SIXTH FRAMEWORK PROGRAMME

FP6-2004-INCO-DEV-3

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

Synthesis report on international trade

ANNEX 5-1: Financing Energy Crops and Agro-forestry
Deliverable D5.5

COMPETE

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

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1 Introduction

The trade of biomass and bioenergy (biotrade) has several potential advantages for both the exporting and the importing countries. For the exporting country the production and trade of biomass and bioenergy can potentially contribute to agricultural diversification and to a stable and reliable source of additional income and increased employment (e.g. for rural communities) and thereby to the reduction of poverty. Furthermore, the production of biomass and bioenergy can potentially also contribute to the sustainable management of natural resources. For importers, biotrade may assist to fulfil greenhouse gas (GHG) emission reduction targets in a cost-effective manner, diversify their fuel mix and lead to a more sustainable energy production.

Despite the apparent advantages of bioenergy, a multitude of different barriers currently exist, hampering the development of biotrade. These include economic, technical, logistical, ecological, social, cognitive, legal, and trade barriers, lack of clear international accounting rules and statistics, and issues regarding land availability, deforestation, energy balances, potential conflicts with food production and local use vs. international trade.

In this synthesis report an overview is presented of the opportunities and barriers for the international biomass and biofuels production for internal trade and export in Africa. The focus is thereby on:

- The present and future potential of trade of biomass and bioenergy from Africa (Section 2).
- The barriers and opportunities for trade of biomass and bioenergy from Africa (Section 3).

The results presented in this synthesis report are taken from earlier work within the COMPETE network, supplemented with results from the literature and especially results from the International Energy Agency Task 40 on Bioenergy Trade network and from the upcoming Bioenergy Review of the International Energy Agency.

2 Present and future bioenergy production, trade and use of biomass energy[1]

2.1 Present and future production and use of biomass energy

Today, biomass provides about 10% (~45 EJ) of the world's primary energy supplies. This share varies widely, however, between developing and industrialised regions. While bioenergy covers an average 22% of the primary energy consumption in developing countries and can reach over 90% in rural countries such as Ethiopia, the total contribution of biomass to the primary energy mix is on average only about 3.4% in the OECD, although many of these economies have set targets to significantly increase this share.

Of the 45 EJ of bioenergy supplied worldwide, close to 90% is of woody origin, with fuelwood by far being the largest contributor (Figure 1). Agriculture contributes 10% to the bioenergy mix, of which 30% is in the form of dedicated energy crops and the rest as by-products (dung, straw, bagasse, etc.). This means that dedicated energy crops currently only contribute 0.27% of the world energy mix. Municipal solid wastes and landfill gas currently contribute 3% of the bioenergy mix, but have a large untapped potential.

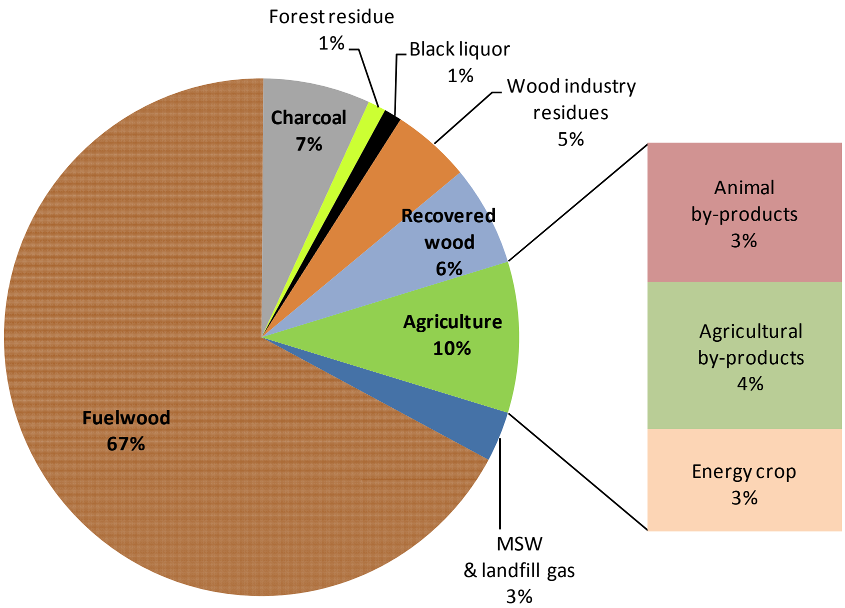

Figure 1: Share of the biomass sources in the primary bioenergy mix
Source: based on data from IPCC (2007)[2]

The production and use of bioenergy is expected to increase rapidly during the coming decades. The International Energy Agency (IEA) has established two scenarios for the future of the global primary energy consumption, which are based on different assumptions regarding the level of government intervention to 2030. While the reference scenario assumes that no new government policies are introduced during the projection period, the alternative scenario includes a set of policy measures addressing climate change and energy security issues. In both these scenarios, the

[1] The text in this section is taken from earlier COMPETE results and from the Bioenergy Review (2009, in press) of the International Energy Agency, Paris, France, unless indicated otherwise, and adopted if necessary.
[2] IPCC (2007), "Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change ", Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.

volume of bioenergy is expected to grow at an average rate of 1.3-1.4% per annum to 2030. By 2050, the volume of biomass used for energy purposes is projected to reach between 90 and 150 EJ (2100-3600 Mtoe) depending on the scenario considered (Figure 2), and could thus contribute up to 23% to the total world primary energy supply. Much higher scenarios are however also feasible, although most moderate biomass potential scenarios, taking into account sustainability constraints, indicate an annual potential between 200 and 400 EJ by the year 2050.

