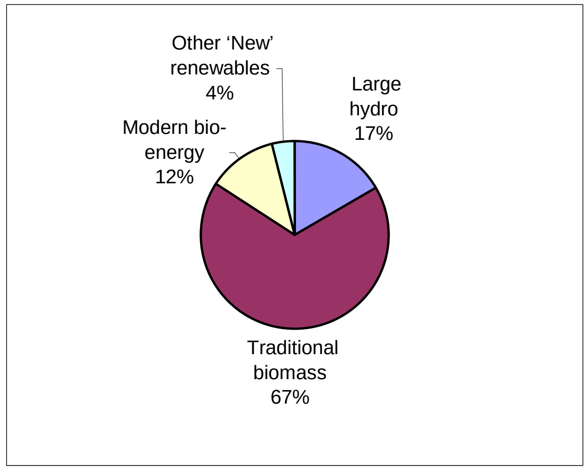


Figure 3a: Shares in 2004 of global primary energy consumption.

Figure 3b: Shares in 2004 of total renewable energy consumption.

Source: IEA (2007)

The overwhelming majority of biomass energy—over 80%—is consumed as solid fuels in traditional uses at low efficiencies for cooking, heating, and lighting; the consumers are the more than two billion people that rely on traditional biomass fuels and/or have no access to modern energy services (UNDP, 2004). The dependence on traditional biomass in sub-Saharan Africa is far greater than any other world region, accounting for over 70% if South Africa is excluded.

The impacts of a lack of access to modern energy are felt in many ways—the sometimes deadly effects of indoor air pollution, the tremendous amount of time devoted to gathering firewood, the lack of health and education services that require reliable energy supplies, and many other problems. Greater access to electricity and modern fuels would open up new economic opportunities and provide basic amenities that are taken for granted in the OECD countries. Cleaner and safer renewable fuels, such as gel fuel made from bio-ethanol, have been proposed as a solution to health and safety issues that can—at the same time—take advantage of the region's under-utilised agricultural capacity (Utria, 2004).

The deforestation in developing countries that was observed in the 1970s was at first attributed to household consumption for woodfuel and charcoal, but subsequent research later showed that the deforestation was in fact attributable mainly to companies and industries that were clearing land for agricultural uses and timber (WEC, 1999). Furthermore, the notion that communities would quickly descend into a "Tragedy of the Commons" in their use of forest resources turned out to be a gross simplification that ignored the role of informal institutions. Local communities that had control over their own resources often showed a marked ability to implement informal customs and institutions to preserve some land and forest for future uses, (Leach and Mearns, 1988).

Consumption of biomass for traditional uses can be sustainable under certain conditions, especially in areas with low population density (Chidumayo, 2002). It is difficult in the longer-term to sustain traditional uses of biomass due not only due to their low efficiency but because of the difficulty of controlling the level and quality of energy services provided. A transition from traditional to modern bio-energy in the developing world is thus an important element in the global transition to sustainable energy.

5.7 The potential for cogeneration

Cogeneration is the concurrent production of process heat and renewable electricity in a biofuel processing plant. There is a potential for substantial surplus electricity production that can be fed to a local or national grid. While some of the biofuel feedstocks are only harvested in the dry season, special boilers with the ability to use alternative biomass could be installed so that the surplus capacity can be supplied throughout the year.

Production of biofuels thus has the potential of addressing *one of the most pressing issues for economic and social development in Africa; the access of modern energy for the rural population*. At present, less than 1% of the people in Tanzania, for example, have access to the national electric grid. There is a need for development activities in many African countries for improving the energy quality of the national grid, for developing the grid outreach as well as developing complementary local grids by developing small scale rural energy centers, where the agricultural small-holders can contribute with feedstocks for production of electricity and cooking fuel.

On a larger scale, industrial scale biofuels production may complement the present national grid or constitute the backbone of new local grids.

6 From biomass to product

What are biofuels? Where do they come from? How are they processed? What are the requirements of water and other inputs?

6.1 Historical Overview of Biofuels

Biofuels have been around for over a hundred years, and bio-ethanol in particular saw significant use in the early part of the twentieth century. Before the era of cheap oil and during times of conflict such as World War II, biofuels have been recognised as a valuable domestic alternative to imported oil. The resurgence of interest in biofuels in recent years is in part for similar reasons of energy security, but now the added issues of rural development and climate change mitigation make the case for biofuels even more compelling. An interesting historical note is that the Model T introduced by Henry Ford during 1908-1926 could run on either petrol or ethanol; consequently the dual-fuel vehicles introduced in recent years are simply a somewhat more sophisticated re-introduction of a capability that was already available at the dawn of the auto age!

6.1.1 Ethanol

Ethanol fuel played a key role in the first four decades of the 20th century. By the mid-1920s ethanol was widely blended with gasoline in many industrial countries. In the Scandinavian countries, a 10-20% blend was common, produced mostly from paper mill waste; in most of the continental Europe ethanol was obtained from surplus grapes, potatoes, wheat, etc.; in Australia, Brazil, and many other sugarcane producing countries, ethanol was produced from cane juice and molasses.

After WW II, few countries showed any interest in ethanol as there was plentiful cheap oil to be had. In the 1970s, after the oil shock, many countries began to again consider the ethanol fuel option, notably Brazil. During most of the 1990s the low price of oil again had a negative effect on ethanol fuel programmes, with many schemes being either abandoned or scaled down significantly. The past several years have witnessed a growing interest in fuel ethanol as a substitute to petrol in the transportation sector on a global scale; this is due to a combination of factors, ranging from environmental and social benefits to climate mitigation and energy security.

There are three broad market categories for ethanol—fuel, industrial, and potable—with the largest volume market today being for fuel. The industrial market is generally associated with chemical and pharmaceutical industries that require ethanol as a feedstock for fine chemicals and other products. The industrial market generally has greater purity requirements than fuel alcohol, since it is directed to specialised production processes rather than combustion as a fuel. The potable market includes distilled spirits and liquors. However, surplus wine alcohol is sometimes re-directed to other markets, such as is the case in some Caribbean countries, which re-process the wine alcohol for export to the U.S. under special trading arrangements.

Not all ethanol is bio-based. Synthetic fuels—both diesel and ethanol—can be produced from coal or natural gas through the Fischer-Tropsch process, as is done in South Africa. Synthetic ethanol is often used in the industrial market, due to specific purity requirements. Synthetic ethanol is chemically identical to bio-ethanol, and market data is not necessarily reported separately; consequently Table 3 gives total ethanol production. The process for gas-to-liquids is analogous to the production of second-generation biofuels in the future via gasification of biomass.

Table 3: Global Ethanol Production by country/region (billion litres)

	2000	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***
Brazil	10.6	11.5	12.6	14.7	14.7	16.1	17.0	19.0
U.S.A.	7.6	8.1	9.6	12.1	14.3	16.2	18.4	24.6
EU	2.4	2.6	2.5	2.5	2.5	2.7	3.4	3.6
Asia	5.9	6.1	6.2	6.7	6.6	6.8	7.2	7.2
other	5.2	5.5	5.5	5.5	5.6	5.8	5.9	7.0
Total	**31.7**	**33.7**	**36.5**	**41.5**	**43.6**	**47.6**	51.9	61.5

Source: F.O.Licht's, 2007; EBIO 2008; NRF 2008

NOTE: Figures include bio-ethanol and synthetic ethanol; about 85-90% of total world ethanol market is bio-ethanol; about 80% of total world ethanol market is for fuel; Some ethanol is processed into ETBE for blending, particularly in the EU.

As illustrated in Table 3, world ethanol production has increased significantly in recent years. The two largest producers—Brazil and USA—have generally been responsible for 60-70% of world ethanol production. All ethanol produced in Brazil is bio-ethanol, as is nearly all ethanol produced in the U.S. Synthetic ethanol is produced in a number of European countries as well as in Middle Eastern countries, South Africa, and some Asian countries. Ethanol can also be processed into ETBE (ethyl-tertio-butyl-ether) by reaction with isobutylene, a refinery by-product. Such re-processing is popular in the EU due to the fuel standards adopted by the automobile industry in EU markets and the preferences of oil distributors in the EU for ETBE rather than bio-ethanol as a final product for blending. In a few EU countries such as Sweden, ethanol is blended directly rather than using ETBE. Sweden is also one of the few countries to run a significant fleet of E100 vehicles; much of the bus fleet runs on ethanol, using specially-designed engines.

6.1.2 Biodiesel

The process of trans-esterification for making bio-diesel has been known for well over a hundred years, although bio-diesel as it has come to be known emerged only in the past twenty years, in terms of the use of refined vegetable oils on a large-scale. Rudolf Diesel first demonstrated his breakthrough engine design in 1893, and it was powered by peanut oil. He believed that the utilization of a biomass fuel represented the future for his engine. In 1911, he said “The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it.” The emergence of cheap fossil fuels, however, encouraged the diesel engine manufacturers to alter their engines to utilise the lower viscosity petroleum diesel.

Research into the use of trans-esterified sunflower oil and refining it to diesel fuel standard was initiated in South Africa in 1979. By 1983 the process to produce fuel quality engine-tested bio-diesel was completed and published internationally (SAE, 1983). An Austrian Company, Gaskoks, obtained the technology from the South African Agricultural Engineers, put up the first pilot plant for bio-diesel in November 1987 and the erection of the first industrial bio-diesel plant in April 1989, with a capacity of processing 30 000 tons of rapeseed as feedstock per annum. Throughout the 1990s, plants were opened in many European countries, especially in the Czech Republic, France, Germany, and Italy.

Table 4: Global Biodiesel Production by country/region (million litres)

	2000	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***
Germany	250	315	511	813	1176	1897	2343	2543
France	373	364	416	406	395	559	654	767
EU-total	813	912	1210	1630	2265	3618	4303	5027
U.S.A.	8	19	57	76	95	284	948	1706
other	125	190	256	284	273	307	368	405
World	**945**	**1121**	**1523**	**1989**	**2633**	**4209**	**5619**	**7138**

Sources: estimated based on European Biodiesel Board, 2008; National Biodiesel Board, 2008.

