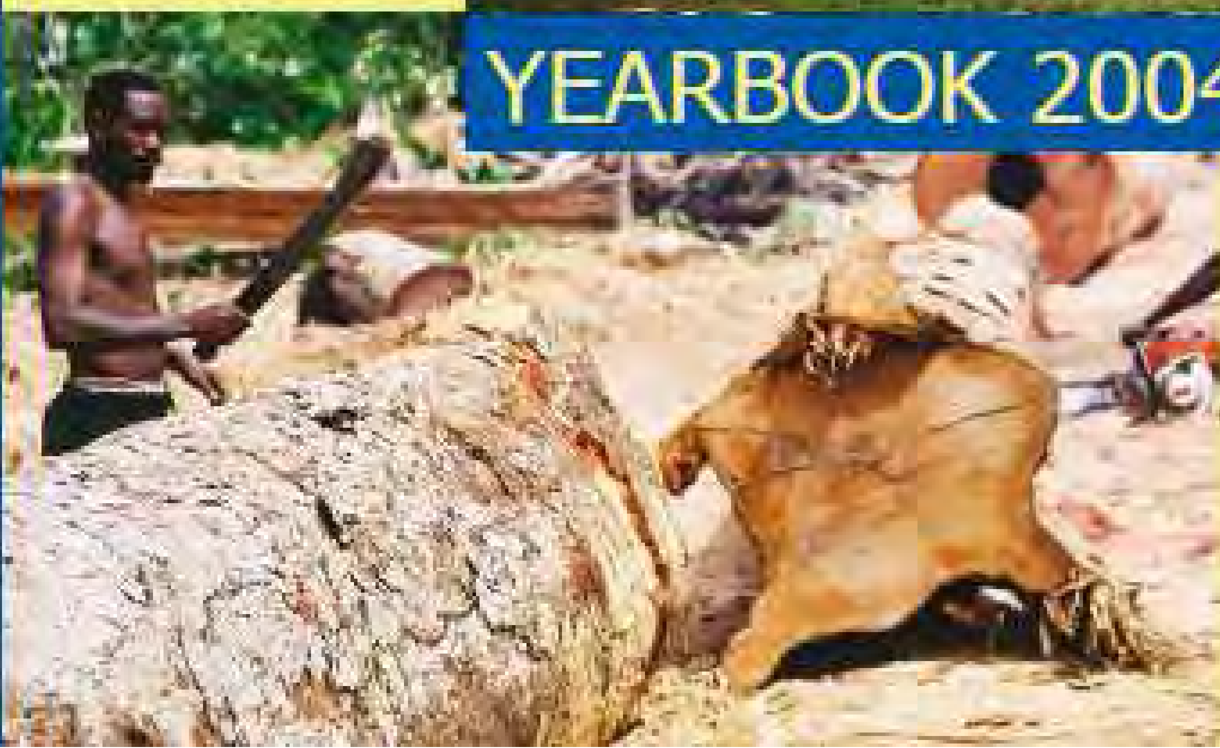
Biomassa-upstream stuurgroep

Quick-scans on upstream biomass

YEARBOOK 2004-2005



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Yearbook 2004 and 2005

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Quick-scans on upstream biomass. Yearbook 2004 and 2005

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Preface

There is little doubt in the scientific and industrial community that biomass will play an important role in the transition towards a sustainable economy. It will increasingly be a source of renewable energy, a raw material for the production of bio-chemicals and the basis for various construction materials. Inevitably, this will lead to an increased demand for biomass, which may surpass the current food-oriented biomass production by an order of magnitude. Entirely new economic chains will develop linking biomass production with final products on a truly global scale. Bringing supply and demand for biomass in some sort of balance is difficult enough. To achieve this in a sustainable way, will be a major challenge and many questions can be raised:

- Which crops are suitable for which purpose?
- Can we genetically modify crops to better suit the application?
- When is this ethically acceptable?
- Under which conditions can biomass be produced in an economically viable way?
- Will a steep increase in the demand for biomass in the “rich” countries cause over-exploitation in developing countries?
- How can we prevent negative impacts on biodiversity?
- How can biomass be certified as a sustainable raw material?

The Biomass Upstream Steering committee (BUS) has made an attempt in the past two years to develop insight in a broad spectrum of questions around the theme of production, supply and trade of biomass. With short studies (“quick-scans”), sometimes extended with a “follow-up”, many aspects have been studied and discussed. This yearbook is the compilation of these explorative studies.

Through this yearbook we hope tot inform a broader audience about the activities of the BUS and thereby contribute to a more sustainable use of biomass.

Dr.ir. Theo van Herwijnen
Chairman BUS

Introduction

Vision on upstream biomass
In the sustainable development of energy systems worldwide, biomass is considered to play an important role. The generation of electricity from biomass (green power) has already been introduced on a commercial scale and the marked introduction of bio-based motor fuels is taking off. Hence, the demand for biomass as raw material for heat and power production, biofuels and bio-based chemicals will greatly be enhanced in the next few years. This increased demand will put strains on the production systems of biomass, which may be even more pronounced when multiple land-use schemes are being considered. The production and conversion of biomass offers great economic opportunities, but may equally impose a negative impact on the environment and on society. The availability and price of solid and liquid biofuels, as well as the other procurement conditions which are to be met, will impact the viability and development of the emerging market for biomass. This illustrates the need for an early assessment of the 'upstream' part of the biomass supply chain and to develop practical initiatives and projects, which may contribute to solving some of the main barriers to the deployment of biomass.

A new initiative: the BUS
In January 2004 Shell Research Foundation and the Institute of Forestry and Forest Products (Probos) have taken the initiative to create a consortium of market parties and research organisations to jointly generate and select new ideas in the field of biomass production, resource development including new species, procurement, collection, logistics and pre-treatment, i.e. on upstream biomass. The Biomass Upstream Steering committee (BUS) also wants to assess the possible impacts of upstream biomass on the economy, society and environment.
The BUS-consortium is unique in its interdisciplinary approach in which both industrial partners and partners from the scientific community participate: Shell Nederland, Shell Global Solutions, Shell Research Foundation, Probos, WUR-Alterra, WUR-Agrotechnology & Food Innovations, WUR- LEI (Agro Economics Institute) and Energy Centre for The Netherlands (ECN).

How does the BUS work?
• Generate innovative ideas for studies related to upstream biomass supply
• Select and rank the most appealing ideas
• Work out the selected ideas in more detail
• Present and discuss the results in an open and often challenging way
• Organise interactive workshops on selected topics
• Develop the initial ideas into concrete project proposals
• Invite market parties to adopt and contribute in funding projects.

Funding
The BUS is funded by the participating organisations themselves, which gives a lot of freedom and inspiration to identify and select interesting new research topics. Shell Research Foundation has made funds available for organising the meetings of the steering committee as well as a support scheme for the development of innovative ideas, to be worked out by the participating research organisations. Other market parties may join BUS's activities, by joining the steering committee, by contributing to the project fund and by adopting and co-funding selected projects.

More info?

Results of the exploratory BUS activities are published on the BUS website: www.biomassa-upstream.nl. It should be stressed that the BUS is exploring different aspects of biomass supply chains, with rather short and limited quick-scan and follow-up studies (see Table 1).