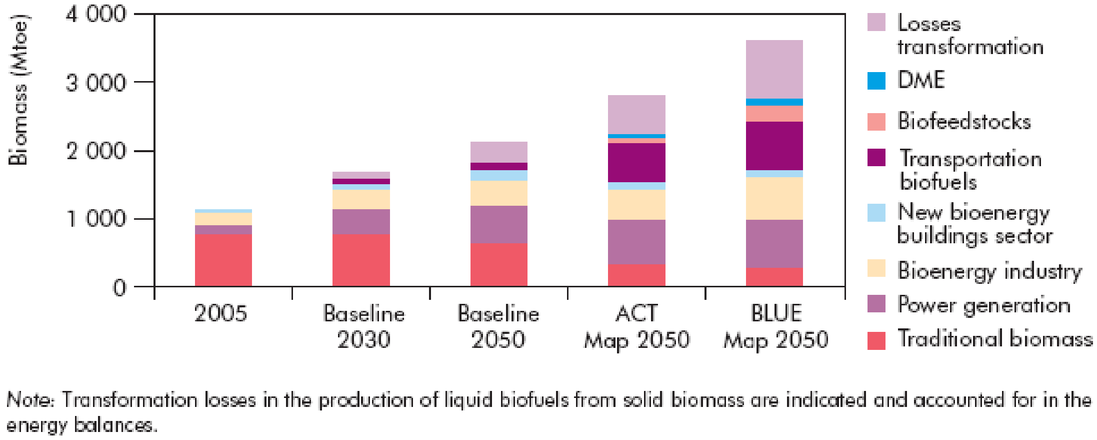

Figure 2: Biomass end use in 2030 and 2050 under various scenarios
Source: IEA (2008)[3]

The projected increase in the global use of bioenergy in the coming decades is (obviously) also an important driver behind the growth in biotrade, which is investigated in detail in the following section. An important aspect thereby is the feedstock type. Therefore, in the following sections the market share of the different bioenergy technologies in the global energy mix is discussed.

2.1.1 Biomass-to-heat

Status

Heat is by far the largest market segment for bioenergy. Of the 45 EJ of biomass supplied to the global primary energy mix in 2006, an estimated 39 EJ (i.e. 87%) is burnt in traditional stoves for domestic heating and cooking primarily in developing countries. In a business as usual scenario, the demand for traditional biomass will grow from 34 EJ today to 36 EJ in 2030 due to population growth. This increase could however be largely offset by an increase in energy efficiency resulting from the introduction of efficient modern stoves. Traditional biomass consumption could be globally reduced by up to 70% by 2050 in the case of fast penetration of modern stoves and large shift from traditional biomass to LPG. In OECD countries the volume of biomass for residential heat is expected to grow by 40%-90% to reach 3.2-4.3 EJ in 2030, mostly due to the growing market for modern boilers and stoves.

Prospects

[3] IEA and OECD (2006), "Energy Technology Perspectives", International Energy Agency (IEA) and Organisation for Economic Co-operation and Development (OECD), Paris, France,.

The global use of biomass and waste in the industrial sector is expected to increase slowly, in line with increased energy demand, by between 1.9% and 2.2% annually to reach close to 13 EJ by 2030. However, while this increase will be in both developed countries and developing countries, transition economies will see an annual drop by 0.6-1% over this period.

2.1.2 Biomass to power and CHP

Status

Biomass-based power and heat plants consumed a feedstock volume equivalent to 3 EJ in 2004, which represents a mere 6% of the global biomass used for energy purposes. Consumption in the OECD countries accounted for 82% of this volume, with Europe and North America leading with close to 1.3 EJ each.

Prospects

According to most energy scenarios, global electricity production from biomass is projected to increase from its current 1.3% share (231 TWh/year) to 3%-5% by 2050 (~1400-1800 TWh/year). In absolute terms, the net increase would thus be 6-8 times the current production, with a significant contribution to CO_2 emissions reduction. In the medium term, the commercialisation of small-scale gasification could be of significant importance in the deployment of decentralised biomass power and CHP systems. However, it is currently unclear as to when this technology will become commercial. Similarly, the commercialisation of Stirling and ORC engines could also enhance the prospects of small-scale biomass power and CHP generation, although the prime movers in these emerging technologies are not expected to focus on biomass-fuelled systems. In the longer term, biomass integrated gasification gas turbines (BIG/GT) and combined cycles (BIG/CC) are promising technologies that could offer greater prospects for relatively large scale power generation from dedicated biomass plants, thanks to their high overall efficiency.

2.1.3 Biofuels

Status

Biofuels today represents less than 1% of the total road transport fuel consumption, and only accounted for some 2% in the final bioenergy mix (in energy terms).