Globally, production of bio-diesel is concentrated in a few countries, with Germany and France accounting for nearly half of global production and consumption, as shown in Table 4. Global production has been increasing at a tremendous pace, with most of the growth in the EU as a result of fairly generous tax benefits and subsidies. From 2000 to 2007, biodiesel production increased globally more than seven-fold, from under 1 billion litres to over 7 billion litres; production in Germany alone increased more than ten-fold over the same period. New financial incentives in the U.S.A. starting in 2005 have significantly stimulated production there.

6.1.3 Other Biofuels

There are other biofuels and other applications, such as the use of unrefined oils or straight vegetable oils, but unlike ethanol and biodiesel they are not global fuel commodities with specific properties. Biogas is also considered a biofuel, although it also has less relevance for international trade. Other fuels such as butanol have also sparked some interest.

6.2 Conversion and end product routes

There are many different routes for converting biomass to bioenergy, involving various biological, chemical, and thermal processes; the major routes are depicted in Figure 4. There can be intermediate steps and the various processing routes are not always mutually exclusive. Furthermore, there are often multiple energy and non-energy products or services from a particular conversion route, some of which may or may not have reached commercial levels. Figure 4 shows only the energy-related products or fuels; simple combustion is assumed and not pictured, in order to simplify the diagram. So-called second generation biofuels include those produced through Fischer-Tropsch synthesis as well as ligno-cellulosic conversion to ethanol. First-generation biofuels include oil crops esterified into biodiesel and direct fermentation of sugar and starch crops.

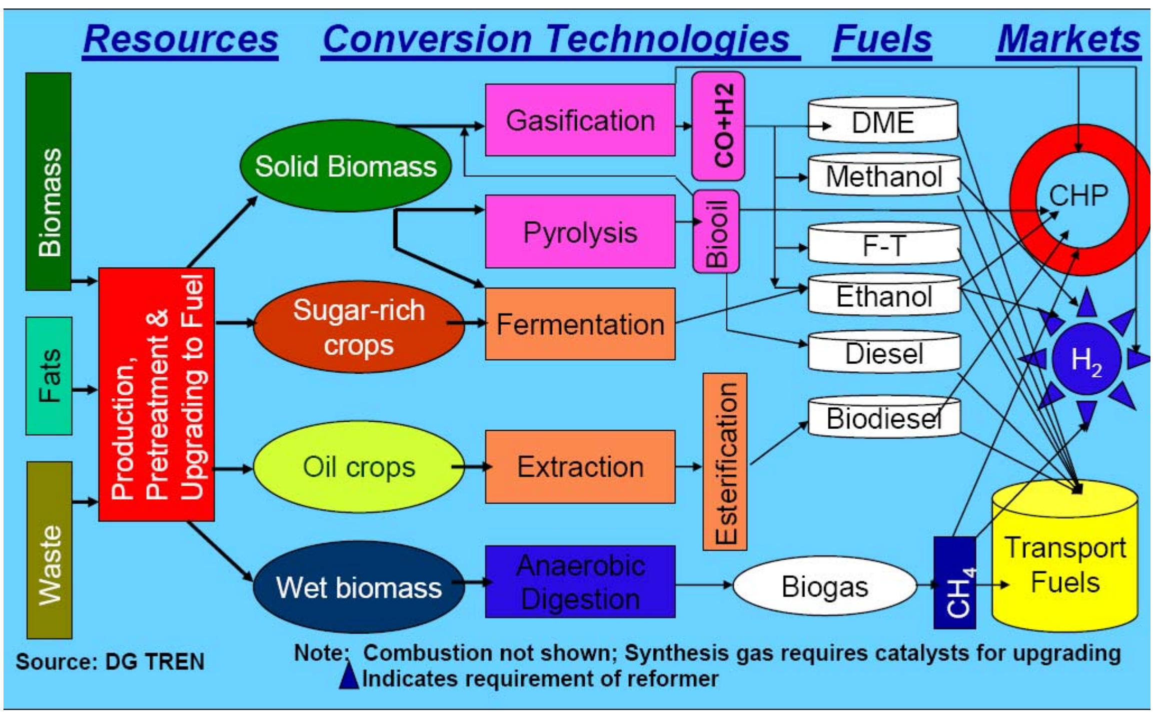


Figure 4. Steps and resources in biomass conversion to energy products and fuels. Source: EC DG-TREN, 2006

Due to the variety of conversion options and final products, it is more difficult to make comparisons of efficiency in biomass utilization than it is for other energy options; bio-energy extends across all energy carriers and involves many different pathways and processes. The efficiency of biomass and bio-energy production needs to be assessed across the various parts of the chain—from the land and inputs used for cultivating biomass through intermediate processing to the useful energy that can be harnessed for particular products and applications.

As an example, bioethanol can either be produced from starch or sugar containing feedstocks, labelled “first generation biofuels”, or from cellulose feedstocks, often labelled “second generation feedstocks”, since the latter would increase the resource base considerably and compete less with food production. The following figures (,) are examples of processing options for the two types of ethanol production from biomass.

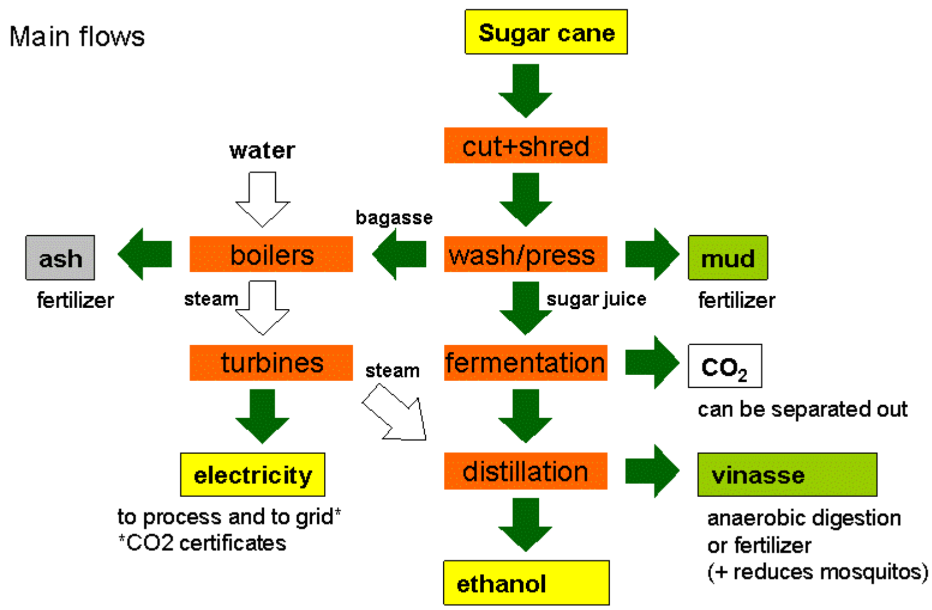


Figure 5 Production process, ethanol from sugar cane. Copyright Renetech AB.

The process in Figure 5 produces around 70-80 liter of ethanol per ton of sugar cane.

To produce ethanol from cellulose feedstocks require a more complex and costly process. Acids and enzymes to facilitate the breakdown of the cellulose into fermentable sugars are expensive and the process has several steps which are at present developed in research projects around the world. Yields are today lower, but depend on system efficiency and a learning curve which is still in its infancy.

On the agricultural or resource side, efficiency depends on choosing crop species and varieties well-suited to local soils and climate. In Brazil, for example, over 500 varieties of sugar cane are used for bio-ethanol production, some of which are designed and developed for optimal growth in particular micro-climates. The productivity of biomass crops grown in tropical and sub-tropical regions, in terms of energy per unit of land, is 4-6 time higher on average than typical crops grown in the temperate climates of Europe.

But even within Europe, there is considerable variation in the productivity of different energy crops.

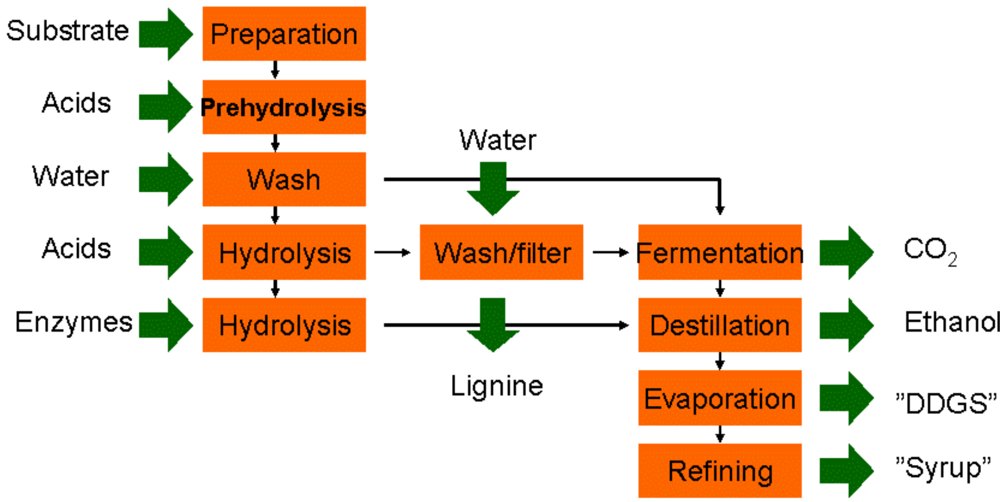


Figure 6. Production process, ethanol from cellulose. Copyright Renetech AB

In terms of minimising overall losses in the industrial conversion side of the production chain, the most efficient use of biomass for energy is for heat, including combined heat and power, where overall system efficiencies can be as high as 80-90%. Matching conversion systems to the scale and structure of demand for heat and power is necessary to minimise costs. Some conversion systems are technologically mature for use of biomass, such as steam turbines and steam engines. Other systems are under development since many decades, such as Stirling engines and the Organic Rankine cycle. Systems differ in scale efficiencies, service requirements, and other characteristics; choice of the optimal system is thus often site-specific (Vamvuka et al, 2007).

Liquid and gaseous biofuels are useful in extending the value of biomass to other sectors, including transport sector or in substituting for natural gas. The efficiency in conversion tends to be on the order of 55-65%. Biogas from animal wastes and other types of "wet" biomass is produced through anaerobic digestion, which is the decomposition of biomass using micro-organisms in a low-oxygen environment. Biogas can be used for many different applications: direct use for cooking or heating, electricity generation, compression for use in transport, or it can also be fed into the natural gas grid after clean-up or purification.