Table 1. Overview of quick-scan issues studied, divided over four biomass categories

Issues	**Biomass in general**	**Forestry residues**	**Agricultural residues**	**Dedicated E-crops**	**Total**
Availability	9, 12, 18, 27*	6, 8, 25, 26	1	16, 23	**11**
Sustainability	3, 20, 21	17	4	5, 19	**7**
Imports & logistics	7	24	2, 13		**4**
Economics	14	22, 28	15		**4**
Quality traits	10, 11				**2**
Total	**12**	**8**	**5**	**4**	**28**

* The numbers in Table 1 refer to the following BUS-studies:

1. Availability of biomass in eastern Europe
2. Large scale physical pre-treatment of biomass at a central yard
3. The sustainability of biomass for bio-energy
4. Removal of biomass without negative effects on soil fertility
5. Sustainable imports of biomass from large scale tree plantations in Brazil
6. Salt water forestry: case study of mangroves
7. Obstacles to imports of biomass, a stakeholder approach
8. How to get more wood from the Dutch forests?
9. Self-sufficiency of The Netherlands in the field of biomass
10. Torrefaction to improve biomass fuel properties
11. Added value by refining of biomass in Southern Africa
12. Bio-fuels in developing countries
13. Palm oil co-production for oil and biomass
14. Biomass energy: exploring potentials and competing resource claim
15. Influence of agricultural practice on biomass availability
16. Typha for bio-energy
17. Social forestry and agro-forestry for biomass production in the tropics
18. The supply of biomass in China
19. Developments in genetically modified oilseed rape
20. State-of-the-art on certification
21. Scenario-to-strategy with Brazilian partners
22. Mobilizing extra wood in Europe
23. Jatropha curcas as a bio-energy crop
24. The harvest of forest residues in Europe
25. Position paper on forestry residues
26. Bio-saline (agro) forestry: a literature review
27. Understanding the factors which determine biomass availability
28. How to get more wood from the Dutch forests?

Quick-scans 2004

1

AVAILABILITY OF BIOMASS IN EASTERN EUROPE

Definition of the problem
In 2004 the EU 2004 was expanded with ten new Member States These acceding countries have a large agricultural area, which could imply a significant increase in production level. It is certainly conceivable that these countries may produce biomass at lower costs. Biomass production should be sustainable and not compete with the production of food and feed crops.

Questions
How big is the market for biomass for energy purposes in the new Member States?
What is the potential for biomass production when taking into consideration the developments in the demand for food and feed.

Marieke Meeusen and Siemen van Berkum, May 2004. Report on BUS ticket no. 48, LEI-WUR

1. Motive

As of 1 May 2004, the EU has expanded with the accession of a number of Central and Eastern European countries (CEE countries). These countries bring a large expanse of agricultural land into the EU, with the potential for agricultural production. These countries may be better able to produce biomass at low costs for the purposes of producing bio-energy. At the same time, there is a desire to produce biomass in a sustainable manner and to meet the needs with respect to food and cattle fodder. Assuming that there is sufficient demand in Europe for biomass for the purposes of producing bio-energy, the question arises of whether there is a role for the CEE countries in the provision of biomass for bio-energy, and what that role could be.

This paper first gives an impression of the current supply and the production potential in the CEE countries. The emphasis is placed on agricultural products, excluding wood.[1] The production potential appears to be great. However, the question is how much of this large potential will actually become available. This question cannot be answered simply; after all, as outlined in this paper, a great many factors combine to determine the actual levels of availability of biomass for bio-energy. For this reason, the decision was made to look at the broad spectrum of factors that ultimately determine the actual availability of biomass for bio-energy. This provides a handle on an initial line of thought on the possible role of the CEE countries as providers of biomass for bio-energy.

2. Current acreage and current production

The new member states currently cultivate about 15 million hectares of grain, almost two million hectares of oil-bearing seed and 600,000-700,000 hectares of sugar beet.[2] Roughly half of these areas are situated in Poland. Hungary and the Czech Republic make up about 25% of the areas in the CEE countries between them. Together, all the new member states produce approximately 50 million tonnes of grain, five million tonnes of oil-bearing seed and 2.8 million tonnes of sugar. Incidentally, most of the new member

[1] There is a large expanse of forest in de Baltic states, Poland and Hungary. After the EU expansion, the total volume of wood in forests within the Union will be 21 billion cubic meters, of which 25% is situated in the new EU member states. The current and future availability of wood from the CEE countries could be further elaborated in a separate paper by Alterra.
[2] No cost prices are known as yet for these products; the Farm Accountancy Data Network for those countries is in the making, but as at 2004 has not yet provided insight into the cost price of the various products.

states are net importers of important arable crops, milk and meat. Consequently, little of this production reaches the international market. For the time being, the agricultural products are mainly used as food for human consumption and as cattle fodder. There is still no significant production of energy from agricultural products in the CEE countries as yet.

The potential availability of other agricultural products (such as manure and organic waste) for bio-fuel use is still unknown. However, the size of the livestock population in the CEE countries is known. This population has shrunk dramatically in comparison to the situation in the years prior to the start of the transition. Of course, this is one factor determining the availability of manure for possible fermentation for the purposes of producing bio-fuel. The fact that CEE agriculture is characterized by its small scale, with many farms keeping only a limited number of cattle, is also important in this respect. The distribution of the manure becoming available is therefore very dispersed across the whole country.

3. Production potential

The production potential in the CEE countries is considerable; there are more than 130,000 hectares of agricultural land, on which the level of production per hectare is only 60-80% of the EU average. This means that there is a potential for greater yields. At the same time, there is still a certain expanse of land that is currently not in use as agricultural land, but that certainly has that potential; there are various factors resulting in not all the land being used for agricultural purposes.

Table 1: A few characteristics of acceding countries

	GDP per capita as a % of the EU average (2002) [1]	Population (in millions)	Agricultural land acreage (UAA, in 1000 hectares)	Proportion of agriculture in employment (%)	Proportion of agriculture in GDP (%)
Cyprus	72	0.8	134	9.2	3.5
Czech Republic	60	10.3	4282	4.5	3.4
Estonia	42	1.4	891	7.6	4.7
Hungary	57	10.0	5854	6.0	3.9
Latvia	35	2.4	2488	13.5	4.0
Lithuania	39	3.7	3489	19.6	6.9
Malta	55	0.4	12	1.9	2.0
Poland	39	38.6	18800	18.8	2.9
Slovakia	47	5.4	2440	6.7	4.5
Slovenia	74	2.0	491	9.9	2.9
EU 15	100	360	131619	4.3	2.0

Notes: Unless otherwise stated, the data is from 2000 and is taken from: European Commission Directorate-General for Agriculture, *Agricultural situation in the candidate countries, country reports*, July 2002;
[1] GDP per capita: index measured in purchasing power standard 2002 (EU 15 average =100). Source: Agra Europe, East Europe, November 2003, p. 4;

Table 1 shows that Poland, Hungary and the Czech Republic are particularly important countries in terms of agricultural production. Latvia, Lithuania and Slovakia are also significant in terms of their agriculture, though to a slightly lesser extent.

Determining factors for availability
The production of bio-fuels from agricultural products is only an attractive option if bio-fuels can compete with mineral fuels and if an alternative use in the form of food and/or cattle fodder does not yield higher profits for the farmer/grower. The price fixing for agricultural products is largely determined by market regulation through the CAP and through international market relations (shortages/surpluses).

Although the production potential is great, the realization of that potential will not happen automatically. The developments in production and prices are influenced by developments in:

- demand for foodstuffs;
- technological developments; and
- agricultural and energy policy.

If the supply is available, the next question is whether and how that supply can be united with the demand. Chain organization and chain-oriented thinking are as yet only partially developed. Many farms produce only for themselves or for the regional market. Logistic organization and processing (in accordance with the EU directives) are just starting to get going. Chain harmonization has made greater progress in sectors where foreign companies are active – in processing and/or in retailing – than in those sectors in which foreign companies are less active. This factor also plays a particular role in animal and/or processed products. For unprocessed (vegetable) products that can be easily conserved such as biomass for bio-energy, the limited chain harmonization forms less of a sticking point.