Prospects

Demand for road-transport fuels is expected to continue to increase significantly in the coming decades, especially in developing countries. Biofuels are expected to play an increasing role in meeting this demand, with an expected average annual rate of growth of production of approximately 6-8% per year. The biggest increase in biofuels consumption is expected to take place in the United States and in Europe (where both consumption and production is expected to overtake those of Brazil within the next few years).

Biogas upgrading to biomethane is undergoing a dramatic development, as a result of the worldwide exponential increase of natural gas vehicles (NGV) (there were 9 million units in 2007 compared with 4 million in 2004). Forecasts for NGV fleets in 2030, range between 100 and 200 million vehicles. The EU target for renewable energy used in road transport is 10 % by 2020, a significant share of which could come from biomethane.

2.2 Present and future trade of biomass energy

Currently the level of biomass energy trade (biotrade) is small compared to that which is typical in agriculture and forestry commodities and also compared to the total global biomass use at approximately 50 EJ (see Table 1). In 2004 most trade in bioenergy was associated with indirect trade (e.g. roundwood of which parts such as bark, saw dust and black liquor are later used for energy). However, the traded volumes of commodities such as wood pellets, ethanol and biodiesel for energy use are increasing strongly. While reliable statistics are not available, it is estimated that since 2006, directly traded volumes are larger than those traded indirectly (on an energy basis).

Table 1: An estimate of the scope of international trade of biofuels in 2006 (tall oil, ETBE and various waste streams excluded) Source: Heinimö and Junginger (2009)[4]

	PJ	Million tonnes
Ethanol	160	6
Biodiesel	>90	>2.4
Fuel wood	40	3
Charcoal	20	0.9
Wood pellets	45	2.6
Palm oil	>60	>1.6
Direct trade:	**>380**	**>16.7**
Industrial round wood	480	50
Wood chips and particles	150	16
Indirect trade:	**630**	**66**
Total	**> 1000**	**>83**

[4] Heinimö, J., Junginger, M., (2009) Production and trading of biomass for energy – an overview of the global status. Biomass & Bioenergy, in press, doi:10.1016/j.biombioe.2009.05.017

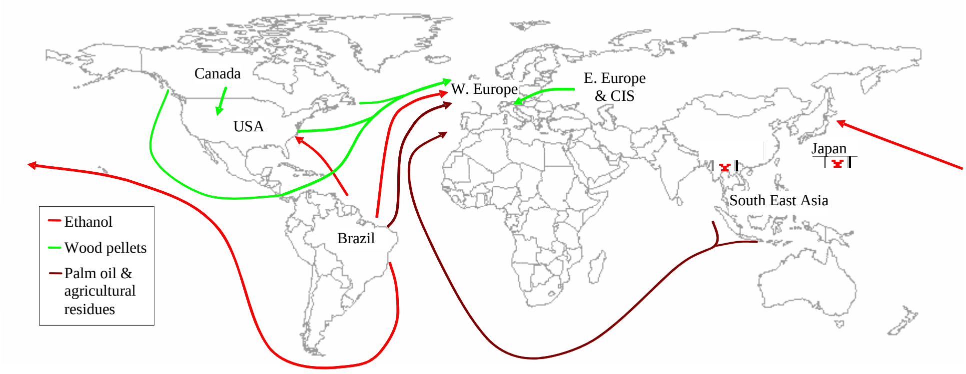

Figure 3: Main international bioenergy trade routes Source: IEA (2009)[1]

Biomass imports contribute substantially to the overall biomass use in some countries, e.g. 21-43% in North-West Europe and Scandinavia. In the longer term several hundred EJ of biofuels might be traded internationally, with Latin America and Sub-Saharan Africa having potential to become large net exporters and North America, Europe and South-East Asia large net importers. However, in the short term the growth of the trade of biofuels is expected to remain limited. The graph below illustrates the development of global ethanol production and trade, with projections to 2017 showing three main trends:

- A steadily growing global bioethanol market whose production is predicted to increase to 125 billion litres in 2017.
- After a surge by around 35% between 2007 and 2009, the global bioethanol price is projected to decrease slowly between 2009 and 2017 to around US$0.50/litre.
- Global bioethanol trade figures are not predicted to increase significantly over that time period.

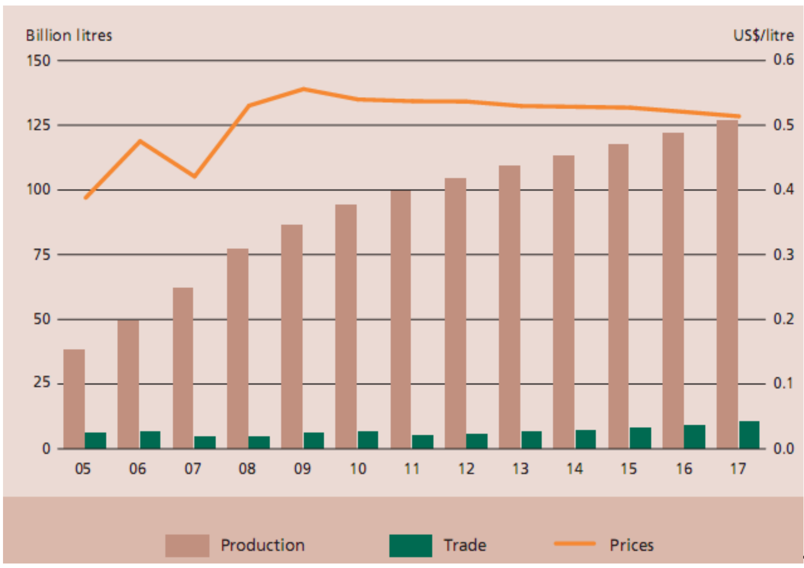

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Figure 4: Global ethanol production, trade and prices to 2017 Source: FAO (2008)[5]