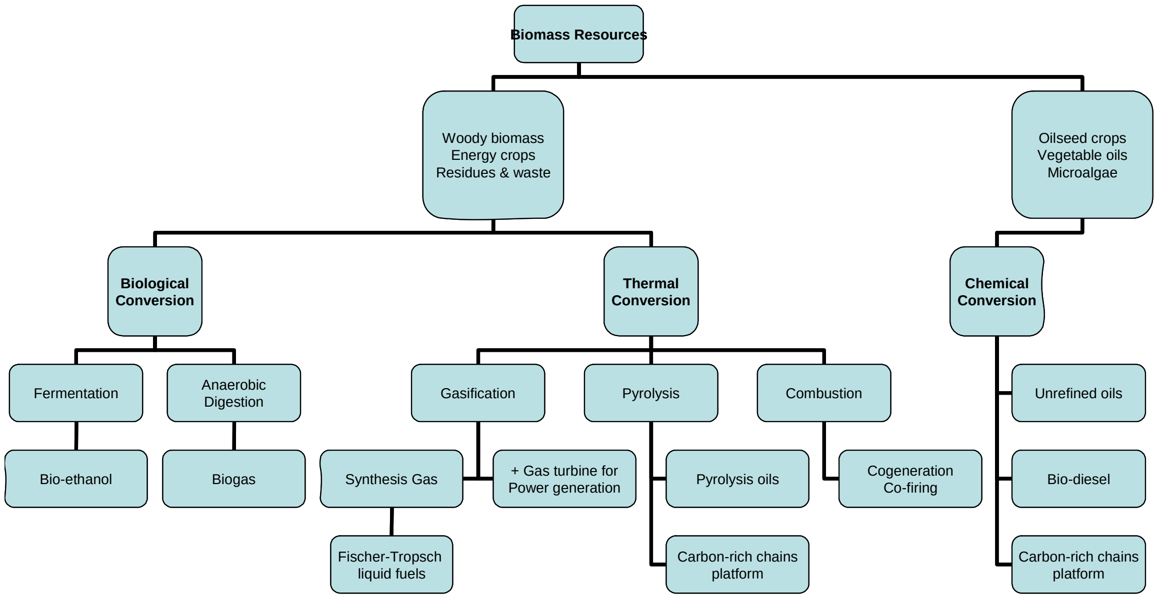


Figure 7. Various conversion routes for biomass to bioenergy

6.3 Cultivation of Feedstocks for Fuel Processing

Possible fuel feedstocks are presented below in Table 5. Each combination of feedstock and processing technology represents a different business case, most of which can be exploited either as corporate cultivation and processing, a combination of outgrower feedstock cultivation and corporate processing, and smallholder cultivation and cooperative processing. The latter would potentially be aimed at subsistence and would not necessarily include industrial aspirations in the earlier stages.

Table 5 Possible biofuel feedstocks[9]

Name	Resulting primary fuel	Byproduct	Refining process	Water needs	Experience in Africa	Implications for outgrowers
Jatropha	PPO or biodiesel	Fertilizer	Cold pressing-Esterification	Low	Fencing crop	Can be grown on any scale
Sugar cane	Ethanol	biomass for cogeneration	Fermentation-Distillation. Cane cannot be stored.	Irrigation often needed, refining needs water	Sugar production	Would typically require joint irrigation schemes
Sweet sorghum	Ethanol	Fertilizer, animal feed, biomass for combustion	Saccarification-(only if kernels are used) Fermentation-Distillation		Limited	Some irrigation needed
Maize	Ethanol	Animal feed	Saccarification-Fermentation-Distillation	refining needs water	Widely grown, no fuel exp	good
Wheat	Ethanol	Animal feed	Saccarification-Fermentation-Distillation	refining needs water	Grown in some areas, mostly large scale	good
Waste	Methane (biogas)	Fertilizer	Gasification, Anaerobic digestion	Most can be recycled	Very little	- - -
Sisal	Sisal fibers for carpets, rope and pulp	Methane (biogas) from leaves residue, ethanol (potentially) from bole	Anaerobic digestion (leaves), Fermentation-Distillation (bole/trunk)	None	Traditional industrial crop	Established outgrowers

6.4 Energy Yields and GHG emissions

6.4.1 Biofuel Yields

The various biofuel feedstocks differ considerably in their energy yields, based on their photosynthetic productivity, adaptability to climatic conditions, and the amount of useful inputs provided. Biodiesel crops are characterised by the amount of oilseed that can be extracted per hectare, while bioethanol crops are described according to total biomass yield. Among the first generation biofuel crops, sugarcane and palm oil are the most productive. However, sweet sorghum and jatropha useful ecological properties since they require less water than sugarcane and palm oil, respectively, and can therefore grow in drier climates. Sweet sorghum grows rather quickly (3-4 months) and therefore

[9] The Biofuels Task Force in Tanzania (draft Biofuels Guidelines) mention the following oil crops and forest resources (national production, if such exists, in parenthesis, thousand tonnes): Coconut (370), cottonseeds (210), groundnuts, palm oil (60), sunflower seeds, copra, kapok, jatropha (18-58), eucalyptus, macadamia nuts, pappea, castor bean, S. caffra, pigeon wood, margosa seeds, desert date, African fan palm and peasic/peach oil.. A project involving the Croton tree (croton megalocapas) is also underway in Tanzania

the figure in Table 6 below is based on two yields per year. Maize and soybean are rather poorly performing as biofuel crops and therefore it seems ironic that the U.S. relies on maize and Brazil on soybean (for biodiesel). Among the main reasons is the long experience that farmers have with these crops and their well-established market distribution and supply networks.

Table 6. Characteristics of various first generation biofuel crops

Crop	*Seed yield (t/ha)*	*Crop yield (t/ha)*	*Biofuel yield (litre/ha)*	*Energy yield (GJ/ha)*
Sugarcane (juice)		100	7500	157.5
Palm oil	9800	70	3000	105
Sweet sorghum		60	4200	88.2
Maize		7	2500	52.5
Jatropha	740		700	24.5
Soybean	480		500	17.5

Since biomass sequesters carbon, GHG emissions of bio-energy systems are neutral. However, since there are fossil energy and other input requirements for biomass feedstocks, there are some energy losses and hence some net GHG emissions result. In some cases, there can also be N2O and methane emissions associated with biomass for energy systems, both of which are also GHGs.

The GHG savings for liquid biofuels tend to be less than that of solid biofuels mainly because of the fossil fuel being replaced, i.e. since coal is the most carbon-laden fossil fuel, any substitution for it has proportionally higher carbon savings. For most liquid biofuels, GHG reduction is directly related to the yield and energy balance of the feedstocks. A rough indication of GHG reductions and yields for various liquid biofuels is given in Table 7.

Table 7. Estimated ranges of GHG reductions and yields for various biofuels

fuel	**Process**	**feedstock**	**location**	**GHG reduction** *(relative to petrol or diesel)*	**Yield** *(litres per hectare)*
ethanol	fermentation	corn	U.S.	15-35%	3000-4000
ethanol	fermentation	sugar beet	Europe	45-65%	4000-5000
ethanol	fermentation	sugar cane	Brazil	80-90%	6000-7000
ethanol	enzymatic hydrolysis & fermentation	cellulosic	U.S.	70-90%	4500-5500
biodiesel	extraction & esterification	soya	Brazil	30-50%	500-600
biodiesel	extraction & esterification	rape	Germany	40-60%	1000-1400
biodiesel	extraction & esterification	Oil palm	Indonesia	75-85%	4000-6000
biodiesel	Fischer-Tropsch method *(biomass as raw material)*	various	various	50-100%	varies

Source: adapted from IEA (2004) and Sakar and Kartha (2007)

There are other potential GHG impacts associated with growing biomass, which depend on the previous use of lands. Land that stores a significant amount of carbon and is cleared to grow biomass incurs a “carbon debt” that has to be “paid off” before the system becomes a net carbon sink again (Fargione et al, 2008). On the other hand, degraded lands that are used for biofuels will tend to incur a low carbon debt or none at all, depending on the properties of soil, the root systems of the new crops, the impact on nutrients, and other factors.

The wide range in GHG reductions and yields for biomass and biofuels, even when substituting for the same fossil fuel, are due in part to the fact that biomass that is produced in tropical and sub-tropical climates has an average productivity that is on average 5 times higher than that of biomass grown in the temperate regions of Europe and North America (Bassam 1998). Since developing countries are located predominantly in the warmer climates and lower latitudes, they have a tremendous comparative advantage. However, the large amount of financial capital available in Europe and North America facilitates the technology and strong infrastructure that can compensate somewhat for the natural disadvantage.

6.4.2 Co-product Allocation

Co-products impact the economics of biofuels and the accounting methodology for co-products affects how GHG emissions are apportioned and therefore how they count in carbon finance or other initiatives to reduce GHG emissions. Often co-products are allocated according to energy content, and crop residues are excluded from the accounted co-products.

ISO 14041 recommends the more sophisticated approach of avoiding allocation either by dividing the process into multiple sub-processes, or by expanding the system boundary to include the functions of all co-products (ISO, 1998). Division into sub-processes is usually impossible for biofuel refining, but expansion of the system boundary is possible and has been demonstrated in the literature (Kim and Dale, 2002; Rosentrater, 2005; Cederberg and Stadig, 2003).

In the system expansion approach the GHG emissions associated with the unit system, as well as the GHG emissions associated with other unit systems affected by the various co-products, are accounted together. A set of simultaneous equations is solved to show the degree to which each product contributes to the GHG total. The method accounts for the degree to which various products substitute for each other in markets. Though this method of accounting is relatively new and requires sophisticated analysis, it is recommended by the ISO and deserves encouragement.

When system expansion is not possible, the ISO standard recommends that inputs and outputs to the system be partitioned in a way that “reflects the underlying physical relationships between them.” One way to do this is to measure the energy consumption associated with a unit-process-based substitute for each co-product, and use these energies as the allocation factors (Shapouri et al, 2002). Only as a last resort does the ISO standard recommend to use an allocation method based on economic or physical values, such as energy content.

