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PRIORITY A.2.3.: Managing Arid and Semi-arid Ecosystems

Third Periodic Activity Report
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ANNEX 5-3-5: Info package for WP7

Deliverable D5.7 (Lead contractor: ESD, Due date: December 2008)

COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa

Responsible Partner:

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Project Partners

Partici-pant role	Partici-pant number	Participant name	Participant short name	Country	Date enter project (month)	Date exit project (month)
CO	1	WIP – Renewable Energies, Germany	WIP	DE	1	36
CR	2	Imperial College of Science, Technology and Medicine	Imperial	UK	1	36
CR	3	Utrecht University	RUUTR.STS	NL	1	36
CR	4	Stockholm Environment Institute	SEI	SE	1	36
CR	5	Austrian Biofuels Institute	ABI	AU	1	36
CR	6	Höhere Bundeslehr und Forschungsanstalt für Landwirtschaft, Landtechnik und Lebensmitteltechnologie Francisco Josephinum	FJ BLT	AU	1	36
CR	7	ETA - Energia, Trasporti, Agricoltura s.r.l.	ETA	IT	1	36
CR	8	European Biomass Industry Association	EUBIA	BE	1	36
CR	9	Practical Action	Practical Action	UK	1	36
CR	10	Consiglio Nazionale delle Ricerche	CNR	IT	1	36
CR	11	E+Co, Inc. (not funded)	E+Co	USA	1	36
CR	13	Institute for Sustainable Solutions and Innovation	ISUSI	DE	1	36
CR	14	AGAMA Energy (Pty) Ltd	AGAMA	ZA	1	36
CR	16	Center for Energy, Environment and Engineering Zambia	CEEEZ	ZM	1	36
CR	17	Environnement et Développement du Tiers-Monde	ENDA-TM	SN	1	36
CR	19	Food, Agriculture and Natural Resources Policy Analysis Network of Southern Africa	FANRPAN	ZIM	1	36
CR	20	FELISA Company Limited	FELISA	TZ	1	36
CR	21	Mali-Folkecenter	MFC	Mali	1	36
CR	22	MOI University	MU	Kenya	1	36
CR	24	Tanzania Traditional Energy Development and Environment Organisation	TaTEDO	TZ	1	36
CR	25	UEMOA - Biomass Energy Regional Program (PRBE)	PRBE	BF	1	36
CR	26	University of KwaZulu Natal	UKZN	ZA	1	36
CR	27	University of Cape Town - Energy Research Centre	UCT, ERC	ZA	1	36
CR	28	Chinese Academy of Agricultural Sciences	CAAS	CN	1	36
CR	29	Centro Nacional de Referencia em Biomassa, Brazil	CENBIO	BR	1	36

Project Partners (continued)

Partici-pant role	Partici-pant number	Participant name	Participant short name	Country	Date enter project (month)	Date exit project (month)
CR	30	Indian Institute of Science	IISC	IN	1	36
CR	31	The Energy and Resources Institute	TERI	IN	1	36
CR	32	Universidad Nacional Autonoma de Mexico	UNAM	MX	1	36
CR	33	Universidade Estadual de Campinas	UNICAMP	BR	1	36
CR	34	Winrock International India	WII	IN	1	36
CR	35	Interuniversity Research Centre for Sustainable Development - University of Rome "La Sapienza"	CIRPS	IT	1	36
CR	36	Universitetet i Oslo	UiO	NO	1	36
CR	37	University of Bristol	UNIVBRIS	UK	1	36
CR	38	University of Botswana	UB	Botswana	1	36
CR	39	University of Fort Hare	UFH	ZA	1	36
CR	40	TWIN	TWIN	UK	1	36
CR	41	Joint Graduate School of Energy and Environment	JGSEE	TH	1	36
CR	42	African Development Bank Group (not funded)	AFDB	Int.	1	36
CR	43	Energy for Sustainable Development Ltd.	ESD	UK	1	36
CR	44	Eco Ltd.	Eco	UK	1	36
CR	45	Chinese Association of Rural Energy Industry	CAREI	CN	1	36
CR	46	Food and Agriculture Organisation of the United Nations (not funded)	FAO	Int.	1	36
CR	47	Conservation International Foundation (not funded)	CI	USA	1	36
CR	48	Foederation Evangelischer Kirchen in Mitteldeutschland	EKMD	DE	1	36

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CDM	Clean Development Mechanism
CER	Certified Emission Reductions
ETS	Emissions Trading System
FT-diesel	Fischer-Tropsch diesel
FIT	Feed-In Tariff
GHG	Greenhouse Gas
H	Hydrogen
CO	Carbon Monoxide
CO_2	Carbon Dioxide
LFG	Landfill Gas
MFP	Multi- Functional Platform
OPEC	Organization of Petroleum Exporting Countries
PPA	Power Purchase Agreement
RD&D	Research, Development and Demonstration
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme

INTRODUCTION

This work has been conducted in the framework of the project COMPETE (Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa), co-funded by the European Commission in the 6^{th} Framework Programme – Specific Measures in Support of International Cooperation (Contract No. INCO-CT- 2006-032448).

The main purpose of this deliverable D5.7 is the identification of a few publications relevant to the scope of this work package -i.e. financing mechanisms and trade of bioenergy projects in Africa- for publication on the COMPETE website. Therefore, three reports have been identified relevant across the scope of this work package and a summary of each of the identified publications is provided.

The structure of this deliverable reflects this approach, i.e. for each of three identified publications the scope, relevance and key messages are provided followed by a more detailed summary of the most relevant sections per publication.

1 'BIO-CARBON OPPORTUNITIES IN EASTERN AND SOUTHERN AFRICA'

1.1 SCOPE, RELEVANCE AND KEY MESSAGES

The scope of this 304 page report includes an overview of opportunities for bioenergy projects in Africa resulting from various aspects around the global carbon markets. This not only represents a promising means to reducing global carbon emissions in an efficient way, but it most of all presents an opportunity for African countries to attract associated investment and technology flows.

With respect to the structure of the report, it is organised in terms of the bio-carbon production cycle and covers the following areas:

- Forest bio-carbon
- Domestic bioenergy and charcoal production
- Bioenergy-related policy options and instruments
- Various specific bioenergy options, each with an increasing level of technological specification, ranging from anaerobic digestion, bagasse cogeneration, biomass use in cement production, biomass gasification and pyrolysis, and finally, landfill bioenergy at the end of the production cycle.

The relevance of this report to WP5 lies in the fact that it addresses aspects relevant to the main set of stakeholders covered by COMPETE -and in particular by WP5-, i.e. policy makers, project developers and investors / financing institutions. The range of most relevant topics covered in this report includes an overview of different bioenergy conversion technologies; technical and non-technical challenges and barriers to bioenergy development; policy frameworks; capital and financing options; and a comparison of financing options for different technologies.

The key messages of this report most relevant to WP5 are as follows:

- Barriers currently hampering bioenergy project development in Africa include
    - inappropriate and poorly devised bioenergy-relevant policy frameworks;
    - lacking expertise of project developers (financial proposal preparation) as well as of financing institutions (bioenergy evaluation);
    - access to financing;
    - land competition;
    - resource competition;
    - technology-specific barriers.