Determining factors for the exploitation of the production potential: demand for food

Where developments in demand are concerned, the main issue is the changes that can be expected in consumption over the next few decades. These changes are driven by general economic developments, with consequences for income growth and consumption patterns. Income growth in the CEE region will result in an increase in the demand for food products, and a shift towards animal products and processed products can be expected. This will have direct implications for the availability of biomass for the energy market. After all, the growing demand for food stimulates the domestic production of agricultural products and the growing demand for animal food products promotes the national production of feed grain. If these products yield a higher price for the grower and farmer than the energy market, only a smaller proportion of the great potential will actually become available for the bio-energy market.

Determining factors for the exploitation of the production potential: technology

Supply, driven by technology, relates to matters such as improvements in productivity through technological developments and increases in scale. The relative price development of production factors is important in this respect.

In view of the low industrial and land productivity, there is a lot of room for improvements in productivity in the new member states. Even relatively low investments (since capital is the expensive production factor) can have a great impact on yield per hectare. At present, the yield per hectare is approximately three quarters of the EU average.

Increases in scale[3] can also contribute to increased and cheaper production. Increases in scale can result in the more efficient deployment of labour, land and capital, and lead to higher yields. The possibilities for increases in scale are also dependent on alternative employment (as well as general economic development) outside agriculture. This is not

[3] In most countries, the structure of agriculture is characterized by its small scale. This is the consequence of the privatization of formerly large production units in owned collectively or by the state. There are exceptions to this rule, such as Poland; in Poland, agriculture has always been predominantly small in scale. Today, the individual family farm dominates in all countries, generally small or very small in size. Only in Slovakia are there still a relatively large number of cooperatives and limited companies, with on average 1,000-1,500 hectares of land. There are also large farms in other countries, with a few hundred hectares of land, but this form is not typical of the region. There are, however, a lot of subsistence farmers who often own and farm exceptionally small plots of land, and who consume the greatest part of their production themselves and rely on sources outside farming for their monetary income. The proportion of these farms in terms of the number of farmers varies per country, but this proportion is particularly high in Poland, for example, where a quarter of the farms cover less than two hectares, and 55% cover less than five hectares.

always a rosy picture; there is widespread unemployment in the Polish countryside, with few alternative options for farmers.

One of the reasons for the relatively low yields per hectare is the very limited use of inputs like artificial fertilizer and plant protection products. The increased use of these inputs results in higher yields per hectare. However, one has to consider whether this increased use fits in with the demands made of the final product – *sustainable* bio-energy – and to what extent. It may be that some of the potential for an increase in productivity cannot be exploited as it does not meet the requirements of *sustainable* bio-energy. Other measures, such as better storage facilities, would have a less negative effect.

Determining factors for the exploitation of the production potential: EU agricultural policy

The application of the Common Agricultural Policy (the CAP) – in its current form, following the Luxembourg Agreement of June 2003 – will to a great extent determine the cropping plan of arable farming in CEE countries. For some agricultural products, the accession of those countries will mean an increase in the relative prices, while other products will see a reduction in their relative prices (in response to the market regulation within the CAP). Consequently, the balances of agricultural products will also change, and farmers will adapt their production plans accordingly. The question is: to what extent will this happen, and how fast? The international market developments are also growing in importance in terms of the retail opportunities of EU agricultural production, in view of the probable reduction of the CAP's border protection effect and the availability of export subsidies within the framework of WTO agreements in the coming years. Prices in the EU will therefore draw closer to those on the global market.

In this respect, the role of the CAP in relation to bio-energy is also significant.

For example, Cargill International is commencing ethanol production from wheat in Poland (Agra Europe, East Europe, February 2004:36). To date, Cargill has produced around 60,000 tonnes of HFS (fructose and glucose syrup) from sugar for the foodstuffs industry. However, as of 1 May, Poland is subject to EU sugar market regulation and, as such, the production of HFS will be subject to a ceiling of around 27,000 tonnes. To make optimum use of the factory's production capacity, Cargill is investing in a new production line for raw ethanol production. Part of the production would have to go to the foodstuffs industry and part of it would go to oil companies for use in fuels.

The production of bio-fuels can be encouraged further through government measures like premiums, taxes and obligations. The question is which policy stimuli will have which effects on the demand for agricultural products for bio-fuel products. The following two policy instruments are relevant here:

- The EU encourages the production of energy crops for biomass with a premium of EUR 45/hectare, with a maximum of 1.5 million hectares for the EU as a whole (Regulation 1782/2003). This financial support is additional to the hectare premium and/or farm premium for the area sown with energy crops. The question is to what extent this encourages farmers and processors in CEE countries to produce bio-fuels.
- In various countries (including Poland), the addition of bio-fuels to mineral fuels is supported by means of fiscal measures. This ought to encourage the production of grain and other energy crops for biomass.

4. Conclusion

At present, raw materials are produced for bio-energy: grain, sugar beet and vegetable oils. These are currently mainly used in foods for human consumption, and in 2004 there are still insufficient quantities to fully meet the domestic demand; many CEE countries have to resort to importing goods.

There is great potential in the CEE countries in terms of agricultural land and agricultural production. The costs of land use and labour are low, and the costs of biomass will therefore also be low. The potential can be seen in the fact that (a) not all land is used as agricultural land and (b) the yields from that land are not yet at the same level as the yields achieved in other EU member states.

Although there is so much potential, this does not mean that there is an abundance of biomass for bio-energy. Whether the CEE countries will play a role as suppliers of biomass for bio-energy, and to what extent, is dependent on (a) the demand for food, (b) the technological developments within agriculture in the CEE countries, and (c) the effects of the Common Agricultural Policy. If or when the demand for food and animal products in the CEE countries rises (influenced by the general economic upturn), farmers will be more likely to produce for the more financially attractive food and animal feed markets than for bio-energy. The extent to which technological developments that result in increases in productivity can be implemented is partially dependent on the relative prices of the three production factors. Lastly, one needs to consider the influence of the Common Agricultural Policy, the economic situation and the developments in the global market on the cropping plan of CEE farmers. These factors are difficult of impossible to predict. It is possible, however, to calculate and determine their influence. For this reason, the recommendation is made to carry out a follow-up study to calculate the influence of the main factors. The results have absolutely no predictive character, but do help to identify the boundaries of the field within which the CEE countries can play a role and to recognize the influence of the various factors.

2

LARGE SCALE PHYSICAL PRE-TREATMENT OF BIOMASS AT A CENTRAL YARD

Definition of the problem
In the very near future The Netherlands will need huge amounts of biomass for co-combustion in existing coal plants. Furthermore, there will be substantial extra demand for biomass for liquid and gaseous biofuels, most of which will be imported. To be able to handle these large amounts of biomass central yards could be needed, where handling, blending and pre-treatment can be optimized to achieve the desired fuel mix. In the coal industry this is already common practice; for the emerging biomass industry it will be useful too.

Questions
1. Which locations will be most suitable to establish central biomass yards in The Netherlands?
2. Which pre-treatment technologies need to be included? (see BUS-ticket 16 as well)
3. Which scale is the most feasible? What will be the approximate investment costs involved?
4. Which parties are willing to set up a joint venture to establish such a central biomass yard?