7 Biofuels policy overview

Stimulating agricultural productivity and rural economic growth?

7.1 Brazil

The rapid development of ethanol production capability in Brazil took place only after the creation of the Brazilian Alcohol Program, known as PROALCOOL, in 1975, with the purpose of producing anhydrous ethanol for blending with gasoline. After the second oil shock in 1979, the government decided to expand production to include hydrated ethanol to be used as neat fuel in modified engines. Sugarcane and ethanol production has increased several-fold during the past three decades, and today Brazil is the most cost-effective producer of ethanol and the second largest in volume after the U.S.

With dozens of new industrial units in different stages of construction, ethanol production capacity is set to expand considerably in the coming years. Brazil has the capacity—land, technical know-how and even finance—to expand its ethanol production capacity 8-10-fold in the next 20-30 years. The global implications of such an expansion have been evaluated at the University of Campinas, one of Brazil's premier research Universities (Cortez, 2006).

With the lowest cost production in the word, Brazil has become the largest exporter of ethanol. The main priority in Brazil has thus far nevertheless been to supply the domestic market. Alcohol is used as an octane booster blended with gasoline, alone as "neat" fuel, and in flex-fuel vehicles, and also as a chemical feedstock and other industrial applications. The flex-fuel vehicles, introduced in 2003-2004 run on any combination of gasoline and alcohol.

A Brazilian programme for biodiesel has also been initiated, with similar objectives to those of the bio-ethanol programme. However, the approach will be different, in that small farmers are expected to provide feedstock for the industrial producers of biodiesel. A regulatory instrument will be used to enforce the social and environmental profile, known as "The Social Fuel seal," which will be awarded by the Ministry of Agrarian Development, as a condition for industrial producers of biodiesel to obtain tax benefits and credits. In order to receive the seal, an industrial producer must purchase feedstock from family farmers, enter into a legally binding agreement with them to establish specific income levels, and guarantee technical assistance and training (PNPB, 2005).

7.2 U.S.A.

Ethanol is produced mainly from corn in the U.S., and domestic producers receive a subsidy of $0.52/gallon ($0.14/litre). Partly as a result of these support schemes and the recent rise in oil prices, U.S. production exceeded Brazilian production for the first time in 2005. Ethanol is sold in most States as an octane enhancer or oxygenate blended with gasoline, and in the Midwest there are also E85 or ethanol-only vehicles, including buses.

Bio-diesel production has also been increasing significantly due to the generous tax credits provided by legislation enacted during 2004-2005. The tax credit is $0.50/gallon ($0.13/litre) of biodiesel made from waste grease or used cooking oil and ($0.26/litre) for biodiesel. If the fuel is used in a mixture, the credit is 1 cent per percentage point of agribiodiesel used or 1/2 cent per percentage point of waste-grease biodiesel. For small biodiesel producers (i.e. production capacity of less than 60 million gallons annually), an additional $0.10 ($0.03/litre) tax credit is provided for each gallon of biodiesel produced by small producers.

7.3 EU

In 2001, the EC launched its policy to promote biofuels for transport, the motivation for which includes several dimensions:
- to reduce greenhouse gas emissions;
- to reduce the environmental impact of transport;
- to increase the security of supply;
- to stimulate technological innovation; and
- to promote agricultural diversification

The policy was to be market-based, but would include indicative (i.e. non-binding) targets and financial incentives in order to maintain progress. The targets were to be based on the percentage of biofuels in the transport market, which was only 0.6% in 2002.

The EU Directive on biofuels came into force in May 2003, under which Member States should ensure a minimum 2% share for biofuels by 31 December 2005 and 5.75% by December 2010 (EC, 2003a). Only Sweden with 2.2% and Germany with 3.8% exceeded the 2% target in 2005 (EC, 2006); Sweden accomplished this mainly through bio-ethanol, while Germany relied on bio-diesel. The biofuels component within the overall roadmap for renewable energy has been revised somewhat in light of the slow progress by Member States; a more recent policy document acknowledges that the 2010 targets will be difficult to meet.

In 2008, the Commission included new targets of 10% by 2020 for renewable transport fuels in the new Renewable energy Directive. The targets are binding on member states. Sustainability criteria were also proposed, including a minimum GHG reduction of 35% and prohibitions on biofuels grown in ecologically sensitive regions.

7.4 Other countries and regions

A number of other regions are significant producers of biofuels or could become significant producers in the near-term. Countries with large domestic markets (U.S., China, and India) are unlikely to become exporters. Other regions could become major exporters in the future, particularly southern Africa and some parts of Southeast Asia. The situation in China and India are briefly mentioned below, since these countries could be major producers but also potentially major importers in the future, depending on market developments.

Although China cannot be regarded today as a major player in biofuels, this could change dramatically in the near future. China is potentially a hugely untapped vehicle market; Chinese automobile use has been growing at a faster rate than in any other country; during the past 5-6 years automobile use has nearly doubled. If this trend continues, the size of the Chinese automobile industry will have significant implications for fuel demand, and some of this demand may very well be met through biofuels.

With the growing mobility of India's increasing population, demand for crude oil long ago surpassed domestic production; diesel demand is much higher than petrol, due to the significant amount of freight transported by road. Bio-diesel production offers the possibility for fuel produced from renewable sources to sustain the growing demand. Some oil-bearing crops such as jatropha, can be grown on degraded lands, which are not well-suited to traditional agricultural crops. Over 65 million hectares of land has been declared "wasteland" in India and another 174 million hectares are close to being called wasteland, and this may present an excellent opportunity for energy crops such as Jatropha.

The Indian national committee on development of biofuels recommended a major multi-dimensional programme to replace 20% of India's diesel consumption. The National Planning Commission has integrated the Ministries of Petroleum, Rural Development, Poverty Alleviation and the Environmental Ministry and others. One objective is to blend petro-diesel with a planned 13 Million t of bio-diesel by 2013, produced mainly from non-edible Jatropha oil, and a smaller part from Pongomia. To this end, eleven million ha of presently unused lands are to be cultivated with jatropha.

7.5 International trade

The case of bio-ethanol is of particular interest for international trade, as it is different from other biofuels and especially from biomass generally in several respects. First, the opportunity to export a value-added product such as ethanol rather than raw biomass is important for developing countries. Second, there are many significant potential producers of bio-ethanol; any of the more than 100 countries that grow sugarcane could enter the market fairly easily in the absence of protectionist measures. Third, the most economical biomass source or feedstock, sugarcane, is found almost exclusively in the developing world. Fourth, unlike biomass or wood products, ethanol markets are impacted significantly by trade barriers and tariffs. While many small sugarcane–producing developing countries are potential producers, both sugar and ethanol are protected products in most markets. Preferential sugar prices have been a disincentive for developing countries to switch to ethanol, since they can obtain more money from subsidised sugar exports.

Some projections suggest that ethanol trade will increase by a factor of 3-4 by 2010 (Rosillo-Calle & Walter, 2006). Between 2010 and 2015, trade is expected to more than double (F.O.Lichts, 2006). More significantly, the number of exporting countries/regions will increase significantly, with countries other than Brazil and U.S.A. making up about 30% of the total, compared to less than 5% in 2005. Exports are increasing as a growing number of countries are developing ethanol fuel policies and programmes.

Fulton (2005) has studied the potential large-scale ethanol production from sugarcane up to 2050, estimated at 633 B/l/yr (14.5 EJ/yr or about 20% of the estimated projected world gasoline demand in 2050). This scenario considers only a maximum of 10% of the cropland area to be used for sugarcane (excluding Brazil). Brazil accounts for nearly half of the total ethanol production in this scenario. It is estimated that 3,460 new industrial plants would have to be built up to 2050, of which 1,720 will be in Brazil; the cumulative associated investment is estimated at US$215 billion. This appears to be an optimistic scenario in terms of a total market size equal to 20% of gasoline demand; on the other hand, the estimated amount of cropland required may in fact be less, given the historical improvement in yields and the possibility to focus production on the most high-yielding regions and the varieties best-suited to those regions.

8 Environmental Impacts

It is difficult to summarise environmental impacts across all the different crops, applications, and conversion processes for biomass-energy systems. In general, most of the impacts come from the land-use side rather than the industrial side of bioenergy production, due to the land-intensive nature of biomass compared to other energy sources. Environmental impacts and emissions are closely linked to the energy and other input requirements for growing biomass; the most productive options are those that have lower input requirements and require less land and/or lower quality soils. Feedstock growing costs are also strongly related to land use, and feedstock costs are generally the major cost component for bio-energy systems.

Bio-energy is inherently land-intensive, meaning that the associated socioeconomic and environmental impacts are generally much more significant than those of other renewable energy systems. A comprehensive list is difficult to summarise briefly, but some key concerns relate to loss of ecosystem habitat, deforestation, loss of biodiversity, depletion of soil nutrients, and excessive use of water. In addition to the provision of a renewable energy source, some positive environmental impacts might include restoration of degraded land, creation of complementary land use options, and provision of non-energy resources and materials. Some specific issues that arise in the case of sugar crops, woody biomass, and oil-bearing crops, are outlined below.

8.1 Sugar crops

The environmental impacts of sugarcane have been analysed in considerable detail in the case of Brazil. When Brazil began its effort to expand sugarcane for ethanol production in the 1970s, the environmental impacts were quite significant, especially the disposal of large streams of waste effluent from ethanol distilleries. Over the past thirty years, dramatic improvements have been achieved in technical efficiency and in the efficiency of key resource inputs such as water. The case of water use is particularly interesting, since cane requires significant amounts of water during a key period in the growth cycle. Cane is rain-fed in Brazil, and furthermore, the amount of water that is recycled in the cane-ethanol processes is on the order of 90% (Macedo, 2005).

In other parts of the world where water is scarcer, sweet sorghum could provide a useful alternative, with its low water requirements, about 65-70% that of cane. Additionally, it has the ability to remain dormant during periods of drought, resuming growth upon the re-occurrence of favourable conditions (El Bassam, 1998). This means there is a much greater likelihood of small scale farmers with no access to irrigation raising a crop of sweet sorghum in dry conditions than one of sugar cane, or even of maize. This could potentially have strong socioeconomic benefits by increasing the productivity of small scale farmers.