- Policy frameworks supportive of biomass energy generation include
    - *Financial incentives*: either increase of price of competing energy source or reduce cost of bioenergy supply
    - *Feed-in-tariffs*: long-term guaranteed price of bioenergy-generated electricity to be fed into the grid
    - *Green certificates*: requirement for consumers to purchase a minimum proportion of their power supply from certified renewable energy/bioenergy sources
    - *Tender schemes*: guaranteeing markets for bioenergy while promoting competition and efficiency

  - *Blending requirements*: nationally mandated blend of ethanol in gasoline / biodiesel in diesel to create a guaranteed market for bioenergy producers
  - *Differential taxation*: combination of increased taxes on fossil fuels and reduced taxes on bioenergy

- Capital and financing options to promote bioenergy within a CDM in Africa context include:
  - Promotion of CDM activities, e.g. reducing transaction costs through simplified modalities and procedures;
  - Self-financing, e.g. through sales of projects' carbon assets;
  - International Funding Agencies, e.g. useful in standardising CDM bioenergy project operation;
  - Microcredit, e.g. can be used as a financing template in Africa, especially for small scale bioenergy projects.

- Comparison of barriers / financing options for different bioenergy technologies - common aspects across technologies:
  - Typically, high upfront cost ventures, requiring government support in the initial start-up phases;
  - General lack of bioenergy project evaluation expertise in the financial sector resulting in high risk perception;
  - General lack of expertise on the project developer side in developing high quality financial proposals, in turn limiting the growth of bioenergy;
  - Possible approaches in supporting bioenergy development:
    - capacity building for the financial sector (bioenergy project evaluation) and for the project developers (preparing (pre-)feasibility studies and financial proposals);
    - easing the conditions attached to finance for bioenergy projects to support the uptake for financing of bioenergy investments;
    - introduction of standard PPAs / feed-in-tariffs to support project developers in raising investment finance;
    - bundling of small projects to attract external financing;
    - shortening of application and approval procedures for existing financing schemes;
    - introduction of supportive policies (e.g. FITs, tax holidays and waivers on import duties on imported bioenergy plant components);
    - establishment of pilot and demonstration projects;
    - capacity building for all stakeholders on carbon financing opportunities.

1.2 SUMMARY OF THE MOST RELEVANT SECTIONS

1.2.1 Global bioenergy drivers and their application to the African context

The primary drivers of the development of bio-energy technologies and their increasing commercialization can broadly be reduced to: energy security, atmospheric GHG stabilization, rural income support and job creation, increased resource management efficiency and combating poor sanitation and pollution-induced human health crises - subject to variations depending on local context.

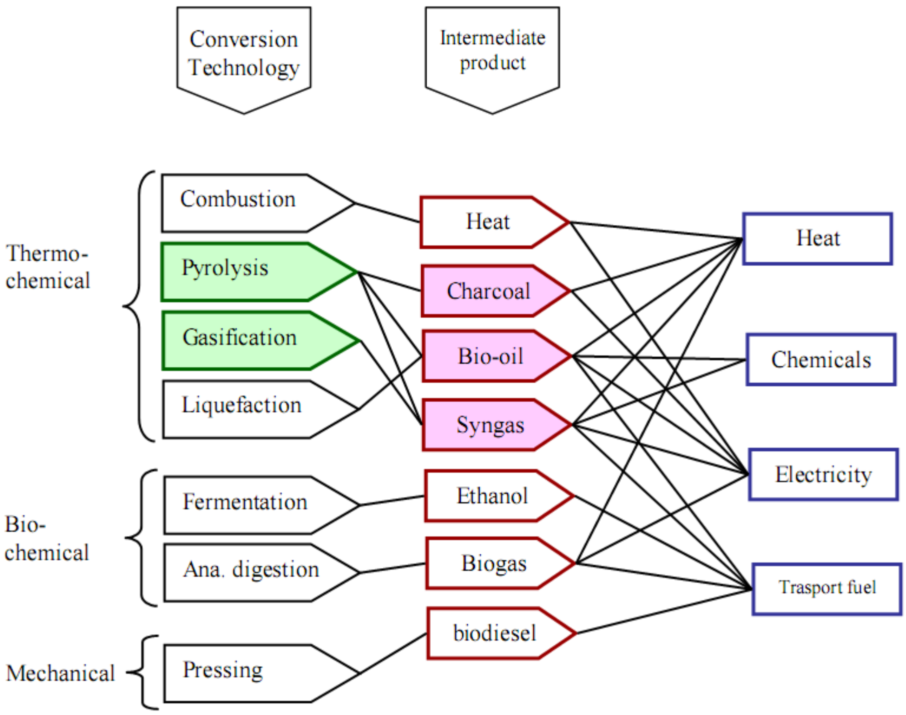
The primary driver of biomass energy development in the EU, USA and Brazil is the desire to diversify sources of energy and increase energy supply security, in response to, for example, the oil embargoes of the Organization of Petroleum Exporting Countries (OPEC) and subsequent global oil crises of the 1970s. Other key drivers of bioenergy development include climate change mitigation efforts, the support of rural livelihoods and job creation and the desire to minimize waste, (i.e. improve the efficiency of resource management). For the latter, for example, ethanol production from sugar processing waste has increased the efficiency of sugar production in Brazil. Similarly, logging and other forest residues are used by the forest industry to export power to the centralized energy grid in North America and Europe. Finally, in China, Nepal and India concerns over sanitation and pollution have driven bio-energy development strongly.

In the African context, energy security is a concern and therefore energy programmes are likely to be driven by their ability to deliver stable, safe and affordable heat and electricity. Secondly, income support and promotion of rural livelihoods is a topic high on the agenda in the African context and as such, it has an important potential to drive bio-energy although it is questionable whether it will be possible to fund this process domestically. The desire for improved efficiency in resource use is also a potentially strong driver of African bio-energy development although this will necessarily be limited to regions with developed (or developing) forest and agricultural industries with significant volumes of waste residue. As for the sanitation driver, this has potential to drive the commercialization of anaerobic digestion from organic waste resulting from animal husbandry, sewage treatment and various other sources of human waste.

1.2.2 Bioenergy market options and states of readiness of different technologies

The available routes for converting biomass to useful commodities are illustrated in the figure below. Fermentation of cellulosic biomass to ethanol is a suitable method for sustainable large-scale ethanol production since it does not compete with food production (in contrast to grain-based ethanol). Biogas production through anaerobic digestion is a low-cost, simple technology but quite slow and not the best option for cellulosic biomass. Mechanical conversion (pressing) of oily seeds, such as rape and jatropha seeds, produces bio-diesel. However, there are a number of economic and environmental uncertainties related to large-scale production of bio-diesel that remain to be resolved, including high production cost, lower energy content, high water and nitrogen requirements for oily seeds production, etc.