Leen Kuiper, April 2004. Report on BUS ticket no.15, Probos

1. Approach

By a quick scan, consisting of interviews and E-mail consultation with experts, an attempt was made to answer the above questions. The following experts have been contacted:
- Wijnand Schonewille, Port of Rotterdam, bulk terminal
- Peter-Paul Schouwenberg, Essent renewables - Amer power plant
- Henk Kwast, Bruins en Kwast, collection of fresh wood and used wood
- Houtbank/Tetteroo - collection and export of used wood
- Michel Leermaker, SITA - collection of used wood
- Cor Siero, Ecochip - collection of wood residues
- Toon Beeks, Biomassa Stroomlijn BV - collection of prunings)
- Rob van Rij, E.ON power plant at the Maasvlakte, in which biomass pellets from a nearby Biomass Pellet factory are co-combusted
- Jaap Koppejan, TNO-MEP - pretreatment for co-combustion
- Silvan de Boer, Eneco
- Toon van Tienen, NUON

2. Results

2.1 Port of Rotterdam

The experts from the port of Rotterdam suggest the following logistic chain:
- Wood pellets pressed on-site at the wood processing industry in exporting countries (e.g. Russian Federation) with good connection to a sea port with bulk export facilities (e.g Archangelsk).
- Transport by self loading bulk carriers to a bulk terminal yard on the 'Maasvlakte', where the wood pellets can be mixed and blended with coal.
- Inland transportation by means of river barges, using the services of 'Regionale Overslag Centra' or 'Binnenvaart Service Centra'. Most biomass power plants and co-combustion plants are located at accessible waterways with a minimum depth of 4 m.
- The ready-to-use fuel mixture can be unloaded and stored at the plant by using conventional equipment (such a elevators and silos).

2.2 Amer 8 power plant of Essent

Favorable site with discharging quay, water depth of 4 m, coalbunker for 120 ktons of coal close to the plant, four biomass-silos 5 ktons each, which allow direct blending (mixing) in combination with the use of hammer mills for particle size reduction. In 2004 some 1.2 million tons of biomass will be used at Amer 8, of which 31% will come from the USA, 27% from Europe, 21% from Asia and 18% from Africa. The imported biomass consists of wood pellets, wood chips, palm kernel expeller residues, citrus pulp, cocoa hulls, corn pellets, olive kernel pulp, paper sludge, vegetable oils.

2.3 Contractor Bruins en Kwast and energy company Cogas

They will jointly built a small bio CHP-plant in Goor in 2004. This is an example in which a forestry contractor has become an energy producer. The power plant will be fueled both by A-quality wood and B-quality wood, totaling 17 ktons per annum. Apart form the supply of warm water to the neighboring industry the CHP plant will produce 12 million kWh of green electricity, to be consumed by 4000 households in Goor. Bruins en Kwast is responsible for the biomass supply. In addition to their forestry contracting work and waste management they run a composting yard, which enables them to sort out and prepare the collected biomass for different markets. Bruins and Kwast considers the coal bulk terminal on the ‘Maasvlakte’ very suitable for large-scale imports of biomass, especially in connection with the ‘Betuwelijn’. A biomass transfer yard could also be located at ‘Moerdijk’ and in Delzijl. It is important that the yard has sufficient buffer storage capacity: at least 10,000 m3 for short-term deliveries. An important factor for the choice of the biomass yard location is logistics, which should be excellent. Bruins and Kwast is certainly interested to participate in a joint venture.

2.4 Collection and recycling of B-quality wood for the particleboard industry

The Wood Distribution Europe company (Houtbank/Tetteroo) is one of the largest used wood traders in The Netherlands. The transfer capacity of their wood yard in Roosendaal is 250 ktons annually (B-quality wood) and in their Moerdijk yard some 130 ktons/a of A-quality wood. They do not collect the used wood themselves, but they are supplied by some 250 companies, which collect, transport and sort out the wood from municipal service yards, wood waste form the packaging industry and lumber yards. Most of the used wood is exported to Italy (250 ktons of B-quality wood) using railway lorries, where it serves as a feedstock to the local particleboard industry. A smaller portion (120 ktons of A-quality wood) is supplied directly to the Presswood company in Ermelo, The Netherlands, which produces base elements for pallets. About 10 ktons/a of A-quality wood is supplied to the board industry in Belgium. At the Roosendaal yard, each week a 36 lorries train with 5 ktons of used wood departs to Italy.

Their logistic supply chain is as follows:

1. Collection of used wood in containers
2. Sorting out
3. Washing
4. Breaking / size reduction and loading
5. Transport by train or ship
6. Further particle size reduction
7. Removing of metal parts by air sieving (ferro and non-ferro)
8. Crushing and pulverising
9. Pressing into eco-particleboard and finishing
10. Furniture production (IKEA-style)

2.5 Collection of prunings by Biomassa Stroomlijn BV

To supply the biomass plant in Cuijk Biomass Stroomlijn BV collects containers with prunings from gardens and landscape maintenance and the management of small woodlands in addition to trees felled due to road and railway construction work. In total some 150 ktons/anum is being collected and chipped, of which 100 ktons is being supplied to the power plant in Cuijk. It is a daughter company of a large Dutch transport company active in waste management (Van Gansewinkel group). With an annual production of 60 million tons, the Dutch waste market is a multi-billion euro industry. The waste sector is dominated by major players such as Sita, Essent Milieu, AVR, Van Gansewinkel Group and Shanks[4]. At present about 40 waste sorting installations are in operation in The Netherlands. Van Gansewinkel has business relations with about 300 small producers/suppliers of biomass. They take care of logistics and quality control (eg by means of pre-treatment and blending). Biomass Stroomlijn has several yards where the collected materials are sorted out, chipped, mixed and stored. However, legislation/permits for storage are very difficult to obtain and this is a limiting factor for the expansion of biomass business.

At the municipality level they have introduced a concept of a cost-effective, small-scale chipping-chain, which consists of:

(1) pruning manually
(2) extraction of branches by means of a tractor with a crane
(3) mobile chipper combined with a trailer
(4) temporary storage on site
(5) container loading and hauling
(6) unloading at the power plant.

In this way, the collection of chipped biomass from prunings and landscape plantings costs about 54 euro per ton, which is relatively cheap, compared with composting (64 euro/ton). The total supply of biomass to the power plant in Cuijck totals 250 ktons of wood chips, which requires about 10,000 trips by container lorries, on each of which 25 tons of wood chips is loaded. Hence, the collection of biomass is mainly a matter of optimizing logistics. In this respect, a number of decentralized wood yards are to be preferred, allowing greater flexibility.

2.6 SITA

SITA has about 40 bulk transfer yards in The Netherlands for the collection and pre-treatment of various waste streams. They are active in a broad spectrum of waste management, ranging from used wood to domestic waste and frying fat. The woody fraction they collect, totals about 80 ktons/annum, most of which is being exported to the particleboard industry in Belgium and Germany and partly to renewable energy companies in Germany (especially since there is no outlet to the power plant of Electrabel in Nijmegen, for the time being). The role of biomass yards should be considered for the whole supply chain. What happens before and after the biomass enters the gate of the yard is equally important, especially in terms of environmental impacts and risk reduction. Locations on the waterfront are to be preferred: the less handling needed, the better (each time biomass is picked up for an extra handling, it costs about 15-20 euro per ton). The demand side of the market largely determines how big the yard should be. The bio-energy market has just started to develop, but other outlets for organic wastes, such as composting and anaerobic digestion are already much more common. Woody biomass is relatively easy to handle and the technologies needed are well known. Technology should match the different types of biomass, but legislation (within EU-25) has an important impact too.

[4] http://www.aoo.nl/images1/aoo_nl/bestanden/AOO2000-00b.PDF

The investment costs to establish a biomass yard with the required safety measures (such as a sprinkler installation) with an annual turnover of 100-150 ktons of biomass and waste is in the order of 7.5 million euro. This includes a 7500 m2 intake and sorting area indoors, divided into several compartments, and with the necessary equipment for handling, sieving, breaking, etc. Because biomass and waste streams often are heterogeneous, a relative large floor surface is needed. Frequently, this is a limiting factor for upsizing. However, the handling of large volumes of imported biomass (e.g 1 million tons/a), is much easier to organize, because the necessary product quality has to be established in the country of origin. SITA's largest waste partition and transfer yard has a capacity of 250 ktons of waste/a. It is located in the 'Waalhaven' in Rotterdam, accessible both for sea bulk carriers and for river barges and tug pushed lighters. On this site, they have still some room available (8000 m2) for extra bulk storage and handling. SITA is willing to consider participation in a future joint venture to establish and run a central biomass yard.