Sweet sorghum has low requirements for nitrogenous fertiliser, about 35-40% of that of sugar cane (Praj, 2005). This has economic benefits for the farmer, as the crop will require less investment in inputs, as well as possible environmental benefits from avoiding impacts of fertiliser run-off. Sweet sorghum has high potassium uptake, however, and is therefore highly depleting of this mineral (El Bassam, 1998).

8.2 Woody Biomass

Woody biomass is a major source of primary energy for the majority of the world's poor, but it could also become a major source of feedstock for production of second-generation (lignocellulosic) ethanol. The environmental impacts of wood fuel use by industries and households are well known, and include:

- health effects of indoor air pollution, which kills more women and children than tuberculosis and malaria (UNDP, 2004)
- contributing to deforestation, a major problem in most southern African countries
- soil degradation and erosion problems

However, the consumption of woody biomass as a fuel need not be inherently unsustainable. Improvements in conversion efficiency and use are needed, especially in more densely populated regions. Woody biomass is also available in large quantities as a residue from wood industries. This has been demonstrated in Sweden and other countries, where sawdust from the wood sawing industry is used extensively for energy. This has the economic and environmental benefits of using what would otherwise be a waste product. The payments from the energy industry are now greatly contributing to the survival of the sawing industry (Kåberger, 2005).

8.3 Oil-bearing and other biomass crops

Jatropha trees yield oil that is highly suitable for use in raw form or for refinement into bio-diesel. This tree is reported to have strong environmental benefits when intercropped with other produce. It can be used as a hedge to prevent soil erosion, and can also have regenerative effects on the soil, being a nitrogen fixer (Francis et al, 2005).

Several oil bearing crops, currently used predominantly in food products, are strongly associated with severe environmental impacts. In particular, soya bean plantations are encroaching on rainforests in Brazil, and the palm oil industry is a major cause of deforestation in Malaysia and Indonesia, in some cases or scenarios threatening species such as the Sumatran Tiger and the Orangutan with extinction (Friends of the Earth, 2005).

One starchy crop that is quite important in the African context is cassava, a staple food crop in many parts of southern Africa; it could serve a dual purpose by providing food and energy. It could also be seen as a food reserve crop in case of food shortages; in Tanzania, farmers devote more than 10% of their land to cassava for this purpose. Cassava is productive on poor soil, resistant to drought and capable of achieving high yields (10 t/hectare). It also has the advantage of being able to remain in the soil for long periods, and can be harvested only when required. This eliminates storage problems, making it an ideal back-up crop, for fuel or food. A major programme has been initiated in Nigeria to make ethanol from cassava.

One relatively new addition to the crops with bio-energy potential is Ensete (*ensete verticosum*), or false banana, which is grown in Southwestern Ethiopia as a staple food and fiber crop, appreciated as an important source of dietary starch. The Ensete grows to a height of between 6 and 12 m high, and has a harvestable lifespan of 4 to 10 years. It is not sensitive to rainfall conditions and ferments in a similar manner to the highly energy efficient but water dependent sugar cane.

8.4 Industrial Processing Impacts: the case of Vinasse

There are many further impacts from the industrial side of bioenergy processing. Stillage or vinasse, a by-product of ethanol production, presents a somewhat special case since it is produced in large volumes but is also a potentially valuable input for further bio-energy production as well as for other uses such as fertiliser. Each litre of ethanol produced is accompanied by 10-15 litres of vinasse. This large volume of vinasse and its high BOD and high COD (80,000 to 100,000 mg/l) poses a problem for its disposal.

The hazardous substances present in the vinasse generate a very high BOD (Biological Oxygen Demand), ranging from 30,000 to 40,000 mg/l and a low pH of 4-5, because of the organic acids which are corrosive and require stainless steel or fibre glass to resist it. Vinasse contains unconverted sugars, non-fermented carbohydrates, dead yeast, and a variety of organic compounds all of which contribute to the BOD (Cortez et al, 1998). The organic components in the vinasse can be used for biogas production through anaerobic digestion, a process in which methane is produced when microorganisms breakdown the components under conditions of low oxygen and low temperature.

One possibility of reducing its polluting effect is recycling it in the fermentation process. Vinasse may be partly used to dilute the sugarcane juice or molasses in the fermentation step. The juice or molasses need to have the Brix (a special mixture of cane juice and Molasses, see Macedo, 2005) adjusted to allow proper yeast growth a process that normally requires water to dilute it. Alfa Laval developed a process called Biostil that uses vinasse to dilute the molasses prior to the fermentation step. In Brazil, detailed and extensive studies and field testing have shown that vinasse is an excellent fertilizer and improves the physical, chemical and biological properties of the soil, namely, it increases the pH, enhances the nutrient availability, improves the soil structure due to the addition of organic matter, increases the water retention capacity and improves the microorganisms' population.

8.5 Land use changes

Land use change has been a significant source of global GHG emissions through time, between 1989 and 2004 land use change accounted for 1.6 ±0.8 Gt C yr-1 (IPCC LULUCF, 2007). GHG emissions from land use change can significantly change carbon stored as a result of the harvest or removal of vegetation, as well as accelerated decomposition rates of soil carbon (IPCC, 2007). Conversion of forest and grasslands to cropland for biofuels production can result in significant GHG emissions and reduce the relative carbon savings of biofuels over fossil fuel sources. Growing recognition of the contribution emissions from land use change can have on the GHG impact of biofuels has increased attention and caution regarding accuracy of LCA calculations (Fargione et al. 2008).

Biofuel feedstock production can contribute GHG emissions from direct land use change, emissions from conversion of land from a prior use (e.g. forest) to biofuel feedstock production, as well as indirect land use change, emissions from conversion of other lands as a result of biofuels production due to increased agricultural pressure or demand for biomass material. Direct land use change GHG emissions can be incorporated, but indirect land use change GHG emissions are much more difficult.

8.5.1 Carbon stocks

Carbon stock and productivity values can vary significantly by ecological zone based on climate, soil, terrain, and management conditions (IPCC Guidelines, 2006). Clearly defined land use classifications and incorporating climate region specific carbon stock values based on the IPCC Guidelines and productivity values based on FAO agro-ecological zones (AEZ) will reduce uncertainty and improve transparency of calculations. The IPCC Guidelines for National GHG Inventories provides guidance on classification of land-use categories so they are applied as appropriately and consistently as possible in inventory calculations.

The IPCC Guidelines provide detailed guidance on calculating annual emissions from carbon stock changes as a result of land use change. Using the FAO agro-ecological zones methodology for calculating the productivity values of biofuels crop production could improve the accuracy of emissions calculations. The FAO agro-ecological zones methodology calculates potential crop yields by matching crop environmental requirements and land resources (IIASA, 2000). To facilitate users a simplified table of biofuel crop production by climate zone or web-based tool with further stratified crop production values could be generated based on the FAO agro-ecological zones methodology.

8.5.2 Direct land use changes

There has been increasing concern that carbon losses from intensification of agriculture and clearing of natural lands leads to large emissions that are not fully accounted for in analysis of the lifecycle assessment of biofuels production (Fargione et al. 2008, Searchinger et al. 2008). GHG emissions from direct land use change can be addressed as annualised emissions from carbon stock changes caused by land use change and emissions from the extraction or cultivation of raw materials.

8.5.3 Indirect land use changes

Indirect land use change occurs when pressure on agriculture due to the displacement of previous activity or use of the biomass induces land-use changes on other lands (Gnansounou et al. 2008). The GHG emissions that result from indirect land use change are known as leakage, defined by the IPCC as changes in emissions and removals of GHG outside the accounting system that result from activities that cause changes within the boundary of the accounting system (IPCC, 2000).

Several recent studies have highlighted that GHG emissions in biofuels production from indirect land use change are more significant than emissions from direct land use change. Recent estimates from Searchinger et al. (2008) based on scenarios to estimate the effect of increasing corn ethanol production in the US, conclude that indirect land use emissions double the emissions of corn ethanol relative to gasoline. Farrell and O'Hare (2008) concluded that shifting corn-soybean production to only corn for ethanol may induce soybean expansion into forest, which would result in GHG emissions 6 times higher than gasoline. The magnitude of indirect land use changes is not expected to be linear, but several factors have been identified which determine the change in cropland including: production of co-products, crop prices, and crop yield (Searchinger et al. 2008).

Several challenges exist to accurately quantifying emissions resulting from indirect land use at a global scale. No current global models of indirect land use change exist. A global trade and economic model with country by country and crop by crop data would be needed. Searchinger et al. (2008) use the FAPRI international model for their analysis, however since this is a partial equilibrium model interaction with other economic sectors is not accounted for. Analysis by the US EPA using the FASOMGHG model provides assessments of leakage as a result of agriculture and forestry sector activities in the US, though the applicability globally may be limited (US EPA, 2005). Revisions to the GTAP and CLUE models have been proposed and may better account for displacements resulting from indirect land use change (Gnansounou et al. 2008).

Methodologies for accounting for indirect land use change are also being developed. CDM methodologies for bioethanol production from sugar cane include consideration of GHG from indirect deforestation by requiring a fixed area radius around a project site to be annually monitored in order to assess the land use change impact of the plantation on the forested area (UNFCCC, 2007). The Dutch government has proposed a general methodology to estimate indirect land use based on determining the relevant markets/areas delivering biofuels to the country, the expansion of each of these markets due to biofuels due to food/feed and in total, how the additional demand is being met, the GHG emissions of expansion of these markets, the impacts of market expansion over biofuels and food/feed, and dividing these effects by the amount of biofuels per market (Cramer Commission, 2007).

The Oeko-Institut has proposed accounting for GHG emissions from indirect land use change by using an "iLUC factor" for calculating the GHG balance of biofuels (Oeko Institute, 2008). Indirect land use change will be different for each combination on possible conversions. Market changes through time can also be expected to change the indirect land use change resulting from biofuels production. If an approach such as the "iLUC factor" were applied a mechanism to revise estimates through time would be needed.

9 Socio-economic Impacts

Can biofuel development be beneficial to all?