[5] FAO (2008), "State of Food and Agriculture 2008", United Nations Food and Agriculture Organisation, Rome, Italy, p. 128.

With respect to the market shares of the major global ethanol producers, the projections to 2017 indicate for the U.S. and Brazil to remain the two most important ethanol producing countries with a combined global market share of around 75%, with the EU, China and India remaining in positions three to five. The share of Africa is expected to remain very limited.

Regarding the global biodiesel production, it increased more than ten-fold to around 10 billion litres over the period 2000-2007. With diesel-fuelled vehicles being much less common in the U.S., biodiesel is a natural fit for Europe, Asia and Brazil. The leading biodiesel producers are therefore in the EU (Germany, France, Italy, Austria), accounting for a global production market share of around 60%. The graph below demonstrates the projected development of global biodiesel production to 2017. It shows three main trends:

- Underlining its close correlation to the other main biofuel ethanol, the global production of biodiesel is predicted to grow steadily to around 25 billion litres in 2017 – a fivefold increase compared to 2005.
- After a surge by around 25% between 2005 and 2009, the global biodiesel price is projected to remain in a corridor between US$1.05/litre and US$1.10/litre between 2009 and 2017.
- Based on 2005 figures, global biodiesel trade is projected to increase, but only until around 2008, from when figures are predicted to remain relatively stable within a small corridor until 2017.

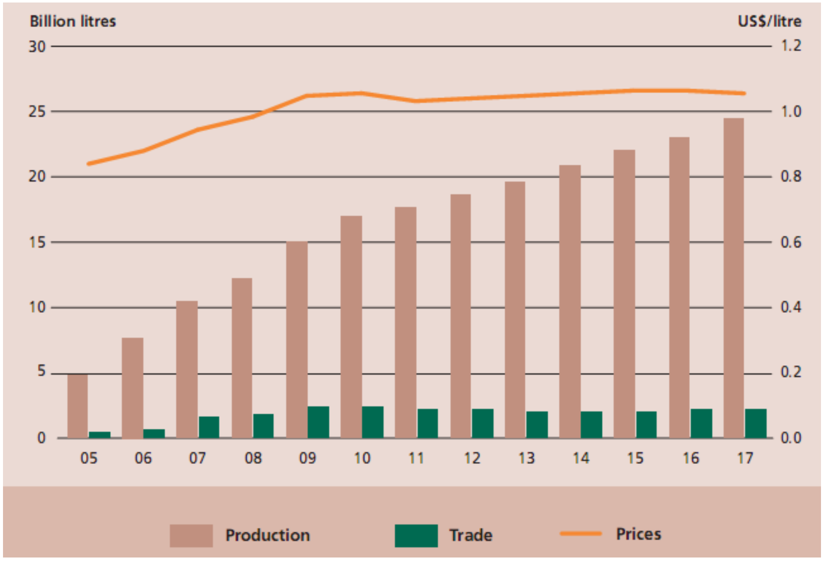

Figure 5: Global biodiesel production, trade and prices, with projections to 2017 Source: FAO (2008)[6]

With respect to the market shares of the major global biodiesel producers, the EU is projected to remain the main producer to 2017 with a market share of around 60%. Indonesia is predicted to grow strongly to become the second biggest biodiesel production market ahead of Brazil, the U.S. (whose annual production is predicted to fall for the decade after 2007) and Malaysia. The production of biodiesel in Africa is rapidly increasing, but is expected to remain relatively limited.

[6] FAO (2008), "State of Food and Agriculture 2008", United Nations Food and Agriculture Organisation, Rome, Italy, p. 128.

However, there are some recent examples demonstrating that international bioenergy activities will also benefit Africa:

- China, for instance has asked Zambia to plant 2 million hectares of jatropha for the production of biofuels[7].
- South Africa signed a contract to export between 70% and 90% of output from a planned 400,000 tonnes a year biodiesel plant to Germany. This is part of an initiative by the South African government to encourage export-oriented growth in the country through the attraction of foreign and local investors[8].
- Ghana has attracted the interest of several nations around the world for biofuel production projects, including India, Brazil, Norway, Israel, China, Germany, the Netherlands, Italy and Belgium[9].

In the longer term, i.e. between 2020 and 2050, especially Africa can potentially become a large-scale, low cost producer of liquid biofuels for transportation but also for untreated lignocellulosic biomass that can be used for the production of second-generation biofuels, but also for heat and electricity generation. The potential of Africa as an exporting region of lignocellulosic biomass is further illustrated using the work of Hoogwijk *et al.,* 2009[10], who estimated the potential of energy crops produced on abandoned agricultural land and rest land in the year 2050, as illustrated in the table below. Rest land is thereby defined as all remaining non-productive land, excluding bioreserves, forest, agricultural and urban areas and is calculated after satisfying the demand for food, fodder and forestry products.