Figure 1: Principal bio-energy conversion routes and high-value products



Source: UNDP-UNEP (2009, with modifications)

Conversion of biomass to liquid fuels can be carried out in three ways, i.e. direct biomass liquefaction; fast pyrolysis; and gasification to syngas followed by catalytic conversion to liquid fuels. Fuel flexibility is one of the prominent advantages of pyrolysis and gasification processes. Biomass is more reactive than coal, which is currently used in several commercial gasification processes and can therefore be pyrolyzed and gasified at lower temperatures than coal but it requires specially-designed solids handling, drying, feeding systems and flexible reactors.

Direct liquefaction

In direct biomass liquefaction, the feedstock is put in contact with a catalyst at elevated temperatures in the presence of added hydrogen. The product is a synthetic oil, or bio-oil. Pyrolysis and gasification are thermo-chemical conversion technologies that decompose biomass and its residues into valuable intermediate products.

Pyrolysis

Conventional pyrolysis is a simple, low-cost technology capable of processing a wide variety of feedstocks. By heating biomass in the absence of oxygen, pyrolysis produces a gas mixture, charcoal and liquid fuel known as pyrolysis oil, or bio-oil. There are two different pyrolysis modes, i.e. slow pyrolysis (also called carbonisation) and fast pyrolysis or flash pyrolysis, with significantly different process conditions and outputs. Slow pyrolysis for charcoal production occurs at approximately 400°C in the absence of oxygen and is a well-known commercial technology, while fast pyrolysis for pyrolysis-oil and other complex fuels is still under development. Slow pyrolysis provides charcoal for cooking for millions of people in developing countries and can also be used as an input in metallurgical and other industrial processes. However, the production of charcoal has a low efficiency of approximately 25 %.

Table 1: Liquid fuels from biomass

Most mature

Fuel	Source	Benefits	Maturity
Grain/Sugar ethanol	Corn, sorghum, wheat, sugarcane	- High-octane fuel for gasoline blends - Widely available renewable sources	Commercially proven
Bio-diesel	Vegetable oils, fats, greases	- Reduces emissions - Increases diesel fuel lubricity	Commercially proven
Green diesel and gasoline	Organic oils and fats, blended with crude oil	- Superior feedstock for refineries - Low-sulphur fuels	Commercial trials in Europe and Brazil
Cellulosic ethanol	Grasses, wood chips, agricultural residues	- High-octane fuel for gasoline blends - Probably only viable scenario for sustainable ethanol production	Demo-plant in Sweden, commercial demonstration in US by 2012
Butanol	Corn, sorghum, wheat, sugarcane	- Low volatility, high energy-density, water-tolerant alternative fuel	Commercially planned by BP & DuPont
Pyrolysis bio-oil	Any lignocellulosic biomass	- Refinery feedstocks, fuel oils, a future source of aromatics and phenols	Several commercial facilities for energy & chemicals
Syngas liquids	Various biomass & organic waste	- Can integrate biomass sources with fossil fuel sources - High-quality synthetic liquid fuels	Demonstrated on a large scale with fossil fuels, commercial biomass projects under construction
Diesel/Jet fuel from Alae	Microalgae grown in agricultural systems	- High yield per hectare, an aquaculture source of biofuels - Can be employed for CO2 capture	Demonstrated at pilot scale in 1990s
Hydrocarbons from Biomass	Biomass carbohydrates	- Synthetic gasoline, diesel and petroleum products	Laboratory-scale academic research

Least mature

Source: NREL (2008)

Fast pyrolysis also occurs in the absence of oxygen, but at higher temperatures (500°C) and significantly shorter vapour residence times. In fast pyrolysis, biomass decomposes to generate mostly vapours and aerosols and only a relatively small amount of charcoal (12% by weight). Fast pyrolysis process is achieved using reactors; common reactor types are the fluid bed, twin screw and rotary kiln pyrolyzers. The main product, pyrolysis-oil, is obtained in yields of up to 75 % by weight on a dry feed basis together with by-products, char (12%) and gas (13%), which can be used within the process to provide the process heat.

Some advantages of fast pyrolysis include CO_2 emission reduction, easy storage and transportation and the products can be an appropriate complement to other thermal conversion processes.

There are a number of technical and non-technical challenges facing fast pyrolysis, including

- *Cost*: it is not currently economically competitive.
- *Availability*: commercial plants that can supply pyrolysis-oil for testing and development of applications are lacking.
- *Standardisation*: there is a lack of standards for use and distribution of pyrolysis-oil and inconsistent quality inhibits wider usage.
- *Information*: more effort is needed on information dissemination about the technology, which does not enjoy a good image from users today.

Gasification

Gasification is the process of partial oxidation of a solid or liquid carbonaceous material by heating at temperatures above 800℃, in the presence of an oxidizing agent (air, oxygen and/or steam). The feedstock breaks down to volatile compounds, water vapour and light hydrocarbons. The raw gas can be combusted immediately to produce heat and electricity, or it can be cooled, filtered, and scrubbed with water or a process-derived liquid to remove condensables and any carry-over particles. The composition of the gas depends on a number of parameters, such as gasification temperature and pressure, feedstock composition, reactor type and gasification agent. Generally, higher temperatures favour syngas production (i.e. higher H and CO concentrations), while lower temperatures yields a higher tar and methane-rich gas. Increased pressure will usually increase the methane yield due to the equilibrium of the reactions. Further, gasification with oxygen and/or steam instead of air yields higher H and CO concentrations. The most prominent advantage of gasification is that of converting a solid fuel (in the case of black liquor, a liquid fuel) to syngas, which can be utilized in a number of ways.

There are a number of different reactor types, including:

- Down-draft fixed bed, also known as co-current fixed bed;
- Up-draft fixed bed, also known as counter-current fixed bed;
- Fluidised bed;
- Entrained flow;
- Slurry bed;
- Supercritical water.

Gasifiers are either pressurised or built for atmospheric operation. Because of the endothermic reactions in gasification, heat must be added. This can be achieved either directly (autothermal) with partial oxidation/combustion in the same reactor; or indirectly (allothermal) by separate combustion of a portion of the feedstock or portion of the produced syngas, followed by heat transfer to the gasifier.

As a technology, gasification has been known for centuries but it has had limited success. In rural areas in developing countries where there is no electrical grid, small-scale biomass gasification systems can be competitive compared with other electrification options such as diesel engines.

Benefits of biomass gasification include CO_2 emission reduction, high efficiency, feedstock flexibility, end-product flexibility, security of supply and synergy effects.

There are a number of technical and non-technical challenges facing biomass gasification, including:

- Feeding herbaceous biomass into, and handling ash discharge from, high-pressure gasifiers remain difficult tasks;
- Real-time monitoring and timely control of critical gasifier operational parameters;
- Minimising tar formation, gas clean-up and conditioning;
- Inadequate government policies and incentives, i.e. market push;
- Lacking infrastructure for quality-controlled feedstock supply at a guaranteed price;
- Raw gas clean-up and syngas conditioning;
- Insecurity of feedstock supply, particularly biomass price uncertainties;
- Security of food supply: bio-energy crops and food crops may compete for the same land area.