Socio-economic impacts that are of primary interest generally include income generation, job creation, provision of new services, creation of new infrastructure, establishing opportunities for entrepreneurs, and stimulating innovative technical and institutional approaches. At the same time, large scale projects have encountered controversy involving the acquiring of traditional land and competition with food crops.

The range and extent of socioeconomic impacts of bio-energy use is greatly dependent on the scale and intensity. The Brazilian model exemplifies the large scale intensive approach, using high capacity central processing points fed by intensively farmed surrounding areas. The establishment of large estates can bring significant benefits to employees, such as health care, sanitation and improved infrastructure (Tomlinson, 2005). Indeed, the large-scale crop enterprises are more economically efficient. However, the question remains whether or not they can be designed to improve local livelihoods.

However, in the African context, the high proportion of subsistence farming amongst livelihoods in rural areas, and the complexities of land ownership under traditional land law regimes, has made such large scale acquiring of land somewhat more controversial.

It has been suggested that a smaller scale approach may be more appropriate, possibly involving the contracting of small scale farmers to work as 'outgrowers', dedicating a proportion of their land to growing a crop for guaranteed purchase by a processing company. Such an approach has the advantage of providing additional seasonal income for poor rural farmers, without dismantling the structure of their existing livelihoods, which may be vital to their survival. However, the lower intensity of land use entails a larger area of agricultural production for each processing plant, resulting in feedstock transport costs becoming a serious obstacle to commercial viability.

A decentralised approach could also help to reduce feedstock transport costs by reducing the weight of the cargo—in other words—by decentralising more of the production process through the setting up of small scale distilleries. This would create another important benefit for the rural poor—access to clean, domestic fuel—with resultant benefits to health from reduction of indoor air pollution. The economic viability of such small scale distilleries has not been proved, however, and concerns have been expressed about the dangers of alcohol abuse. It is nevertheless an area worthy of some further investigation.

Seasonal employment can pose social problems in industries such as sugarcane in southern Africa. The sudden influx of migrant seasonal workers into regions to which they have no attachment has been reported to have negative effects on community cohesion, causing ethnic tension and disintegration of traditional structures of authority. Migrant workers sometimes establish unauthorised settlements that they are unwilling to leave at the end of the season, ultimately increasing overall unemployment levels and pressure on land for subsistence farming. Due to the sometimes drunken and promiscuous behaviour of migrant workers, it has also been observed that HIV infection rates are high around sugar cane plantations (Cornland et al, 2003; FAO, 1995).

A major area of concern for critics of biofuels is the possibility that bioenergy crops could replace land for food crops. Another advantage of sweet sorghum as an alternative to sugar cane is that as well as producing sugary stems suitable for ethanol production, many varieties also produce edible grains, which can be ground to make 'mealie meal', a staple food in many parts of southern Africa. This has the attraction of providing potentially a double benefit- subsistence food and an income, allowing the farmer the chance to rise out of poverty, without losing self sufficiency.

9.1 Impacts and Sustainability of liquid biofuel from non forest sources: Contributions to Development Objectives

How does FDI biofuel development impact on national energy needs? The trade balance? Employment? Access to food?

Domestic use vs Export

An aspect of larger scale biofuel production development is whether the produced fuel is to be used domestically or not. Most requests for land/investment permits state that displacement of imported fuel is a goal. This would require fuel policies that made it attractive for national fuel distributors to use domestically produced fuels rather than (their own) imports.

Since diesel is the main vehicle fuel in the most African countries, amounting to 75% of total sales in Tanzania, for example, the production of biodiesel should be a priority for receiving incentives. This means that ethanol-based biofuels would be less advantageously treated. In a longer term especially for on-farm vehicles, ethanol fuel is possible for adapted h-d engines.

The lack of physical infrastructure is mentioned as a critical challenge to development of a domestic biofuels industry. This is unfortunately correct – any major production facility which is denied export for legal or practical reasons will be considerably less attractive for investors since it would not be linked to the international product market and demand. On the other hand, since deficient infrastructure increases the cost of imported commodities such as (fossil) fuels, inland production of renewable diesel replacement (e.g. jahtropha) could be embraced by oil companies as a means to reduce transport cost.

It is very important to keep in mind that biofuels do not all require the same production and distribution infrastructure. Blending locally produced ethanol in imported gasoline, for example, would enable existing distributors to maintain their wholesale and retail infrastructure. However, this will not solve the energy and fuel problems of the rural areas, which is where the feedstock will be produced.

Another important area for the potential use of biofuels in developing countries is in the area of domestic food preparation. At first glance it does not seem that many of the proposed biofuel projects are aimed at producing fuels for energy-efficient cooking facilities while in practice most developing countries already rely on biomass in some form for this activity which is carried out daily by most of the population. In terms of impact on livelihoods, cooking fuel should be an important consideration.

10 Land Rights

Is land really "available"? How intensively do different crops exploit the land and other resources?

There is a dichotomy between the strategic, macro-planning of natural resource use at the national level and what is happening on the ground in terms of the land rights of small-holder peasant farmers, especially in Eastern and Southern Africa. The content of government policy and regulations governing Foreign Direct Investment (FDI) is a result of the macro-planning process. Without the input of local resource use realities, these regulations and policies can lead to serious resource use conflicts between national and local interests.

Indeed, controversies over what is popularly termed "land-grabbing" have been so heated in regards to biofuel development, that a number of countries, among them Tanzania, have placed a moratorium on the development of new projects until the ramifications can be sorted out.

10.1 Introduction

Rural areas in Eastern Africa are increasingly facing processes of globalization, commoditization and monetization. The state and private sector, including domestic and transnational companies, are emphasizing the need for external investment, modernization of the agricultural sector and utilization of rural resources to accelerate economic development. As a result, many countries in Africa are hosting major investments in agriculture.

Traditionally, development efforts in the agricultural sector focused on the production of food and cash crops. The issue of energy production within agriculture is a recent area of interest for many countries in Africa.[10]

Energy is recognized as having multi-faceted impacts on development. Energy affects all aspects of development - social, economic and environmental -including livelihoods, access to water, agricultural productivity, health, education and gender related issues. It is well recognized now that none of the Millennium Development Goals can be met

[10] On July 2006, thirteen non-oil producing African countries, Ethiopia included, established the Pan-African Non-Petroleum Producers Association in an effort to initiate alternative energy sources where biofuels are merited as key alternatives. Since then, many countries have set national strategies and began allocations of rural land and labour to produce fuels.

without major improvement in the quality and quantity of energy services in rural areas of Africa where the majority of the population lives. (Desta and Mulugeta, 2002)

A major implication of this mainstream development agenda is that large land areas are being allocated to the production of renewable energy resources in the form of liquid biofuels. Various actors, including the state, the private sectors (transnational and domestic investors) and the rural people are involved in biofuels production. This process is engulfing extensive rural land and labour resources, and thus generating different production system models.

Of the all of the different production systems possible for biofuel, smallholder-based outgrower schemes are projected to be a significant future source of feedstock. There are various reasons for this.

First, from agronomic point of view, biodiesel feedstock production (such as jatropha and castor) can be produced by smallholder farmers on their own farms. Jatropha particularly has been promoted as a drought resistant crop that can be grown on marginal lands as a hedge plant or in intercropping systems.

Second, the smallholder farming system constitutes a significant part of the rural population and the introduction of biofuels into the system is perceived as means of improving the livelihoods of the rural people.

Finally, the smallholder farming system in particular and the rural areas in general are potentially suited for contact farming systems. Contract farming in this case serves as an intermediate institutional arrangement that allows the agro-industry companies to participate in, and exert control over, the production process without owning or operating the farms.

Despite these positive potentials for biofuel production possibilities, there are critical issues that need to be considered. Will biofuel investment support or undermine smallholder farmers? In addition to the agronomic demands and energy efficiency of the biofuel crops, much depends on the form of production, be it small, medium or large-scale production in highly capitalized farm units employing labour or smaller units based on own-farm or outgrower schemes. These production systems, then, function within a determinatory framework of land rights and socio-economic institutions.

Thus, the impacts of biofuels production on rural areas hinges on many factors including rural and agrarian structures and reform needs, production support and protection, integration of biofuels in the livelihoods of the rural people, and access to regional and global markets.

10.2 Land contracts and markets

Will biofuel investment support or undermine smallholder farmers?

A common challenge in African agricultural investment policies is that the difference between the perception/expectation of investors of access to land and the reality of

African land tenure system. Both domestic and foreign biofuel companies have an industrial and entrepreneurial understanding as regards their agricultural establishments. The realities of African land tenure are issues that are generally poorly understood by investors.

Rural communities in Africa have many ‘legitimate’ and ‘accepted’ ways of accessing and using resources often subsumed into two broad institutional clusters: formal and informal. The formal land access and use rights are rights defined by the state. Many African states use constitutional and legal orders to define and demarcate certain goods such as land, forests, wild life, minerals etc. under their control for different purposes. Such purposes usually include distributive purposes so that there is some balance and equity when different social groups access these goods. The informal land access systems, also called customary systems, are locally (ie by the rural communities themselves) defined systems of land and other natural resources access. In many African countries, the formal and informal systems co-exist, but they can also overlap and undermine each other. People may oscillate between the formal and informal systems depending on their social power. Such processes may weaken the legitimacy of the institutions and inflict insecurity and conflicts.In such circumstances, government-backed land allocations for large-scale commercial farms may just be another source of insecurity to rural people and rural peoples may have unsettled issues as regards the land allocations to companies.

Threats to land right needs also be seen from the overall economic and investment incentive structure. African policies on commercial farming are predominantly government-backed and driven by the need to attract foreign direct investment. In many cases, land is used as an incentive to attract investments. This includes provisions of large tracts of land, low land rents and long lease terms (often 33 to 99 years). Over dependency on land as a means of investment incentive, however, raises risks and uncertainties that need to be addressed. Do such strategies capture full value of the land? Are current governance structures transparent and legitimate enough to carry out such incentives and contracts?

10.3 Smallholders versus industrial/corporate farming

A fear is expressed frequently in Africa that by establishing large-scale cultivation schemes the local workforce would be hired as unskilled labor rather than acting as competent smallholders. The corporate dynamics of a large estate with a large number of employees would typically favor policies of low wages and specialization. Where this is the case, resilience, competence building and flexibility of the employees could suffer. On the other hand, employment in a developing large-scale business operation could, under the right conditions, be a source of income and a way of introducing skills, practices and technolgies.