2.7 TNO/MEP on large scale imports and pre-treatment of biomass

When considering new initiatives, e.g for liquid and gaseous biofuels, a central biomass yard in the vicinity of the sea port of Delfzijl would be the most obvious choice, because Groningen is very busy creating an 'Energy valley'. However, you would still need facilities for biomass transfer to existing coal plants. With respect to stock buffering the need for mixing/blending, drying and size reduction will depend on the subsequent conversion technology. I guess the larger the facility the more cost efficient, so the size will be determined by the processing plant(s) that obtain the materials. Large scale (500-1000 kton/y) would be likely. I am not sure, which parties are willing to set up a joint venture to establish such a biomass yard , but I guess the established companies involved in blending coal could do the job as far as the use in coal power plants is concerned. Additional know-how will need to be incorporated for particular processes, such as drying, size reduction, etc.

2.8 Eneco energy

At this moment ENECO focuses on relatively small-scale stand alone CHP-plants which will run mostly on local feedstock and of which the produced heat can be sold locally. ENECO has no co-combustion facilities yet. Thus, large scale imports of biomass is not yet an issue. However, large scale biomass yards, once established, may supply stand alone biomass plants too, in which case decentralised yards would be preferred. The necessary pre-treatment on the yard will depend on the type of conversion plant and the technology applied. ENECO is opting for solid and proven technologies with modest biomass specifications, which do not require a lot of mixing and blending. The question raised about forming a joint venture will be discussed in ENECO's management team.

3. Conclusions

1. This quick scan has yielded some interesting information about the way in which biomass is collected and handled in The Netherlands at present.
2. However, the questions raised proved to be a little bit too specific and too detailed. The experts interviewed had some difficulties in answering them properly.
3. Biomass handling and pre-treatment and waste management and recycling often go hand in hand, needing the same kind of logistics.
4. The waste sector is dominated by a few large players and further mergers and up-scaling is to be expected[5]. Combining different activities by horizontal integration is a strategy often deployed to face the increasing competition and to maintain a leading market position.

[5] BVOR (Branche Vereniging Organische Reststoffen)

5. If new biomass yards are to be established in The Netherlands in the very near future to handle large quantities of imported biomass, it seems a good idea to make use of the existing experiences and know-how of the waste and recycling sector and to cooperate closely (e.g form a joint venture) with one or more of the leading firms.
6. Two large biomass yard located at the Maasvlakte and Delfzijl for large scale imports of clean biomass and a number of smaller yards in conjunction with existing waste recycling and composting yards will enable a flexible supply of feedstock which is tailor made to the quality requirements of the bioenergy producers.
7. Pre-treatment of clean biomass will consist of particle size reduction, homogenization, blending and quality control and management. These measures require standard technologies which can best be outsourced to the fuel suppliers. Usually biomass is not dried prior to energy conversion. However, pelletising biomass and waste could be an interesting (but rather expensive) option for some end-users (i.e private consumers).
8. Pre-treatment of used wood and other organic waste products form the agro-food industry may need additional steps of sorting, sieving, removing of unwanted materials and, in some cases, pulverizing.

4. Follow up?

A number of questions still remain unanswered:

- How many biomass yards will effectively be needed by 2010?
- What are the investment costs involved? (we didn't get much information on this point)
- How to overcome the difficulties with legislation and (environmental) permits? How serious are these barriers to the large scale deployment of biomass?
- What are the exact pre-treatment steps (in conjunction with BUS-ticket no 16)?

Recommendations

1. Organize an in-depth workshop with an group of experts / captains of industry to assess the viability of large-scale biomass yards in The Netherlands in greater detail; to formulate a joint vision coupled to a number of recommendations in the form of a concrete action plan; and to bring potential business partners together. Both the BUS and Novem may be approached to facilitate such a meeting.
2. Vision and action plan will be discussed with the participants of the ongoing 'Transition on Biomass' and the outcome of the discussions may be presented to the Dutch authorities, e.g to the Secretary of State of the Ministry of Economic Affairs.

3

THE SUSTAINABILITY OF BIOMASS FOR BIOENERGY

Definition of the problem
Biomass is not always per definition more sustainable than other raw materials. To judge the sustainability of raw materials for the agro-sector a checklist with criteria and indicators has been developed . So far the various biomass streams have not been scored yet.

Questions
1. Under which conditions biomass may be considered the most sustainable?
2. Which production, supply chain and price measures must be taken into consideration to guarantee the sustainability of biomass for bioenergy?

Wolter Elbersen, May 2004. Report on BUS tickets no.19 and 52, WUR-A&F

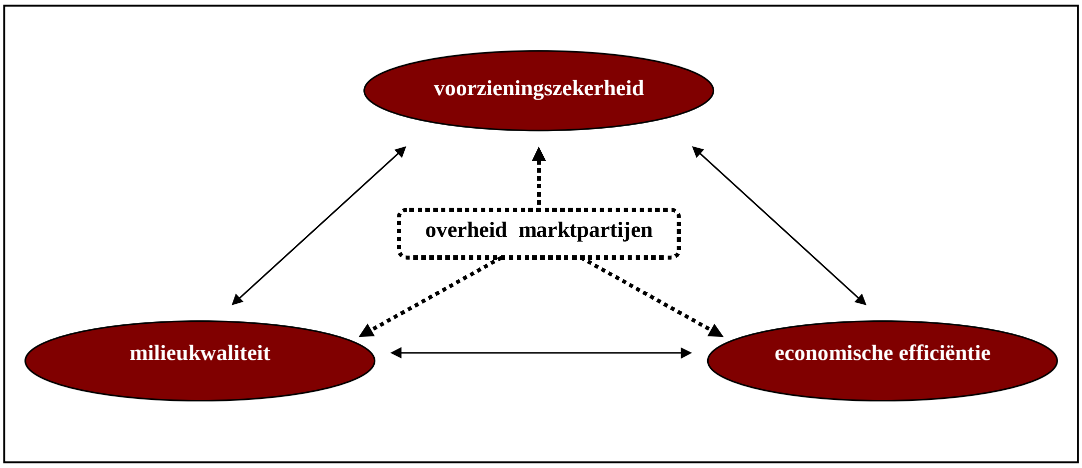
1. Introduction

This is a report of a short study into the sustainability of biomass for bioenergy. The research questions have been formulated in two "BUS" project ideas (# 19 en #52)

The essence of the research topic is that the utilisation of biomass is technically possible but there are many social, economic or ecological barriers. Another description of the three fields is People, Profit, Planet. The Ministry of Economic Affairs (EZ) refers to three requirement for the energy supply system; Reliable (security of supply), Clean (environment) and affordable (economically efficient) (Stoop, 2004; Goos en Uitert ,2004).

The word sustainable is generally used with respect to ecological (planet, clean) sustainability. But often the other two factors (economic and social aspects) should also be included. In the context of this presentation we will look at all 3 dimensions.

Figure 1: Aspects of a sustainable energy household, according to the Ministry of Economic Affairs (2004)



In the two project ideas the following questions have been formulated:

- Which sustainability criteria and indicators are "self evident" and over which will there be more disagreement?
- Which parties have to be brought together in order to come to a consensus?
- Which parties in the Netherlands are involved in this issue?
- Under what conditions is what biomass most sustainable?
- Which measures with respect to plant production, supply chain organisation, price have to be taken in order to achieve sustainable energy sources?