Anaerobic Digestion

Anaerobic digestion exploits the metabolism of microbes in oxygen-deprived environments to digest organic matter and exhale methane. It takes place at low temperatures (ambient) and the product is known as biogas, which typically has a composition of 60% methane and 40% carbon dioxide. Biogas can be combusted for cooking and/or heating or used in internal combustion engines to produce electricity or rotation. Common feedstocks include sewage sludge, crop residue, carbon-intensive industrial by-products, landfill wastes, and practically any other plant or animal waste. A wide array of commercial technologies exists at multiple scales with performance guarantees. Small-scale biogas production is the simplest of the bio-energy production technologies.

Alcoholic Fermentation

Alcoholic fermentation -a well developed technology all over the world- exploits the metabolism of organisms in oxygen-deprived environments which consume sugars to produce ethanol and carbon dioxide. ‘First generation’ ethanol based biofuels are derived directly from food crops such as sugarcane, sugar beet, maize, sorghum and wheat. However, since the use of these kinds of feedstocks can result in ‘food versus fuel’ issues, the development of ‘second generation’ biofuels - which are derived from non-food crops- use a combination of acids and enzymes to convert plant cellulose into ethanol. Second generation biofuels have great potential although they are not yet commercially available.

A number of crops are available for commercial ethanol production for bio-energy but the most common are maize (in the USA, where maize is called ‘corn’) and sugarcane (mostly in Brazil, but also worldwide). Sugarcane is most common because it is the most energy-efficient and lowest cost of first generation biofuel feedstocks and is already widely grown.

There are three main factors determining ethanol’s competitiveness with fossil fuels, i.e. price of oil (which needs to be at least US$30/barrel), labour costs and foreign exchange savings.

In an effort to emulate the successful sugarcane production in Brazil, there were attempts to establish sugarcane schemes in a number of African countries (most of them in countries of the Southern African Development Community). Results were mixed, and resistance from the petroleum industry has significantly slowed the pace of development. However, considerable potential exists in Ethiopia, Zambia and Mozambique.

Drawing from case studies in Zimbabwe and Malawi, there are a number of key factors in ethanol production, i.e. enforced national blending targets; low-cost, available feedstock; the role of international price fluctuations and non-energy specific national policies; and the relationship between renewable energy firms and fossil fuel companies.

Biodiesel

The difference between ethanol and the other common type of biofuel, biodiesel, is that the latter -unlike ethanol- does not exploit microbial technology in its production.

Biodiesel is produced by mechanically separating vegetable oil from oil plants and by then treating it with methanol. The resulting biodiesel performs very similarly to petroleum-based diesel fuel. While a diesel engine can run on the raw vegetable oil, performance is superior if it has first been processed by this low-cost procedure into biodiesel. A variety of vegetable oil crops have been used as feedstocks for biodiesel including palm oil, sunflower seed, cottonseed and Jatropha, with the most common being soy oil and rapeseed oil.

Currently, Europe is the leading biodiesel producing region (using rapeseed oil as the main feedstock), but Malaysia and Indonesia (e.g. palm oil) and the Philippines and India (e.g. Jatropha) are catching up.

The key determinant to cost minimisation of biodiesel production is high oil yield so the local availability of oil productivity maximising crop constitutes which type of vegetable oil is dominant in a region.

One of the major advantages of biodiesel is that it requires very few, if any, modifications to pre-existing diesel infrastructure, including the case of B20 (mixed with petroleum diesel at a 20:80 ratio) which does not require any engine modifications. Other advantages include that biodiesel is safer to burn, it is biodegradable and that it reduces net green house gas emissions significantly.

Pure Plant Oil (PPO)

Experience with PPO in Africa is widespread, but mostly small-scale, e.g. Jatropha plantations in Mali. A good example of successful PPO project implementation in Africa is the establishment of Multi-Functional Platforms (MFPs) in Tanzania. MFPs combine a (modified) diesel engine (driving a press for producing Jatropha oils), a generator (for electricity production) and a mill (to grind cereal) or a compressor (for inflating tyres). MFPs are run on a commercial basis (by an entrepreneur selected by local villagers) with revenue coming from the collection of connection/service, maintenance fees.

In summary, the most important aspects related to the commercialisation of bio-energy technologies are as follows:

- Low-cost, available feedstock supply;
- Opportunities for public-private partnerships;
- International financing;
- An enabling policy environment;
- The role that bio-energy technologies can play in meeting non-energy goals (such as waste management).

1.2.3 Barriers to bio-energy development

A number of barriers to bio-energy development have been identified, including:

- Opposition (both active and passive) of major energy suppliers and equipment manufacturers to bio-energy development;
- Technology and process costs that make bio-energy largely uncompetitive with fossil fuels;
- Lack of consumer awareness about bio-energy benefits;
- Fuel chain complexity: bio-energy is the only type of renewable energy whose feedstock cannot always be harnessed free of charge;
- Inappropriate and poorly-devised policy frameworks;
- Land competition: non-waste/residue-based bio-energy faces competition from food crops and livestock to promote other livelihood values, notably food security;
- Resource competition: many bio-energy feedstocks have alternative uses in addition to bio-energy. This creates a two-sided price competition: low bio-energy prices are needed to compete with fossil fuels, while high prices are needed to secure feedstock in a competitive market;
- Adequate demand: bio-energy projects have a good chance of failing if the primary demand for heat and power are low lead capacities (e.g. lighting / cooking); therefore, there are higher chances of success for heat / power applications, such as water pumps, small-scale manufacture / industry and other electricity / shaft uses;
- Unsuited sites: due to the low rainfall in most parts of Sub-Saharan Africa (SSA), some of the most important bio-energy crops, i.e. sugarcane and palm oil, are largely unsuitable for SSA. Despite an overall low productivity agriculture, the situation looks better for soy and jatropha in Africa;
- Management capacity: poor construction, incorrect operation, inadequate maintenance, poorly designed dissemination programmes, inadequate monitoring and low ownership responsibility are common;
- A temporal gulf exists between government funding to encourage the commercialization of a socially beneficial technology and private sector funding for the same technology;
- High and increasing costs associated with developing the first conceptual plant, the first pilot plant and the first commercial plant for large-scale bio-energy development;
- Little incentive for investors to engage in the risk associated with renewable energy projects in Africa.

The table below provides an overview in table form of the types of market barriers of bioenergy developments.