These results show that Eastern and Western Africa have -globally- the largest potential of lowest-cost energy crops (below US$1 GJ^{-1}). West and East Africa are also among the four main regions that are thought to be able to produce a significant amount of energy crops at costs below US$2 GJ^{-1}. At these cost levels, large scale ethanol production is expected to become competitive with conventional gasoline, assuming that technological developments will be stimulated.

IPCC scenario ->	**A1**				**A2**				**B1**				**B2**			
	<$1 GJ^{-1}	**<$2 GJ^{-1}**	**<$4 GJ^{-1}**	**EJ yr^{-1}**	**<$1 GJ^{-1}**	**<$2 GJ^{-1}**	**<$4 GJ^{-1}**	**EJ yr^{-1}**	**<$1 GJ^{-1}**	**<$2 GJ^{-1}**	**<$4 GJ^{-1}**	**EJ yr^{-1}**	**<$1 GJ^{-1}**	**<$2 GJ^{-1}**	**<$4 GJ^{-1}**	**EJ yr^{-1}**
Canada	0	11,4	14,3	18	0	7,9	9,4	12	0	11,1	12,1	14	0	10	11,1	13
USA	0	17,8	34	53	0	6,9	18,7	33	0	24,5	32,9	36	0	27,6	39,4	49
Central America	0	7	13	17	0	2	2,9	4	0	4,1	7,6	11	0	1,6	3,3	5
South America	0	11,7	73,5	87	0	5,3	14,8	24	0	27,6	60,7	63	0	6,1	32,7	43
Northern Africa	**0**	**0,9**	**2**	**5**	**0**	**0,7**	**1,3**	**4**	**0**	**0,7**	**1,5**	**3**	**0**	**0,7**	**1**	**2**
Western Africa	**6,6**	**26,4**	**28,5**	**50**	**7,9**	**14,6**	**15,5**	**23**	**1,2**	**13,3**	**13,7**	**27**	**1,4**	**4,5**	**4,6**	**6**
Eastern Africa	**8,1**	**23,8**	**24,4**	**41**	**3,6**	**6,2**	**6,4**	**16**	**2,6**	**13,9**	**14,1**	**22**	**0,9**	**1,8**	**1,8**	**5**
Southern Africa	**0**	**12,5**	**16,6**	**43**	**0,1**	**0,3**	**0,7**	**10**	**0**	**11,7**	**12,6**	**29**	**0,1**	**0,2**	**0,4**	**2**
OECD Europe	0	3	11,5	14	0	5,6	12,5	14	0	2,7	9,1	9	0	6,9	15,4	16
Eastern Europe	0	6,8	8,9	9	0	6,2	6,3	8	0	7,9	8	8	0	7,6	8,2	9
Former USSR	0	78,6	84,9	127	0,8	41,9	46,6	68	0	66,9	69	88	0	60,1	61,7	78
Middle East	0	0,1	3	13	0	0	1,3	8	0	0	2	4	0	0	1,4	3
South Asia	0,1	12,1	15,3	27	0,6	8,2	9,8	14	0,1	6,4	8,3	14	0	1,4	2,8	6
East Asia	0	16,3	63,6	107	0	0	5,8	23	0	49,8	61,1	77	0	0	21,4	46
South-East Asia	0	8,8	9,7	10	0	6,9	7	7	0	2,9	3	3	0	2,5	3,5	4
Oceania	0,7	33,4	35,2	55	1,6	16,6	18	34	10,4	28,1	28,6	35	5,5	24,3	24,8	30
Japan	0	0	0,1	0	0	0	0	0	0	0	0,1	0	0	0	0,2	0
Global	**16**	**271**	**439**	**675**	**15**	**130**	**177**	**302**	**14**	**272**	**344**	**443**	**8**	**155**	**233**	**316**

[7] http://www.biofuels-news.com/industry_news.php?item_id=700
[8] http://www.biofuels-news.com/industry_news.php?item_id=649
[9] http://www.biofuels-news.com/industry_news.php?item_id=659
[10] Hoogwijk, M., A. Faaij, B. de Vries and W. Turkenburg (2009) Exploration of regional and global cost-supply curves of biomass energy from short-rotation crops at abandoned cropland and rest land under four IPCC SRES land-use scenarios, Biomass and Bioenergy, 33, 1, p. 26-43.

Table 2: The total estimated (technical) potential of energy crops for the year 2050 (EJ), at abandoned agricultural land and rest land and the estimated potential at various cut-off costs for the four land-use scenarios (A1, A2, B1, B2)
Source: Hoogwijk *et al.,* 2009[10]

3 Barriers for bioenergy use and bioenergy trade[11]

3.1 Supply side risks and barriers

Some essential supply side concerns, which the bioenergy sector has in common with the food and forestry sector, relate to the risks of biological production. El Nino, drought and other weather-related impacts, fire and pests (including insects, plants diseases and vertebrates) affect bioenergy as well as food and fibre production and can drastically reduce the availability of bioenergy feedstocks. The recent years' increases in prices for major food commodities are illustrative of the possible effects: adverse weather conditions in 2006 and 2007 in some major crop producing areas is cited as one of the major causes of this price increase.