The obvious solution to this problem is the development of outgrower schemes. Outgrowers have successfully been included in industrial scale farming in Tanzania, most notably in the case of the Kilombero Sugar Estate and the Katani Sisal Estate. Both of these, however, have been the result of long processes of change. Successful examples of outgrower agribusiness development, including joint irrigation schemes, can be found in neighboring African countries, including Malawi and Ethiopia. Outgrower jatropha plantations in Konso in the south and in Tigray region in the north in Ethiopia are other examples.

A summary of the impacts of biofuel production on large and small scale is presented in Table 8 below.

TABLE 8: Impacts of biofuel production on the large and small scale

ELEMENTS	SCALE	Impacts
Source (feedstock)	Small scale Sugar cane outgrowers	Increased local incomes, require secure tenure & infrastructure
	Large Scale Sugar cane plantation	Increased mechanization, skilled employment
Conversion technology	Small scale	Distillation to ethanol difficult on small scale
	Large Scale	Location close to export infrastructure
Fuel Type (end product)	Small scale use	Ethanol for cooking stoves?
	Large Scale use	Ethanol for blending in vehicle fuel (fossil fuel)
Organization	Small scale/ local	Difficult to produce locally, not difficult to consume as cooking fuel but most vehicles and generators require diesel.
	Large Scale/ Global	Primarily geared to export markets in industrialized countries

10.4 Contract biofuel farming

Contracting is an institution that guides 'coordination between growers and buyers-processors that directly shape production decisions through contractually specifying market obligations (by volume, value, quality and, at times, advanced price determination); provides specific inputs; and exercises some control at the point of production i.e., a division of management functions between contractor and contractee. (Little and Watts 1994, p 9).

Even using this rather simplified definition, there are key questions as to companies' choice and overall outcome of contract farming. According to Ellis, the primary purpose of agrarian contracts is 'to reduce transaction costs in the context of the unevenly developed markets and scarce information found in the rural societies of many developing countries' (Ellis 1993:146-147). In other words, contact farming is an institutional response to imperfections in markets for credit, insurance, information, factors of production; and in transaction costs associated with search, screening, transfer of goods, bargaining, litigation and enforcement. Seen in these terms, contract farming has the potential to incorporate low-income growers into the modern sector. This is believed to create economies of scale in the long run, as well as access to international markets, and dissemination of skills and techniques.

However, there are critiques that contract farming should not be seen within the boundary of market imperfection only. As case studies done on major African export crops in the 1980s show, contract farming is not necessarily the institutional panacea for smallholder involvement in agro-industrialization (Havnevik et.al. 2007; Gibbon & Ponte, 2005; Reardon and Barrett 2000). Africa has been losing out on international markets and its share of world agricultural trade has declined for nine out of ten major exports (NEPAD). The World Bank's World Development Report 2008 stressed the difficulties that African smallholders face in trying to compete in the global market (WDR 2008). The outcome of contract farming, thus, hinges on broader agrarian, national and international political and economic structures as well.

10.5 Embeddedness of products in rural livelihoods

Will consumption of biofuels be part of the social and economic life of the rural people who produce them? How can biofuels be integrated into the local and regional markets?

Transnational companies are not the only agents driving the commercialization of biofuels in Africa. In fact, domestic investors are also playing active role, both as independent investors but also in collaboration with foreign investors. The implication of these processes needs to be studied across two perspectives. One is whether domestic investments are qualitatively different from foreign ones in terms of their embeddedness in the local social and economic fabric of the rural and urban areas of the country. This includes their marketing targets.

The other perspective has to do with the scale of biofuel production. Some preliminary investigations show that the scale of investments in Ethiopia are fairly evenly distributed between big and medium/small sized projects, while in Tanzania the investments are big and few. An understanding of the implications and impacts of these structural differences is crucial to address the relevance of scale in biofuels.

Rural entrepreneurship and organization: Rural producers do not respond simply as individual actors to their political and economic imperatives only. Both entrepreneurial and organizational aspects of rural people are crucial in disseminations of the technical and management know-how, access to rural finance, and connections to potential markets. The rights to form economic associations and be recognised by the formal/ state systems (as firms and economic actors) are critical steps to secure access to different resources.

The inclusion of rural people in the production processes needs to be seen from this perspective as well. In contexts where rural entrepreneurship and organizational structures are poor, inclusion of rural people in biofuel production as contract farmers and outgrowers may signify industrial appropriation of rural production processes. In the worst scenario, such processes may subjugate and constrain labour. Rural entrepreneurship that is dynamic, economically independent and organizationally strong and capable of rejecting paternalistic interventions is crucial preconditions to ensure smallholder benefits. In the absence of such conditions the overall negotiating capacity of the rural people with the biofuel companies is weak and fragmented.

Household & community impacts: Institutionalized and informal social practices determine how individuals organize themselves and create social capital. This applies at different scales of social and economic structures: at the household, community and other economic groupings. Far from being orderly adaptive structures, rural households are founded on conflicting relations.. Individual members of households' have different decision making powers. Control and access to resources, social networking and marketing can be significantly different among members of households depending on gender, age, education, etc. Female headed households often tend to lack farm resources such as farm implements and labour. Female-headed households tend to be subsistence oriented, while male-headed households are strong on cultivating cash crops. How contract biofuel farming impacts on gender and power relations in rural areas as well as influencing household labour and income are still key questions to be explored further.

At village and community levels, social relations are shaped by patronage and kinship relations and this has been a crucial aspect in accessing resource use in many rural areas in Africa. Existing authorities and roles (formal or traditional) can easily be expanded to take on new challenges. How these local power and relational realities impact on contract decisions of household resources is critical as regards the long-term social and economic sustainability of contract biofuel farming.

The impacts of contract farming on power relations, access and control of rural resources across gender and different ethnic and age groups of rural people are important aspects of biofuel production. Production of biofuels is still new for rural households in Ethiopia. Its expansion may change the rural setting in terms of production organization, promoting shifts in production objectives and social power relations including access and control over natural resources.

How will biofuels influence rural communities' economy and livelihood structures? What are the impacts of biofuels on access to and control of resources and marketing of biofuels? How are biofuels impacting on gender and power relations in rural areas? How are biofuel productions influencing household labour and income? How can rural land and labour resources be best integrated into biofuels production to ensure sustainability? These are some of the questions that need to be explored in the different specific situations.

Framework Agreements and National Policy: An effective participation of different stakeholders in biofuel production depends on good governance, transparency and the accountability of institutions that guide the different actors. In promoting biofuel investments, governments play a role through establishing the regulatory framework that governs the investment – including through national legislation and through framework government-to-government agreements such as bilateral investment treaties (BITs) and cooperation agreements in agriculture. These intergovernmental agreements may be

part of broader bundles of development aid, non-financial assistance and business involvement
.

Agrarian structure: Legal frameworks for protection of land rights in biofuel contracts are invariably linked to the agrarian structure of rural Africa. A central issue of the agrarian question in Africa is related to the land: land tenure and land reform. For many African countries, land lies at the heart of social, political and economic life. Due to population growth and market developments, pressure and conflict on land resources is increasing in many African countries. Customary land tenure systems are under increasing pressure and the development of formal land institutions is generally very slow.

In many African countries, including Ethiopia and Tanzania, rural land is state owned and rural people have only usufruct rights. Historically, rural areas in general have faced strong interventions from the State. Redistribution of rural land, lack of clear ownership and insecure tenure terms have been challenges to the smallholder farmers. In Ethiopia, in particular, the right to land ownership is exclusively vested in the State. Farmers have user rights of the land and permanent transfer of land is prohibited (Proclamation No. 1/1995, Article 40, No. 3). The impact of insecure land tenure on contract biofuel farming decision by local people is an area that needs future investigation.

In many cases, ownership of ‘communal’, national and protected lands, and sparsely populated areas are also controlled by the state. Governments are directly involved in leasing and renting of land for capital intensive commercial farming. In the case of Ethiopia, the expansive areas allocated for biofuels are principally from such areas. The ongoing processes of acquisitions of land for food and energy, thus, need to be seen in relation to the broader land tenure and land policy of the state.

In the face of the expanding commercialisation of agricultural sectors, ensuring security and ownership of the land for the rural people demands political support and long-term commitment. To secure full participation of the rural people in biofuel production, the land issue must be mainstreamed into the wider economic agenda to secure property rights for the poor and rich alike.

10.6 *Critical dimensions of biofuel farming*

Figure 8 shows the major elements that need to be considered in the production of biofuels, particularly when smallholders' land and labour resources are engaged in the process.