Table 2: Market barriers of bioenergy developments

Barrier	Key characteristics	Typical measures
Uncompetitive market price	- Scale economies and learning benefits have not yet been realised.	- Learning investments -Additional technical development
Price distortion	- Current technologies may be subsidised, e.g. cost of negative environmental impacts may not be included in their prices.	- Removal of subsidies - Special offsetting taxes or levies
Information	- Availability and nature of a product must be understood at the time of investment.	- Standardization - Labelling - Reliable independent information sources - Convenient and transparent calculation methods for decision making
Transactions costs	- Costs of administering a decision to purchase and use equipment.	
Buyer's risk	- Perception of risk may differ from actual risk. - Difficulty in forecasting over an appropriate time period.	- Demonstration - Routines to make life-cycle cost calculations easy
Finance	- Initial cost may be high threshold. - Imperfections in market access to funds.	- Third party financing options - Special funding - Adjust financial structure
Excessive/ inefficient regulation	- Regulation based on industry tradition laid down in standards and codes not in pace with development.	- Regulatory reform - Performance based regulation
Capital Stock Turnover Rates	- Sunk costs, tax rules that require long depreciation and inertia.	- Adjust tax rules - Capital subsidies
Technology-specific barriers	- Often related to existing infrastructures in regard to hardware and the institutional skill to handle it.	- Focus on system aspects in use of technology - Connect measures to other important business issues such as productivity and environment

Source: IEA Bio-energy (2006)

1.2.4 Policy frameworks supportive of biomass energy generation

A number of policies supportive of bio-energy have been identified, including:

- *Financial incentives* that either increase the price of competing energy sources, or reduce the cost of bio-energy supply;
- *Feed-in tariff*, i.e. a guaranteed price over a predetermined length of time to bio-energy producers who sell electricity into the grid to encourage bio-energy;
- *Green certification*, i.e. the practice of requiring consumers to purchase a certain portion of their power supply from certified green sources. This provides a guaranteed market for bio-energy and promotes an auditing programme that encourages efficiency from bio-energy-generating entities;
- *Tender schemes* to guarantee markets for bio-energy while promoting competition and efficiency;

- *Blending requirements*, i.e. a nationally-mandated blend of ethanol in gasoline as a financial incentive to create a guaranteed market for bio-energy producers, and thereby lower investment risk and cost;
- *Differential taxation*: a combination of increased taxes on fossil fuels and reduced taxes on bio-energy to encourage bio-energy development.

In addition, measures that also help promote bio-energy include research development, entrepreneurial development, power purchase liberalization and demonstration projects.

1.2.5 Capital and financing options for biomass energy within a CDM in Africa context

Financing programmes to promote bio-energy is a difficult task given its current marginal profitability especially in Africa, because of the relatively large up-front capital costs required. The following financing options exist within a CDM in Africa context:

- *CDM*: CDM so far has had low visibility of Africa due to complexity of CDM requirements, resulting in transaction costs that are too high to be overcome. However, bio-energy in general has been one of the most successful CDM project types globally. Means of promoting CDM activities in Africa include reducing transaction costs through simplified modalities and procedures;
- *Self-financing*: Differentiated taxes and user fees have been used throughout Europe to fund Feed-in-tariffs, R&D and other incentives to promote bio-energy. However, this is considered only weakly applicable in the African context, given generally low electricity access and metering conditions. If projects can finance themselves through sales of their carbon assets, this would greatly reduce the perceived complexity of CDM projects;
- *International Funding Agencies*: existing international funding agencies like the World Bank and GEF and perhaps establishment of new funding agencies can be used to standardize CDM bio-energy project operation;
- *Microcredit*, especially in small scale biogas projects can be used as a financing template in Africa.

1.2.6 Comparison of financing options for different technologies

Biogas

Production of bio-gas is often a high upfront cost venture, and many biogas programmes require government support in the initial start-up phases. There are limited financing options available for those who want to invest in biogas technology individually or as a community. Traditional banks are unwilling to fund biogas projects due to market uncertainties and perceived high risks. Furthermore, there is limited data and information on the biogas industry to guide investors and financiers in making sound judgments and decisions in biogas projects development. However, there is a general lack of expertise in developing high quality financial proposals, especially in the rural areas in Africa which in turn obviously limits the growth of biogas.

In terms of ways to potentially overcome this situation, one option would be to provide training on biogas technology for financiers to enhance their understanding of the viability of investments in biogas.

Another way of increasing access to financing options for biogas technology is the option of easing the conditions attached to finance for renewable energy projects in order to counteract the potential negative impact of over-stringent conditions on the application and uptake for financing of biogas investments. Finally, the option of introducing subsidies for biogas projects needs to be carefully evaluated as subsidies are an important option to reduce the upfront costs of biogas units.

Cogeneration

The initial set-up cost of a cogeneration project is significant and therefore constitutes a major barrier for many project developers to mobilise the required start-up capital. Both the project developers as well as the financial institutions face various challenges when it comes to financing cogeneration projects, including

- the absence of standard PPA and feed-in-tariffs - making it harder for project developers to raise investment finance;
- the absence of low-cost, long-term financing – especially for larger scale projects requiring a larger amount of debt financing;
- lacking in-house expertise to look for funds, prepare bankable pre-feasibility and feasibility studies, and negotiate with lenders to obtain the most favourable financing terms – particularly applicable to small to medium-sized project developers;
- lack of in-house expertise within financial institutions in terms of project evaluation resulting in having to outsource this expertise, which in turn means that these increased costs will eventually be added to the overall financing costs for the project;
- lack of untied assets and/or lack of financial strength to provide or mobilise guarantee instruments in lieu of asset-based collateral;
- those project developers / investors with higher debt/equity ratios than those normally accepted by banks struggle to be able to borrow on their balance sheets;
- some projects are too small to qualify for external financing, resulting in additional complexity in identifying further projects so that these can be bundled;
- long application and approval procedures which tend to discourage potential developers.

The general lack of knowledge and familiarity among financial institutions of cogeneration technologies and feedstocks makes them wary of approving loans for cogeneration investments, as they perceive them to be high-risk ventures. Bundling of cogeneration investment opportunities facilitates negotiation of attractive and lower interest rates from the financial institutions by the project developers as it helps realize benefits of economies of scale. Furthermore, biomass cogeneration projects are good candidates for CDM financing. Wider dissemination of cogeneration financing could be achieved by the following means:

- Institution of attractive and pre-determined feed-in tariffs (FITs) and standard Power Purchase Agreements (PPAs) for cogenerated power;
- Innovative financing schemes should be developed by financial institutions in collaboration with project developers, e.g. by tapping into various international and regional initiatives that can provide funding for biomass cogeneration projects such as GEF and CDM;
- Sustainable Biomass Feedstock Development focusing on more efficient exploitation of existing agricultural wastes;

- High-Pressure Technology and Technology Transfer emphasising on encouraging existing agro-industries to adopt high-efficiency cogeneration plants that can efficiently utilize existing wastes to generate electricity for own consumption and sale to the national grid, coupled with long-term renewable energy training programmes designed to develop a critical mass of locally-trained personnel with the technical, economic and social-cultural skills needed to sustain efficient biomass cogeneration.

A large number of biomass cogeneration projects have benefited from the CDM. In Africa, the CDM could provide the incentive required to upgrade or install cogeneration equipment in sugar mills in a cost-effective manner. Projects would use a number of approved consolidated baseline and monitoring methodologies under which renewable biomass projects could generate carbon credits. CDM projects in Africa could justify additionality through barrier analysis, under which some of the identified barriers include: investment barrier, technological barrier, barrier due to prevailing practice, institutional barriers (e.g. access to the grid), price risk of biomass residue, and biomass collection and storage barriers.