The danger of pest and insect attacks, as well as the susceptibility to fire, is a clear disadvantage, particularly of monocultural plantations. These risks can be reduced through proper planning and management (including continuously changing or rotating the genetic base in use), but they cannot be eliminated. In general, diversity is normally the best mechanism to minimize the risk.

Longer term supply side concerns include uncertainties about the effects of climate change, in that increasing temperatures and shifting rain patterns can profoundly change the suitability of different parts of the world to the production of certain crops. In addition, soil and water degradation, for instance due to improper irrigation practice or excessive crop residue removal, can also severely impact the productivity of cultivations and at worst make further production non-feasible.

The principal market needs from a feedstock supply perspective relate to securing quantity, quality and price (Table 3). However the specific challenges are different for different bioenergy feedstocks. A distinction can be made between different bioenergy feedstock categories:

- Bioenergy feedstocks that are also produced for food, fibre and other material purposes.
- Dedicated bioenergy feedstocks which are specific to the bioenergy sector.

The current production of biofuels for transport relies on food commodity feedstocks with established markets and logistics. These feedstocks have the advantage of being well-known by farmers that have already invested in machinery and other facilities related to the production (to a large extent this also applies to agricultural residues). Similarly, much of the solid biomass that is used for heat and power in industrialised countries has been extracted from forests as part of well established forest industry practices. Extraction of new forest assortments, such as thinning wood from silvicultural activities and felling residues, require adapted machinery, but could benefit from similar development that has taken place within the established forest sector.

For these feedstocks, price variability remains a risk. The feedstock competition with the food and forestry sectors makes the business situation more complicated, since the feedstock prices are also influenced by the supply-demand balances in these sectors. Apart from the price competition, the food and forest sector can also affect the bioenergy supply through lobbying and other general strategic efforts to improve their own prospects.

The supply side challenges are quite different for dedicated bioenergy crops; many of these feedstocks are largely unproven in production and face agronomic, technical, institutional and not

[11] The text in this section is based on earlier COMPETE results and from the following two sources, unless indicated otherwise:

- Junginger,M., Zarrilli, S., Ali Mohamed, F., Faaij. A. et al. (2009) Inventory of opportunities and barriers for international bioenergy trade (paper in preparation)
- IEA (2009) Bioenergy Review. International Energy Agency, Paris, France (report in press).

least cultural barriers. For many of the lignocellulosic grasses, the technologies and infrastructure present on farms can be used directly in the production. Woody crops on the other hand require either adapted agricultural or forestry equipment.

	Major challenges
Quantity	• 'Chicken and egg' problem in developing biomass supply side • Lack of fluid market in non-commodity biomass feedstocks • Small supplier base • Lack of adequate and integrated infrastructure
Quality	• Biomass variability in physical characteristics and chemical composition • Low density • Lack of infrastructure to verify quality of supply
Price	• Potential for variability because of limited supply base • Difficulty in securing long term contracts (longer than 2-3 years)

Table 3: Major challenges in relation to securing quantity, quality and price of biomass feedstock

3.2 Technology risks and barriers

Although each bioenergy technology has its own technical challenges to overcome that depend mostly on its development status, a number of risks and barriers to deployment are common across the range of technologies. The principal concerns are discussed below, the majority of which relate to the physical properties and chemical composition of the biomass feedstock.

Robustness to feedstock variability

Most bioenergy conversion technologies are not very flexible to changes in feedstock quality and moisture content. This may impact on both the performance and reliability of the plant, which in turn affects the economics.

Feedstock handling

Solid biomass feedstock generally has a low bulk density and comes in a variety of structures and types, which makes it technically difficult to handle and store. Reliability of the feeding systems into the boiler / reactor is a common issue and is considered one of the main technical challenges still to be overcome, particularly for gasification units that operate under pressure.

Economies of scale

Commercially available technologies, apart from technologies for heating applications, generally suffer from poor economics at small scale. This is a particular problem because of the difficulty in supplying mainly lignocellulosic feedstocks to large plants due to insufficient resource availability, distribution, density and logistics. Addressing this risk will require the commercialisation of technologies with improved economics at small scale and an improvement in the availability of biomass and its supply logistics.

Co-product contamination

The solid co-product fraction of bioenergy conversion (ash, digestate, etc.) may contain contaminants such as heavy metals. This is particularly the case when feedstocks such as short rotation crops, straw, grasses, husks, as well as waste wood are used, which usually contain higher concentration of alkali metals than traditional woodfuel. In the context of increasingly strict environmental regulation, questions remain regarding the most affordable manner for treating and using these by-products and disposing of them in the most environmentally sound way.

Toxic emissions

Similarly, further R&D effort for flue gas cleansing will be required to meet increasingly stringent limits on toxic emissions (NOx, CO, particulates, etc.). This is particularly important for small-scale combustion units, as they need simple and affordable solutions.