These type of questions are also the basis of a vision which has been drawn up by different actors in the Dutch Biomass field (Sustainable bio energy. A vision on socially acceptable bio energy. Van Son et al, 2002). Perhaps it is useful to see if the criteria and agreements which have been drawn up here are workable and if it is possible to get more insights in the underlying assumptions. A further refining of such a set of criteria and agreements could leave more space for to produce more biomass and more biomass at a higher level of sustainability.

The Main Research Question
The subject is very broad and a large body of knowledge already exists. An understanding of the existing discussions and opinions can help to enlighten the research priorities needed to bring large scale sustainable production and supply of biomass within reach.

The following research question was chosen:
Name and discuss shortly the factors in the three sustainability categories (Planet,People,Profit) that determine if biomass chains will or will not be constituted. Give an insight into the parties that play a role here at the national and the international level. What are the "Bottlenecks" and how can they be dealt with?

A table with factors pertaining to the 3 sustainability categories has been composed together with a short discussion and an indication if the factor can be considered a positive or a negative driver and if it can be considered a bottleneck.

Results and a short discussion
In table 1 to 3 an overview (not exhausting) is presented of often mentioned factors that may play an essential role in assessing biomass to bioenergy chains on the basis of environmental (planet), economical (profit), social (people) performance. The factors have been chosen from current literature. The assessment of the factor is based on ongoing discussions within the biomass field and literature. Systematic assessment of literature and interviews could make the list more objective and quantitative.

In the process of composing such a table it becomes clear that large differences exist between different (potential) bioenergy chains. What is an obstacle for one chain will be a driver for another biomass chain. For example the CO_2 input/output ratio can be very different between different energy crops (rape versus switchgrass). Each biomass chain will have a different score.

The exercise of composing the table shows some other aspects that will be of importance. For example some factors differ in importance between countries:

- Erosion is not a large issue in the Netherlands and therefore also not a point of discussion in relation to biomass chains.
- Scarcity of water is another example of a factor that has different priorities in different countries.
- The use of GMO's is viewed even more differently.

- Biomass to energy chains based on genetically modified crops (imported or produced abroad) are a problem in Europe but will be OK in the USA.
- If climate is the main driver for development of bioenergy the CO_2 abatement potential is most prominent.

It other factors like high fossil fuel costs or security of supply are the main drives concessions may be made to the CO_2 input/output score of a biomass to energy chain.

Much discussion exits about the necessary "level" of sustainability. What is sustainable, more sustainable and most sustainable? Here the claims abound but very little agreement exists about the hard figures (what is the yield, cost, etc). And there is little agreement about the importance of the factors constituting sustainability. What is the value of biodiversity and what is the contribution or threat to sustainability of bienergy production systems. Many existing bottlenecks in biomass production and supply can be removed by providing more insight in the real numbers needed for assessment of PPP sustainability and the underlying mechanisms.

With respect to certification systems it should be possible to join in with other plant production systems that need to become more sustainable. FSC wood and by-products for energy is an example. Other production chains include sustainable palm-oil production, cocoa, etc.
Concerns may be raised about the viability of certification systems in the long term when very large amounts of biomass are needed. Does certification exclude too much non-certifiable biomass?

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Achieving the goals set forth in theis *A Vision for Bioenergy and Biobase Porducts in the United States* will have benefits that reach beyond the U.S. Biomass industries:

- **National Security** – Domestic bioenergy sources could help our nation to substantially reduce dependence on petroleum.

- **Environmental Protection** – By offsetting fossil fuel use and related emissions of nitrogen oxides, sulfur dioxides, and other pollutants, bioenergy and biobased products will contribute to cleaner air and water. Further more, increased cultivation of carbon-fixing plants will help mitigate greenhouse gas emissions that contribute to global climate change. It will also provide a productive avenue for using agricultural, industrial, commercial, municipal, and forestry wastes.

- **Rural Economic Growth** – Growth in biobase products an bioenergy will stimulate rural development efforts in farming, forestry, and associated service industries.

By 2030, a well-established, economically viable, bioenergy and biobased products industry will create new economic opportunities for rural America, protect and enhance our environment, strengthen U.S. energy independence, provide economic security, and deliver improved products to consumers.

From: The vision for Bioenergy and Biobased products in the Unites States, 2002.

Table 1: Environment (Planet) factors and criteria that play a role in the discussion on biomass and bioenergy.

Factor or criteria	Positive aspects	Concerns	Country specific?	Is it a bottleneck?
Waste	Application for energy reduces waste production	Cascade use is better (also see competition)	More in the Netherlands than abroad	Not a real bottleneck
		Is the use of waste green? (see discussion on bone meal, chicken manure)	More in the Netherlands than abroad	In NL often a current bottleneck
		Bioenergy chains should not add to waste production (gypsum, ash, etc)		May become a bottleneck
Climate Change	Biomass is climate neutral (or mostly)	Is CO2 input/output of the chain low enough?	More in NL and EU than where Climate Change is the main driver	Yes. Is the main driver , determines discussion in NL and to quite an extent in EU.
		Emission of other climate gasses associated mostly to crop production (N2O fertilisation, etc)	More in NL and EU than where Climate Change is the main driver	Is bottleneck in many types of energy crops, especially annual crops.
Water-use	Energy crops can contribute to "watershed protection" more water retention	Energy crops use water (see also competition)	UK, USA less in NL	Over time it will be
Pollution (in general)	(Perennial) energy crops emit less pollutants (pesticides, fertilisers) than annual crops	Crop production may emit nutrient/pesticides		Yes, for annual crops
Biodiversity	A lot of biomass can be produced without adverse effects on biodiversity. Much synergy with	Use of "non-native" energy crops is a concern for biodiversity.	USA yes – In Europe it is not much part of the discussion	Yes, over time it will be a factor. When volumes increase.
		Monocultures are detrimental for biodiversity. Intensification of agriculture can reduce biodiversity	Is part of discussion in EU	Yes. Potentially if volumes increase
	Many biomass crop production systems (perennial) potentially can increase biodiversity compared to current agriculture.	More demand for biomass will lead to utilisation of marginal lands and nature areas	NL and EU, in relation to importing biomass	Yes. It is a factor in discussions.
GMO	More efficient production is possible (less	May have unwanted effects on	Concern in NL and EU less	Yes in EU it is not feasible at

	costs, more yield)	biodiversity (super weeds, etc)	in USA and China	the moment.
Soil fertility/ nutrient balance	This may be a co-drives for biomass chain development in NL. Many forms of bioenergy can contribute to more efficient recycling of nutrients (manure co-fermentation, ash recycling, etc). Removal of nutrients may be desired (verge grass, crop residues)	Long distance transport of large volumes of biomass may lead to nutrient imbalances in the world. Solutions lie in use of low nutrient half-products (pyrolysis oil, HTU, Et-OH, etc)	In NL importing nutrients is a problem. There are concerns over problems in Third world.	In short term synergies can be found. In longer term problem has to be dealt with
Erosion	Many biomass cropping systems can contribute to decrease in erosion (compared to current uses). Conversion of annual crops to perennial crops	If marginal lands are taken into production annual cropping can lead to erosion. (connected to biodiversity and economic and social sustainability.	In NL less of an concern. In USA and other countries it may be a co-driver for energy crops development.	Has to be dealt with. EU Biofuels directive mentions it as a potential bottleneck
Emissions to the air	Utilisation of biofuels (ethanol, biodiesel) can reduce emissions of nitrate, soot, etc)	Many bioenery forms contribute to emissions.	In NL it is a concern. In USA it is often a co-diver.	Yes. In NL one of the main problems.Many problems can be solved. Biodiesel will not be able to fulfil future emission standards in EU.