Biomass pyrolysis and gasification

Policy and financial instruments that can promote biomass pyrolysis and gasification are similar to those identified for the general development of bioenergy:

- financial incentives – i.e. either increasing the price of competing energy sources or reducing the cost of bio-energy supply;
- research, development and demonstration (RD&D) – required to cover high costs of developing new technologies;
- entrepreneurial development – complementary to direct financial incentives and includes joint ventures between international financing organisations, governments and private companies;
- power purchase liberalization – legislatively requiring the dominating large-scale energy companies to purchase bio-energy from small-scale producers.

The funding options available are also similar to the ones already mentioned earlier and include self-financing, CDM, international funding agencies and microcredit.

Landfill to energy

A number of issues are associated with landfill gas (LFG) financing:

- Limited financing options:
    - the upfront costs are high and may require government support in the initial start-up phases;
    - those limited financing options available for LFG-to-energy projects include municipal funds, taxes and levies and international donor funds such as the World Bank and GEF;
- Inadequate pre-feasibility and full-feasibility studies, largely down to the expertise (which is expensive if outsourced) in accurately estimating the energy generation potential which in turn are crucial in projecting revenue streams;
- Absence of pre-determined tariffs available for landfill gas projects;
- Lengthy and complex PPA negotiations; lack of standard PPA documentation.

There is a need to enact supportive policies and perform proper financial analysis to steer project developers to the most attractive investment opportunities and mobilize financing for landfill technology assessments and project implementation. In particular, there is a need to put in place:

- Attractive revenue-sharing schemes, where all involved in the collection and management of waste have clear incentives;
- Fiscal incentives such as tax holidays and waivers on import duty on imported components for the construction of LFG-to-energy plants.

There is also a need for governments to issue a standard price offer as well as to implement a standard PPA for the generation of LFG to make it lucrative for local investors and to ensure a level playing field among energy sector investors. Training in accurate pre-investment analysis based on successful projects is also a key ingredient. Finally, cooperation between countries for knowledge sharing is also important, as well as the establishment of pilot and demonstration projects in order to stimulate the expansion of the landfill industry.

2 'CAN BIOFUELS BE SUSTAINABLE BY 2020?'

2.1 SCOPE, RELEVANCE AND KEY MESSAGES

The scope of this report covers five main areas related to possible implications of the implementation of the biofuel sector up to 2020 in the Netherlands - ranging from general bioenergy/biofuel issues (including agriculture / natural resource use and biofuel conversion technologies), to capital availability / investments and the economic perspective of mandatory mixing of biofuels.

The most relevant aspects of this report to WP5 include

- an overview of the current status of first and second generation biofuels markets;
- analysis regarding the difference in investment costs and risk profiles (along with the resulting implications) on a project basis between first and second generation biofuels;
- required overall investment efforts for 1st and 2nd generation biofuels, i.e. comparison of investment costs per unit energy produced and per unit GHG mitigation;
- long-term issues related to investments in biofuels, i.e. analysis of interrelation and implications of continued investments in 1st generation biofuels versus introduction of 2nd generation biofuels.

The key messages of this report that are most relevant to WP5 are as follows:

- overview of the current market status of 1st and 2nd generation biofuels
  - all current production of biodiesel and bioethanol is classified as 1st generation biofuels;
  - 2nd generation biofuels include biodiesel from Fischer-Tropsch diesel (FT-diesel) and bioethanol from ethanol produced from lingo-cellulosic feedstock;
  - resulting from significant governmental funding, most of the 2nd generation bioethanol plants in the pipeline will be installed in the U.S.;
  - initiatives to develop FT-diesel originate in Europe, but seem to be on a much smaller scale than those of 2nd generation bioethanol; the underlying reasons for this trend are related to FT-diesel plants not benefitting from the same advantages in terms of feedstock, interlinked technologies and gradual investments compared to 2nd generation bioethanol;
  - future market shares for biofuels will depend on developments of both, relevant policy conditions and prices of oil and feedstock;
  - most studies assume market entry of 2nd generation biofuels between 2010 and 2020 – depending on input assumptions.

- difference in investment costs, risk profiles and overall investment efforts between 1st and 2nd generation biofuels
  - due to required investments in R&D and mainly in the development of conversion technologies and the realization of conversion installations, average investment costs for 2nd generation biofuels will be significantly higher than those for 1st generation biofuels - estimates range from an increase by a factor of 4 (per unit energy produced) up to a factor of 8.5 (per unit GHG mitigation);

  - on a project level, this will result in an overall increase of second generation installation investment costs from a maximum of around 50 million € for first generation plants to an order of several hundreds of million Euros per project for 2nd generation plants;
  - the share of capital expenditure in the total production costs of biofuels is expected to increase from a current level of 10-20% to a level of between 50-60% for 2nd generation biofuels – with the relative costs of feedstock reducing accordingly;
  - as a result, the risk profiles will shift from a current susceptibility to changes in commodity prices for 1st generation biofuels to uncertainty related to investment costs for 2nd generation biofuels;
  - the consequence of this shift in risk profiles is that 2nd generation biofuel plants will be much less flexible in responding to poor market conditions, i.e. these new and capital intensive plants will need to operate even in times of unfavourable commodity prices; in contrast to that, 1st generation biofuel plants have the option to reduce output -even up to the point of temporary shutdown- without too high remaining capital costs.

- long-term issues related to investment in biofuels
  - studies have suggested a long-term role for biofuels particularly in sectors such as aviation and long-distance heavy road transport, for which the alternative technologies (such as the hybrid, the all-electric vehicle and the hydrogen-fuelled fuel cell vehicle) are not suitable;
  - in terms of the interrelationship between investment decisions into current 1st generation and future 2nd generation biofuels, there needs to be a clear distinction between biodiesel and bioethanol production facilties; while 1st generation ethanol production facilities can be retrofitted into 2nd generation facilities (and can in fact be used as a step-up to 2nd generation production), the same does not apply to biodiesel where -due to the lacking technology link between the two generations- investment in 1st generation biodiesel would introduce a lock-in effect hampering introduction of 2nd generation biofuels.

2.2 SUMMARY OF THE MOST RELEVANT SECTIONS

2.2.1 Future markets of first and second generation biofuels

The current production of biodiesel and bio-ethanol is all classified as first generation. The second generation alternative for biodiesel would come from Fischer-Tropsch diesel (FT-diesel) and for bio-ethanol from ethanol produced from lingo-cellulosic feedstock, or methanol and hydrogen from lignocellulosic feedstock.

*Ethanol***:** Lignocellulosic material is currently the main feedstock for 2nd generation ethanol and there is increasing interest globally in it. The U.S. is providing significant funding and set up many ethanol initiatives utilizing a mix of residues such as waste wood, straw or bagasse. It is estimated that second generation ethanol plants globally in the pipeline will total almost 1.5 billion litres per year litres in 2012, with the majority of these plants being planned in the U.S.

*FT Biodiesel***:** The most important initiatives are European based and the development is not expected to grow as rapidly as for bio-ethanol because of technology and investment risks. FT-diesel plants do not have the advantages in terms of feedstock, interlinked technologies and gradual investments of bio-ethanol plants, but require large scale initial investments.