3.3 Market risks and barriers

Competition and competitiveness

Bioenergy faces competition from alternative sources in all its market segments. Whilst bioenergy is generally cheaper than most alternative renewable resources, it is usually not cost competitive with conventional fossil solutions without public support. The competitiveness of bioenergy is very much dependent on the cost of biomass (including any transport costs). Many local factors also affect the competitiveness of biomass such as infrastructure, cost of alternatives and regulatory aspects (e.g. grid accessibility). Some examples where bioenergy is competitive with conventional sources are: power generation from waste gases, certain heat applications based on woodchips and pellets, and ethanol production from sugarcane. See also the issue of policy and regulation below.

Competition within the bioenergy sector

Within the bioenergy sector, there is no competition yet between the commercial technologies that tend to be relatively similar in terms of (1) the biomass types they can use, (2) their regional availability, and (3) the final product they can deliver. However, the advent of new technologies could change this. In particular, new technologies for the production of biofuels from lignocellulosic feedstock could lead to competition for biomass resources between transport fuel applications and heat and power applications. Technological advances in conversion technologies for biomass fuelled heat, power or transport would affect the competitiveness and use of bioenergy for those different applications, as would advances in the competitiveness of other renewable and non-conventional fossil sources of energy.

Policy and regulation

A stable and supportive policy environment is a prerequisite for the successful deployment of biomass in different applications. Similarly, there is a need for clarity and foresight in regulatory aspects, such as planning regulation and emissions standards. Furthermore, several countries have implemented policies and regulations that are aimed at protecting domestic production from cheap imported biofuels. Three different policy instruments can be distinguished:

1. ***Measures to promote domestically produced biomass over imported biomass for energy purposes.*** An example is tax exemptions in France, which are available only for biofuels that are both produced and sold in the French market. Producers from other EU countries are thus excluded, leaving them at a competitive disadvantage (Euractiv, 2008[12]).

[12] Euractiv (2008) Dossier Biofuels, Trade and Sustainability. Last update 16 September 2008. Available at: http://www.euractiv.com/en/trade/biofuels-trade-sustainability/article-171834

2. ***Import tariffs for various biomass commodities***. Examples are the import tariffs that are applied on bioethanol imports both by the EU (0.19€ per litre) and the US (US$0.14 per litre and an additional 2.5% ad valorem). In general, the most-favoured nation (MFN) tariffs range from roughly 6% to 50% on an ad valorem equivalent basis in the OECD, and up to 186% in the case of India (Steenblik, 2007[13]). Several preferential trade arrangements concluded by the EU with developing countries foresee duty-free or reduced tariffs for ethanol. However, for both the US and the EU, loop holes in legislation have been reported to circumvent import tariffs. For the EU, blending bioethanol with other chemicals and importing it as 'miscellaneous chemicals' has been reported as a loop hole (Desplechin, 2007[14]). For biodiesel, tariffs applied by developing countries are generally between 14% and 50%[13]. Biodiesel feedstocks, however, as agricultural commodities, are generally protected through agricultural support payments and tariffs. Oilseeds, many of which can be used to produce biodiesel, are an exception for the EU, which has an agreement in place to accept oilseeds duty free.

3. ***Export subsidies, intended for domestically-produced biomass***. An example is the subsidies granted in the US to allow US exporters to undercut their European rivals. Biodiesel is bought on the EU market or from low-cost biofuel producers such as Argentina, and then shipped to the US where a small percentage of gasoline is added to the fuel to qualify for the subsidy ($1/ gallon) offered on B99 fuel - 1% gasoline, 99% biodiesel[15]. The fuel is then sent back to Europe and resold at a price lower than the domestic market.

It thus seems that tariff barriers are particularly important for liquid biofuels, while no or only indirect tariff barriers for wood pellets (or other solid biofuels) were found in the literature.

Investor confidence

Supply side risks such as feedstock availability and price, and how these are affected by competing uses is a major source of concern for investors. Since feedstock costs represent 50-90% of the production costs of bioenergy, not being able to secure long term supply contracts results in uncertainties on the viability of projects. The cost of feedstock is a key aspect that differentiates bioenergy from all the other renewable resources that feed on "free" fuel (e.g. sunlight, wind, etc.). On the technology side, feedstock variability and its impact on conversion processes also affects investors' confidence. Furthermore, the range of feedstock and technology options adds complexity to investment decisions, particularly considering the absence of a critical mass of knowledgeable investors (although this has in part been redressed in recent years). Also, the very high cost of first-of-a-kind demonstration plants, and the insufficient record of success stories, tends to restrain investments. The interaction of biomass with other sectors, such as food and forestry, and the policies affecting them, is also a source of risk, placing further uncertainty on the future development of the bioenergy sector. Finally, the fragmented nature of policy support directed to bioenergy (focusing on feedstock production, conversion or end-use) enhances policy risk.

Public and NGO acceptance

Public and NGO acceptance is a major risk factor for all alternative energy sources, but bioenergy in particular. The public needs to be informed and confident that bioenergy is environmentally and socially beneficial and does not result in negative environmental and social trade-offs.