Table 2: Economic (Profit) factors and criteria that play a role in the discussion about biomass en bioenergy.

Factor or criteria	**Positive aspects/ explanation**	**Concerns**	**Country specific?**	**Is it a bottleneck?**
Competition for fibre (paper industries, wood products, etc)	Paper industries can also benefit because of new outlet for energy products (Electricity, ethanol, etc)	Energy uses should not compete for Recycled paper. Competition for wood	In NL it is an issue	Should be looked at
Competition for land (food production)				Yes, should be in longer term
Competition for water				Yes, in longer run.
Cost effectiveness	Many wastes and by-products will have a value as fuel.	Biomass is (generally) an expensive energy source	All	Yes
Business risks		Prevent diseases and plagues. Is issue in crop production, monocultures, importing biomass. Other examples: Self heating in biomass	All	Less. Not in long term
		GMO discussie	EU	In the long term
Waste	Waste utilisation	Waste production	Is a factor in NL more than in USA	Yes,
Security of supply	Biomass is often produced locally and sources of biomass are more diverse	Importing biomass may reduce political support and introduce uncertainties	In USA security of supply is main driver for biomass. IN EU it is important driver in NL discussion is limited (mainly Ministry of Economic affairs and industry concern is seems)	In shorter term it is an issue. Importing biomass from outside EU is political issue. There is pressure to come to WTO or bilateral agreements

Table 3: Social (People) factors and criteria that play a role in the discussion about biomass and bioenergy

Factor or criteria	Positive aspects/ explanation	Concerns	Country specific?	Is it a bottleneck?
Competition with food production	There are many possibilities to find synergy with food production. Biomass demand stimulates sustainable food chains in the shorter to medium term	Ethanol en biodiesel demand can compete with food demand. Especially in the third world this appears to be a concern.	In NL and EU this is a discussion especially in relation to third world.	Could be. Should be dealt with
Employment	Biomass production and conversion can create jobs. See Biodiesel claims in Germany. Job creation is sometimes a “co-driver”	Biomass production and conversion to energy does not require much employment per GJ or ha.	In EU, USA less in NL	It should not be bottleneck but is always a factor. Especially mentioned in EU and USA, less in NL.
	Indirect spin-offs in other areas like tourism (biomass production) or in sustainable chemistry that can also make use of biomass feedstock or “ intermediates” (sugars, ethanol, pyrolysis oil, etc)		It appears a factor in all countries	Can be a powerful “co-driver
Creation of prosperity in the third world and Eastern Europe.	Can contribute to prosperity.	It can compete for resources in these areas and lead to unwanted effect (see Green revolution)	No	Needs to be addressed. Can be co-driver

Annex 1
Sustainability checklist developed by WUR-LEI which can be helpful to assess the sustainability of raw materials in the agricultural sector, subdived into the three P's (Meeusen, M., 2003).

Planet	
Transport	Beperking goederentransport
Energie	Energiebesparing
	Zelf-opgewekte energie
	Duurzame energie
Lucht	Luchtkwaliteit
	Reductie stankoverlast
Bodem	Reductie grondgebruik
	Bodemkwaliteit
	Reductie bodemerosie
Water	Besparing waterverbruik
	Kwaliteit oppervlaktewater
	Kwaliteit grondwater
	Grondwaterstand
Afval	Afvalpreventie
	Afvalverwerking
	Hergebruik van afval en materialen
Materialen	Gebruik van hernieuwbare grondstoffen
	Reductie gebruik hulpstoffen
	Reductie gebruik materieel
Fauna	Biodiversiteit
Flora	Biodiversiteit
	Aanplanting
Milieubewustzijn	Bevorderen milieubewustzijn
	Milieumanagement
People	
Arbeidsomstandigheden	Werkplek
	Welzijn van werknemers
Dierenwelzijn	Diergezondheid
	Natuurlijk gedrag
	Vrijheid van pijn, honger, dorst en stress
Voedselveiligheid	
Transparantie	Normstelling
	Controle en certificering
	Etikettering en voorzien van keurmerken
Normen en waarden	Emancipatie
	Respecteren van mensenrechten
	Voorkomen van dwang- en kinderarbeid
	Verdeling van welvaart
Locale omgeving	Landschap
	Natuur
	Historische gebouwen
	Recreatie
Maatschappelijke verantwoordelijkheid	Welzijn
	Maatschappelijke gevoeligheid
	Sociale cohesie

Profit	
Aanpassingsvermogen aan de markt	Productkwaliteit
	Innovativiteit
	Responsiviteit
Ketendoelmatigheid	Ketenafstemming
Kosten en efficiëntie	Prijs-kwaliteitverhouding
Strategisch potentieel	Concurrentiepositie
	Flexibiliteit
	Absorptievermogen
Ethiek in business-to-business-context	Bevordering marktwerking
	Rechtvaardige verdeling van lasten en baten over zakelijke partners
	Normstelling
	Zelf naleven van neven- en bovenwettelijke regels, codes, normen en afspraken
	Aanzetten van zakelijke partners tot naleving van neven- en bovenwettelijke regels, codes, normen en afspraken
	Controle en certificering
Werkgelegenheid	Kwantiteit van werkgelegenheid
	Kwaliteit van werkgelegenheid
Arbeidsproductiviteit	

Annex 2
Chapter form the GAVE rapport: Den Uil et al., 2003. Conventional bio-transportation fuels. An Update. ECN, ATO.

Socio-economic factors
In the Netherlands mitigation of the greenhouse effect through a reduction of greenhouse gas emissions is the main motive for the use of biomass to displace fossil fuels. It is absolutely clear that the highest effect on reducing the greenhouse effect is reached through displacing coal for electricity production. Hence the question is why are bio-transportation fuels promoted if they are considered to have a lower effect on greenhouse effect mitigation? Clearly other environmental and socio-economic factors that are important play a role here.

In a recent report (IEA, 2002) three phases in are distinguished in the development of alternative fuels:

- Phase 1 = Experiments and small scale tests
- Phase 2 = Pilot projects and demonstration
- Phase 3 = Commercial activity

Many countries are in phase 3. For example Brazil and the USA with ethanol and Germany with bio-diesel. In the Netherlands some projects pilot projects and demonstrations have been implemented particularly with bio-diesel (Bio-diesel powered boats in canals in Amsterdam and some activities in Friesland, recent introduction in Venlo). These developments are based on support for a limited period and will die out if support and a structure for a longer period is not available.

The question would be how could development to phase 3, commercial activity be implemented in the Netherlands both for bio-diesel and for ethanol?

It will be necessary to have political support based on a mix of benefits (environmental, economic, and agricultural) and supported by a coalition of groups.

The motives that have been put forward to utilise bio-transportation fuels vary over time and between countries. In Table 1 a list of the most important motives has been compiled that have been used as arguments to implement bio-transportation fuels worldwide. Which mix of motives will lead to successful implementation of bio-transportation fuels? The motives deemed most relevant to the Netherlands are in italics.

An analysis of important factors that determine success of implementation of bio-transport fuel projects in the EU and USA was made in a recent report (IEA, 2002). Some of the most relevant conclusions are:

- In all countries where alternative fuels have been implemented to the commercial phase Agriculture has been one of the stakeholders. Politically, the potential effects of alternative fuels on agriculture and regional development have played an important role.
- Because alternative fuels are more expensive than fossil fuels (gasoline, diesel) support to cover the difference is costs is imperative. No implementation has occurred without this support and in cases where it has been removed, implementation has halted.
- Successful implementation of alternative fuels has incorporated the oil companies (distributors, blenders) in all cases.
- Commercial actors require definite rules, preferably aver a long time, such as legislation on fuels and magnitude of financial support.
- Countries in the phase of experiment, pilot projects and demonstration should benefit from the experiences in other countries already in commercial phase.