Overall, the market for biofuels is considered not to be mature enough to extrapolate current growth trends. Current estimates are based on the assumption that the second generation biofuels will enter the market after 2010 or will even not be available before 2020 with the main parameter influencing the future share of second generation biofuels being the policy conditions to incentivise the development and uptake of second generation technologies.

2.2.2 Capital availability and investments

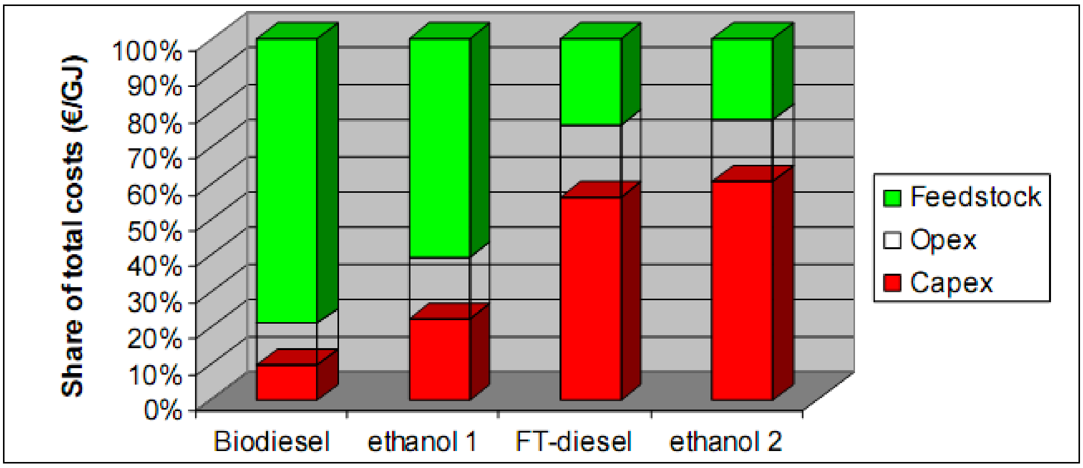
The introduction of biofuels will require substantial amounts of new investments, particularly for research and development of conversion technologies and the realization of conversion installations. These investments are both technology- and project-based, with a clear difference between currently used first generation biofuels and future second generation biofuels.

Investments and entailed risks per project

On a project basis, investment costs for conventional (i.e. 1st generation) biodiesel and ethanol installations are estimated to be in the order of several tens of million Euros and are usually not expected to go beyond 50 million €. For second generation installations, however, both investment costs per unit product, as well as reference size of the installation are to increase. This will particularly apply to gasification-based routes, such as FT-diesel, which will entail investment costs in the order of several hundreds of million Euros per project.

Another main difference between 1st and 2nd generation biofuels is the share of investment costs in the total production costs of biofuels. Whilst they only represent a minor share in production costs for 1st generation biofuels, capital costs make up more than 50% of production costs for 2nd generation biofuels – as illustrated in the below graph. Investments costs are substantially higher for 2nd generation biofuels since they make use of innovative and yet to be developed technologies as opposed to 1st generation installations which make use of conventional, proven technologies.

Figure 2: Relative shares of feedstock costs, operational expenditures (Opex) and capital expenditures (Capex) in total biofuel cost price for different biofuels. Source: Londo et al., (2008)



This difference also results in different risk profiles of 1st and 2nd generation biofuels. While 1st generation biofuel investments are more susceptible to changes in commodity prices of both their feedstock, as well as the biofuels produced, the risk related to making investments in 2nd generation biofuels does not lie in commodity price changes, but in the uncertainty related to the investment costs.

As a consequence of the high capital costs for 2nd generation biofuel plants, these types of plants are much less flexible in responding to poor market circumstances and need to -because of their high capital costs- continue to operate even in times of unfavourable commodity prices. In contrast, 1st generation biofuel plants, however, have the option to reduce output -even up to the point of temporary shutdown- without too high remaining capital costs.

Overall investment efforts for biofuels

As outlined already, the investment costs for 2nd generation biofuels are significantly higher than those for 1st generation biofuels with the scope of investments including both R&D investments and funding by governments and industries, as well as industry investments in commercial installations, the latter taking the lion's share. Both in terms of investments per energy production and per tonne, 2nd generation biofuels are highly capital-intensive.

The relative scale of investment costs for 1st and 2nd generation biofuels is presented in the table below, illustrating for instance the relative low investment costs for 1st generation biofuels particularly when related to their energy production capacity.

Table 3: Indication of specific investment costs for 1st and 2nd generation biofuels, and for a mix of renewable and other GHG and fossil energy mitigating technologies

	Investment costs per unit energy produced ($/GJ.yr)	Investment costs per unit GHG mitigation ($/t CO_2.yr)
Average all technologies[1]	50	700
1st generation biofuels[2]	20	700
2nd generation biofuels[1]	170	2800

1 *Source: IEA Energy Technology Perspectives (2008), ACT Map scenario, plus own calculations.*
2 *Source: REFUEL data (Deurwaarder et al., 2007), modified.*

Long term issues related to investment in biofuels

To establish to what extent biofuels will fit into the long-term energy economy it is vital to know whether there will be a long-term market share for biofuels, and to what extent investments in 1st generation biofuels may introduce a lock-in effect hampering introduction of 2nd generation biofuels. The question may be asked whether the long-term perspective for biofuels is sufficient to defend major short-term investments in the technology. Studies conducted foresee a long-term sustaining role for biofuels, particularly in sectors such as aviation and long-distance heavy road transport, for which the alternative technologies (such as the hybrid, the all-electric vehicle and the hydrogen-fuelled fuel cell vehicle) are not suitable. Therefore, kerosene and diesel producing biofuel technologies, such as the FT process, are predicted to maintain a position in the market in the long run, even in the (uncertain) case of a strong take-off of the electric / fuel cell vehicle.

As to whether 1st generation biofuels will hamper the introduction of 2nd generation biofuels, it is important to differentiate between ethanol and biodiesel production. 1st generation ethanol production facilities can be retrofitted into 2nd generation facilities and can in fact be used as a step-up to 2nd generation production. The same does not apply to biodiesel where investment in 1st generation biodiesel may become a barrier for 2nd generation production due to the lacking technology link between the two generations.

3 'OPTIONS FOR TRADING BIOENERGY PRODUCTS AND SERVICES'

3.1 SCOPE, RELEVANCE AND KEY MESSAGES

The scope of this report includes an overview of options for trading bioenergy products and services. In particular, this report presents four main bioenergy-related trading options for business and policy makers, i.e. trade in biomass fuels, electricity, renewable certificates and carbon credits. In terms of the report's structure, it covers the following areas:

- Energy- and climate change-related characteristics of bioenergy;
- Bioenergy markets and trading flows;
- Drivers for increase in bioenergy use;
- Illustrative description (including graphs and examples) and analysis (including decision criteria) of the effectiveness of the above mentioned four main bioenergy-related trading options.

The main relevance of this report to WP5 lies in the presentation of often untapped opportunities from trading bioenergy products and services for Sub-Saharan African countries beyond the obvious option to trade solid and liquid biomass.