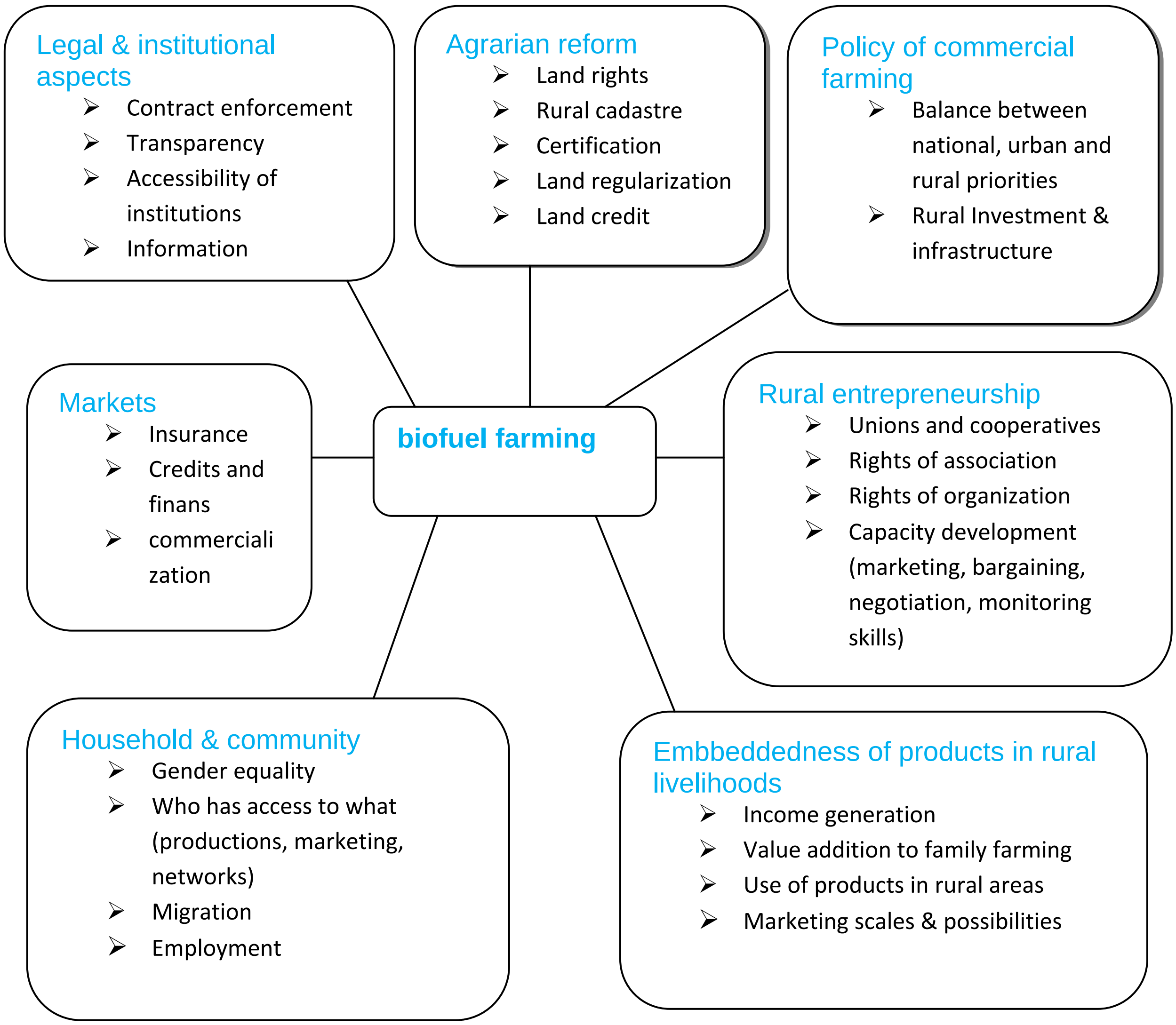


Figure 8. Elements or issues in biofuel farming.

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ANNEXES

Annex 1 - Acronyms

AfDB African Development Bank
BOD Biological Oxygen Demand
CERs Certified Emission Reductions
CSO Civil Society Organisation
DFI Development Finance Institutions (state-owned risk capital investment funds)
export credit agency (ECA)
Association of European Development Finance Institutions (EDFI)
EIA Environmental Impact Assessment
FAO Food and Agriculture Organization of the United Nations
FELISA Farming for Energy for Better Livelihoods in Southern Africa
GHG Green House Gas
GTZ German Technical Cooperation
IIED International Institute for Environment and Development
IUCN International Union for Conservation of Nature
MDB Multilateral Development Bank
MEM Ministry of Energy and Minerals
MoU Memorandum of Understanding
NBTF National Biofuels Task Force
NGO Non-Governmental Organisation
RAZABA Zanzibar People's Ranch
SUSO Sugarcane Smallholder and Outgrower Scheme
TFWG Tanzania Forestry Working Group
TIC Tanzania Investment Centre
TNRF Tanzania Natural Resource Forum
US EPA United States Environmental Protection Agency
WWF World Wildlife Fund for Nature

Annex 2 Project Finance Template

There are a number of standard procedures used to determine the financial viability of an investment in biofuel. The outline for the Project Review Report below presents in detail the steps taken to carry out the financial assessment of an investment project.

Project Review Report

The report is to comment on the following:

1) *Technology Review*
   a. Significant technology risks and consequences to the ability of the Project to meet its obligations and expectations;
   b. Whether the design of the proposed bioenergy facility is appropriate for the intended purpose and intended working life. This analysis should include an assessment of the [xxx *specific technical issues listed xxx*]
   c. Review should also include a comparison of expected performance with other similar Plants using similar technology in other parts of the world;
   d. Review of reference/ benchmark facilities – number of such facilities, comparability, transferability to African environment / proposed feedstock etc etc

2) *Review of Project documents*, including, without limitation:
   a. The design and build contract documentation (in particular, the strength of the arrangements for defining and proving performance and the associated LD's, warranties and liabilities);
   b. The waste/fuel supply arrangements and contracts;
   c. Arrangements for [recycling/disposal of ash / residues]
   d. The operation and maintenance agreement or arrangements;
   e. Electrical connection agreement;
   f. Energy sale agreements;
   g. The allocation of risks between the various parties and the overall risk profile of the project;

3) The *capability and experience* of the major contracting parties to fulfil their obligations under the terms of their contracts;

4) *Suitability of the site* for construction to include [a Flood Risk assessment, adequacy of Proposed Layout (receiving, processing and storage areas) *and others as required*]. Cost and programme implications of site, soil and identification of likely risks and implications of unidentified ground conditions including the likelihood of archaeological finds, obstructions, contamination (to the extent not the obligation of the Contractor);

5) The *status and conditions of permits*, licenses, planning permissions or other consents required for the development, construction and operation of the proposed facilities, including:
   a. Planning permission and conditions;
   b. Authorisation under Environmental license and conditions (including a review of the application for the Environmental license which may also contain obligations or commitments);

6) Comment on the *capability of the main sub-sub contractors* (contractors for major civils/technology components).

7) Review the *level of Project costs* against industry norms (including construction, operation and major maintenance costs) and whether they are budgeted on a realistic basis and are accurately reflected in the Financial Model;

8) Review the *Proposed Project Management* from Financial Close;

9) Comment on the *overall timetable for Completion and potential risks of delay*. The adequacy of the level of liquidated damages in respect of delays during the construction phase;

10) The *projected technical life of the proposed facility*, the achievability of the stated output specifications over the project life and the adequacy of any performance liquidated damages payable in the event of such specifications not being achieved.

11) Any issues associated with the *Owner's obligations*, particularly with respect to fuel supply arrangements and on Interface issues especially between EPC Contractor and Waste Suppliers;

12) Comment on *security package* including guarantees and bonding. Also comment on Defects Liability and Latent Defects.

13) *End of life issues*.

14) O&M Arrangements:

- Comment on the competence of operators
- Review maintenance schedule, lifeclycle arrangements and philosophy
- Comment on service start up proposals
- Resourcing requirements
- Review of potential alternative O&M providers

1.2 Financial Model

Review and comment on the appropriateness of the Technical Assumptions included in the Base Case Financial Model and, where necessary, liaise with the Model Auditor to ensure any changes to Technical Assumptions are fully reflected in the Financial Model.

1.3 Other Advisors

Liaison with Lenders' Legal, Insurance and Financial Advisers to ensure appropriate amendments and conditions are included in the Project documentation including, without limitation, the Facility Agreement, construction, fuel supply, off-take, and operation and maintenance contracts.

Comment on insured values relating to plant and equipment and periods of delay for reconstruction or replacement of plant.

Phase 2 – Construction Period

The services will include:

1) Attendance at any syndication presentation to potential participant banks and assistance with any queries that may arise during the syndication process;

2) Monitoring of construction progress and provision of quarterly reports for the Bank summarising the status of construction;

3) Provision of independent certification to the Banks that draw-downs under the loan facility are payable;

4) Approval of the issuance of any change orders associated with the construction contract;

5) Attendance at performance, completion and reliability tests and provision of independent certification that Completion has been achieved in accordance with the Facility Agreement;

It is assumed that the total period for the design and construction through to testing and acceptance of all the facilities will be [xx] months.

Project Finance Assessment

1.1 Project Review Report

The report is to comment on the following:

3) Technology Review
   a. Significant technology risks and consequences to the ability of the Project to meet its obligations and expectations;
   b. Whether the design of the proposed bioenergy facility is appropriate for the intended purpose and intended working life. This analysis should include an assessment of the [xxx *specific technical issues listed xxx*]
   c. Review should also include a comparison of expected performance with other similar Plants using similar technology in other parts of the world;
   d. Review of reference/ benchmark facilities – number of such facilities, comparability, transferability to African environment / proposed feedstock etc etc

4) Review of Project documents, including, without limitation:
   a. The design and build contract documentation (in particular, the strength of the arrangements for defining and proving performance and the associated LD's, warranties and liabilities);
   b. The waste/fuel supply arrangements and contracts;
   c. Arrangements for [recycling/disposal of ash / residues]
   d. The operation and maintenance agreement or arrangements;
   e. Electrical connection agreement;
   f. Energy sale agreements;

g. The allocation of risks between the various parties and the overall risk profile of the project;

3) The capability and experience of the major contracting parties to fulfil their obligations under the terms of their contracts;

4) Suitability of the site for construction to include [a Flood Risk assessment, adequacy of Proposed Layout (receiving, processing and storage areas) *and others as required*]. Cost and programme implications of site, soil and identification of likely risks and implications of unidentified ground conditions including the likelihood of archaeological finds, obstructions, contamination (to the extent not the obligation of the Contractor);

5) The status and conditions of permits, licences, planning permissions or other consents required for the development, construction and operation of the proposed facilities, including:

c. Planning permission and conditions;
d. Authorisation under Environmental licence and conditions (including a review of the application for the Environmental licence which may also contain obligations or commitments);

7) Comment on the capability of the main sub-sub contractors (contractors for major civils/technology components).

8) Review the level of Project costs against industry norms (including construction, operation and major maintenance costs) and whether they are budgeted on a realistic basis and are accurately reflected in the Financial Model;

9) Review the Proposed Project Management from Financial Close;

10) Comment on the overall timetable for Completion and potential risks of delay. The adequacy of the level of liquidated damages in respect of delays during the construction phase;

11) The projected technical life of the proposed facility, the achievability of the stated output specifications over the project life and the adequacy of any performance liquidated damages payable in the event of such specifications not being achieved.

12) Any issues associated with the Owner's obligations, particularly with respect to fuel supply arrangements and on Interface issues especially between EPC Contractor and Waste Suppliers;

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