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[13] Steenblik, R. (2007) Subsidies: the distorted economics of biofuels, Discussion paper No. 2007-3, December 2007. The Global Subsidies Initiative (GSI), International Institute for Sustainable development (IISD), Geneva, Switzerland.
[14] Desplechin, E. (2007) Customs inconsistencies destabilise European bioethanol industry, International bioethanol association, available at: http://www.industrial-ethanol.org/uploads/IEA%20Biofuels%20Article%20Nov%2007.pdf
[15] http:///www.hgca.com/content.output/3629/3629/Markets/Market%20News/Biodiesel%20'Splash%20and%20Dash'%20.mspx

Certification systems

Various efforts have been undertaken aimed at ensuring a sustainable production and supply of biomass through certification systems. Criteria have been developed (or are considered) for either feedstocks (such as palm oil) or for final products. CDM aspects are included, as well, although the existing CDM system lacks sophisticated multi-criteria decision methods for identifying, selecting and assessing project activities from a sustainability perspective. The different standards and regulations under consideration are discussed in more depth by van Dam *et al* (2008)[16] and (2009)[17]. Two major potential barriers may be distinguished:

1) Criteria, especially related to environmental and social issues, could be too stringent or inappropriate to local environmental and technological conditions in developing countries. Many developing nations therefore view attempts to introduce sustainability criteria as a form of "green imperialism". Furthermore, small stakeholders may have particular difficulties to meet the requirements, also considering the high costs of the certification procedure.

2) The possible proliferation of different technical, environmental and social sustainability standards for biofuels production. With current developments by the European Commission, different European governments, several private sector initiatives, initiatives of round tables and NGOs, there is a real risk that in the short term a multitude of different and partially incompatible systems will arise. According to Van Dam *et al.* (2009)[17] some 60 sustainability standards for biofuels production are currently operational or are being developed.

It is currently too early to say whether any of the sustainability certification schemes in existence or proposed will on balance enhance or hinder trade.

[16] Van Dam, J., Junginger, M., Faaij, A., Jürgens, I., Best, G., Fritsche, U. (2008) Overview of recent developments in sustainable biomass certification. Biomass & Bioenergy, Volume 32, Issue 8, August 2008, Pages 749-780.

[17] Van Dam, J.*et al.* (2009; forthcoming) Overview of certification systems for biomass and bioenergy.

4 Conclusions

Biomass has the potential to contribute substantially to the world's future energy supply. Moderate biomass potential scenarios, taking into account sustainability constraints, indicate an annual potential between 200 and 400 EJ by the year 2050.

Global trade in bioenergy feedstocks (e.g. wood chips, vegetable oils and agricultural residues) and bioenergy products (e.g. ethanol, biodiesel, wood pellets) is growing rapidly and currently estimated to exceed 1 EJ (about 2% of current bioenergy). The contribution of Africa to this trade is currently limited and this situation is expected to remain so for the coming decade. However, in the longer term, much larger quantities of biomass and bioenergy products might be traded internationally, with Latin America and Sub-Saharan Africa acting as potential net exporters and North America, Europe and Asia as potential net importers. Especially the production and export of untreated lignocellulosic biomass from Sub-Saharan Africa in the longer term (to 2050) is a potentially interesting option. This is especially true when the technology for the production of second-generation biofuels becomes mature and commercially available, although the production of heat and electricity generation is an attractive application, as well.

The main reasons for Sub-Saharan Africa's attractiveness as a producer and exporter of lignocellulosic material are mainly the low costs of production and the large potentials from abandoned agricultural land and rest land. The use of these areas does not lead to competition with the production of food. Rest land is thereby defined as all remaining non-productive land, excluding bioreserves, forest, agricultural and urban areas and is calculated after satisfying the demand for food, fodder and forestry products.

However, there are a number of technology and market risks and barriers that need to be addressed and mitigated in growing the bioenergy sector:

Feedstock supply
This is susceptible to the inherent volatility of biological production (e.g. due to weather and seasonal variations), which can lead to significant variations in feedstock supply quantity, quality and price.

Economies of scale and logistics
Most commercially available technologies suffer from poor economics at small scale, but larger scales require improved and more complex feedstock supply logistics.

Emissions to air and co-product contamination
The solid co-product fraction of bioenergy conversion (ash, digestate, etc.) may contain contaminants such as heavy metals. Also, there may be a need to reduce and control air emissions from devices, in particular at smaller scales, to comply with increasingly stringent regulations.

Policy and regulations
Several countries have implemented policies and regulations that are aimed at protecting domestic production from cheap imported biofuels.

Competition
Bioenergy technologies compete with other renewable and non-renewable sources, and compete for feedstock with other sectors such as food and feed. Also, the development of 2nd generation

biofuel technologies would lead to competition for biomass resources with other bioenergy applications.

Public and NGO acceptance

This is a major risk factor for alternative energy sources, and bioenergy in particular. The public needs to be informed and confident that bioenergy is environmentally and socially beneficial and does not result in significant negative environmental and social trade-offs.

Certification systems

Various efforts have been undertaken aimed at ensuring a sustainable production and supply of biomass through certification systems. However, it is currently too early to say whether any of the sustainability certification schemes in existence or proposed will on balance enhance or hinder trade.

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