The key messages of this report are as follows:

- There are four main drivers for increase in bioenergy use, i.e. i) reduction of CO_2 emissions; ii) policy measures and price mechanisms; iii) positive correlation with local socio-economic development and energy security; and iv) opportunities for sustainable management and use of natural resources;

- The options to trade bioenergy products and services include both energy trading products, (i.e. liquid and solid biofuels and electricity), as well as non-energy trading services (i.e. renewable certificates and CO_2 credits);

- Criteria to evaluate the effectiveness of trading options include supply potential; secure demand; logistical capacity; reference systems; sustainable development; diversification; policies and regulations; and flexibility and risks;

- Consequences / potential / advantages of the various bioenergy trading options include:
    - Creation of a global market of renewable energy carriers derived from bioenergy sources;
    - Large-scale and efficient use of CO_2-neutral biomass resources;
    - These new global markets can generate substantial income sources for the developing regions in the world;
    - More stable global energy markets due to a larger number of energy suppliers compared to the current situation;
    - International bioenergy trading market has the potential to lead to the development and sustainable use of the production of products and services from bioenergy in developing countries;
    - Physical trade of biomass or energy carriers is not always the most effective solution from both a cost as well as a GHG mitigation perspective;

- In view of the resulting addional costs and energy uses and also despite the optimised chain design of international logistics, local use and subsequent trading of electricity, CO2 credits or renewable certificates provide important alternatives;
- The variety of potential products and services from sustainable bioenergy markets allows countries to select the most efficient mechanism for each unique situation.

3.2 SUMMARY OF THE MOST RELEVANT SECTIONS

3.2.1 Drivers for increase in bioenergy use

The list below summarises the main drivers for drivers for increasing the use of bioenergy:

- *Reduction of CO_2 emissions*:
Biomass is a CO_2 neutral energy source to the extent that CO_2 uptake by plants for growth equals the release of CO_2 from the energy conversion. Since both reductions as well as emissions of CO_2 or other GHGs are a global phenomemon, trading bioenergy can present a cost-effective GHG emission reduction opportunity;

- *Policy measures and price mechanisms*:
Demand for bioenergy is also increasing as concerns about climate change lead to implementation of policy measures that favour renewable energy sources over their fossil-fuel-based competitors. Examples of such policy measures and mechanisms are renewable energy mandates, feed-in tariffs for electricity from renewables, trading of green certificates and cap-and-trade systems for GHG. Demand is also driven by price mechanisms such as subsidies and taxes; all of these mechanisms seek to internalise the externalities of fossil fuel use in terms of climate change and other impacts, and provide a more balanced energy choice;

- *Positive correlation with local socio-economic development and energy security*:
There is not only a demand for useful energy, but also for 'climate friendly' energy systems and energy systems that bring with them all the other advantages of renewable energy (such as job creation, reduction of local air pollution, reduced reliance on a limited resource); biomass energy can help meet all three demands; furthermore, biomass may diversify the total portfolio of fuels used and imported by countries, thereby reducing the risks of supply disruptions in terms of both quantity and price, especially in the case of biofuels for transport since they replace oil imports;

- *Opportunities for sustainable management and use of natural resources:*
Bioenergy trade also presents opportunities for sustainable management and use of natural resources. This is particularly applicable in cases when biomass production is combined with better agricultural methods, or restoration of degraded and marginal land.

3.2.2 Overview of options to trade bioenergy products

Liquid and solid biofuels

International bioenergy trade can include direct transport of biomass materials (chips, logs, and bales), intermediate energy carriers (such as bio-oil or charcoal) or high quality energy carriers such as ethanol, methanol, Fischer-Tropsch liquids (biodiesel) and hydrogen.

Electricity

International trading of electricity is already established. Electricity produced from biomass will usually be CO_2 neutral, and can be an effective means of meeting energy demands of the electricity importer while at the same time not adding to the CO_2 emissions of the exporting country. Countries may be importers or exporters of electricity for only parts of the year, parts of the day etc., depending on peak load demands, electricity price variations, and other factors. A key advantage of this trading option is that production of renewable energy can be optimised in power plants with better technologies and economies of scale that could not be realised without the increased flexibility and increased demand of trade.

Trading non-energy services

'Non-energy services' include benefits from biomass energy that are unrelated to the energy such as environmental, social, and emission reduction benefits compared to other energy sources. The emission reduction benefits are packaged in various forms and, for example, change their owner in emission trading schemes.

Renewable certificates

Renewable certificates can be used to meet the demand for renewable energy, e.g. in the context of national renewable energy targets. The 'renewable certificates' represent the local services and benefits of renewable energy, such as pollution abatement and jobs. This option allows a country to produce renewable energy above and beyond its own national targets and then sell the remaining amount in renewable certificates to another country, while using the electricity in domestic markets. The purchasing country in turn will be able to meet domestic targets of renewable energy sources by importing certificates if their national legislation on renewables accepts certificates from other countries. Green Certificates are already on sale in the EU.

CO_2 credits

CO_2 trading provides the flexibility of investing in those places where energy investments are due anyway, thus reducing the costs of CO_2 mitigation. The amount of credits will depend on the baseline scenario of the 'buyer' country whereas for physical biomass or electricity trade the baseline scenario of the 'seller' country is of interest. There are several arrangements in which corporations, governments, or groups of these, purchase carbon credits either directly or indirectly through 'carbon funds', such as the World Bank Prototype Carbon Fund the European Emissions Trading System (ETS) which caps the emissions of combustion installations with a rated thermal input exceeding 20 MW.

3.2.3 Effectiveness of trading options

To determine how to most efficiently reconcile supply of and demand for renewable energy it is important to establish whether a cost-effective biomass potential, and whether applications for biomass, exist domestically. If local resources are scarce but domestic applications exist then the biomass trading option might be viable. If neither the resources nor the applications exist, then the purchase of renewable certificates and/or CO_2 credits is the only remaining option. Decision makers also need to evaluate the environmental and social aspects of the different options.

Some criteria of importance to policymakers, decision makers in the energy sector and energy users to evaluate the effectiveness of trading options include:

- *Supply Potential:* What is the technical and economic potential for a sustainable supply of services of the exporting region?
- *Secure Demand:* How will demand for services develop in the importing region?
- *Logistical Capacity:* What logistical and conversion capacity is available in importing and exporting countries?
- *Reference Systems:* What is the reference energy system for importing and exporting countries? For example a low carbon intensity for importer and high carbon intensity for exporter indicate it may be better to use biomass locally and trade bio-electricity, credits, or certificates, or a combination.
- *Sustainable Development:* What are the opportunities for matching 'services' production and export with rural and sustainable development?
- *Diversification:* Is there a need for diversification of the energy supply mix in exporting and importing countries?
- *Policies and Regulations:* Which trading options are favoured under existing policies such as targets and regulations e.g., trade barriers, renewable energy or CO_2 carbon accounting rules?
- *Flexibility and Risks*: Which options allow more flexibility over time than others? For example, CO_2 credits and green certificates will only be needed at the end of a longer period, whereas the import of physical energy carriers needs to be concurrent with the demand for the energy.

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