The Netherlands
Agricultural pressure to introduce bio-fuels has been limited over the last decade in the Netherlands mainly due to the small area of set aside land approximately (10.000 ha) and the focus on other issues.

Since 1998 a some factors that are important for introduction of bio-transportation fuels have changed in the Netherlands:

- Animal diseases (Foot and Mouth Disease, BSE, Swine pest), feed contamination (, increased environmental restrictions (Nitrate, smell, etc) and popular pressures have led to political decisions to limit the use of many by-products in animal feed and to reduce the total number in farm animals over the coming decades (VROM 2001). This has led to a decreased demand for by-products, used as fodder, from the large Dutch agri-processing industry (potato peels, molasses, seed crushing industry, etc). An interest for alternative uses both for oil and fat and for sugar and starch containing by-products has arisen (Elbersen et al., 2002; Rabobank, 2001). The availability of these by-products will depend on alternative uses and on the price that can be paid when it is used as a bio-fuel feedstock.
- A EU directive has been put forward to replace an increasing amount of renewable transportation fuels. Starting with 2% in 2005 and increasing to 5.75% in 2010 (CEC, 2002).

Decisions have not been made on the EU directive but it is clear that bio-transportation fuels will have to be introduced in the Netherlands in the short term. The question is not if but how and when exactly bio-transportation fuels utilisation will have to be implemented. It seems likely that utilisation of by-products and taking maximum advantage of the environmental effects that bio-transportation fuels offer could create the broadest support for a commercial introduction of biofuels.

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Annex 3
Overview of motives arising from concern about the environment, economy and agriculture that contribute to implementation of the use of bio-transportation fuels by different countries, entities or organisations. The most relevant motives for the Netherlands are in italics.

General motive	Specific	Country	Reference
Environmental			
Reduction in greenhouse gas emissions. Kyoto protocol	Discussion about the impact continues	EU, Japan	CEU, 2002.
Reduction in air, water and soil, pollution.	Lower CO, hydrocarbons, particulates, air toxics, mutagenicity. Higher Nox	USA, China, EU,	Enguidanos et al., 2002. CEU, 2002.
The reduced pollution leads to specific implementation in areas where the impact is largest (example; captive fleets).	Biodiesel for: diesel powered boats (canals, recreation); Inner-city busses,	USA, EU,	EPA, 2002.
	Ethanol for: smog reduction (in winter),	USA,	
Economic			
Depletion of fossil fuels		USA, EU,	
Reduce dependency on foreign oil		USA, EU, (NL Min of Economic affairs, less with other entities)	EOS presentations 2002, CEU, 2002
Cost		Brazil	
Trade balance		Asia, USA	CEU, 2002
Getting experience – broadening the way for new developments			GAVE,
Agriculture			
Alternative utilisation options for organic by-products	Recent	NL, UK, USA,	Elbersen et al., 2002. Rabobank, 2001. CEU, 2002.
Utilisation of set-aside land		EU, USA	CEU, 2002
Rural income		EU, USA, not NL	CEU, 2002
Stabilisation of farmer income (sugar)	Examples are ethanol production from sugarbeets or wine if prices are low. This will result in stable prices and income	EU, France	
Promote more market oriented CAP (Common Agricultural Policy)	Multifunctional agriculture, new agro-products, sustainable rural development		CEU, 2002

4

HOW MUCH BIOMASS CAN BE REMOVED FROM A SYSTEM WITHOUT NEGATIVE EFFECTS ON SOIL FERTILITY?

Definition of the problem
Crop residues usually are left on the fields or put back to contribute to the maintenance of soil fertility (C, N, K, P, etc). In case all biomass is going to be harvested the nutrient cycle is no longer in balance and deminishing of soil fertility may occur.

Questions
1. How much biomass can be removed from a system without negative effects on soil fertility?
2. Discuss the factors that determine these effects on soil fertility, with special emphasis on straw in Poland.
3. Discuss the effect on farm management and agri-economy.

Jan Verhagen and Wolter Elbersen May, 2004. Report on BUS ticket no. 30, WUR-PRI and WUR-A&F

1. Rationale and question

The main driver for sustainable energy production is solving environmental problems of which climate change is the most important. Sustainable energy options being developed should therefore be implemented in a way that does not compromise other environmental values like soil C-loss, nutrient loss, soil erosion, etc.
Large quantities of inexpensive agricultural by-products, such as straw, are available at relative low cost. Many of these by-products do have a value though in the current systems. How much straw can be removed without compromising sustainability and soil fertility? The benefits of removing or leaving behind crop residues like will have to weighed. A short list of the arguments is given below.
Benefits of leaving crop residues behind are:
- Less erosion
- Retention of soil moisture
- Recycling of nutrients
- Increase or maintenance of soil organic matter (if no-till methods are used)
- Reduction in diurnal temperature cycling

Benefits of removing (part of) the crop residues are:
- Less hampering of mechanical management
- Reduction of weeds and diseases
- Alleviation of low spring temperatures
- Less nutrient loss to the environment
- Additional revenues for agriculture

In this exercise we calculate the amount of straw that can sustainably be removed from fields in Poland.

2. Approach

This study is a quick scan on crop residue management in relation to soil fertility with a special focus on Poland. It draws on existing readily available material and expert knowledge. Data on crop production levels and area are derived from the FAO statistical database. Indices and parameters are derived from literature.

3. Agriculture in Poland

Polish agriculture is characterized by significant fragmentation; an average farm size is 8.44 ha of utilized agricultural area with about 50% of agricultural holding owners producing exclusively or mainly to satisfy their needs, in order to lower the costs of living of their families. Systematic changes in the ownership and area structure as well as those in land use are taking place, however at a slow pace. As compared to 1996, when the previous General Agricultural Census was conducted, in 2002 the total area of land utilized by agricultural holdings diminished from 20.8 million ha to 19.3 million ha, i.e. by 1.5 million ha (6.9%), including a decrease of the utilized agricultural area from 17.9 million ha to 16.9 million ha, i.e. by 1 million ha (5.5%). The number of agricultural holdings of the area over 1 ha fell by 91000 (4.4%) and at present it is 1956000.

A significant part of farms are involved in agricultural production applying traditional methods with a low usage of mineral fertilizer and plant protection chemicals as well as industrial feedstuffs to feed farm animals, in particular cattle. There are also commercially oriented farms, using modern methods of agricultural production capable of competing with EU agricultural holdings in terms of quality and productivity (Ministry ofAgriculture, 2003).

3.1 Cereal production in Poland

In Poland the follow cereal are grown barley, buckwheat, mixed grain, oats, rye triticale and wheat. FAO reports a total cereal production of 21.507.080 ton for the year 2003. This is equivalent to 18.281.018 ton dry matter (assuming moisture content of 0.15). Total area used for cereal production in that year was 7.806.920 hectare.
No specific information on soil tillage, fertilizer or farm management is readily available.

4. Soil organic matter

Soil quality, soil structure, soil fertility and the water holding capacity of the soil are some of the functions related to organic matter. Recently soil organic matter as carbon reservoir was added to the list. In this quick scan we will focus on the soil fertility aspects in relation to crop residue management which are positively correlated to the size of the soil organic matter pool.
The soil organic matter content is related to biophysical factors (e.g. soil texture, climate) and management practices (soil tillage, fertilizer, crop residue management) In agricultural systems the annual dynamic related to crop growth and harvest that determines the carbon dynamics. The soil organic matter pool is mainly supplied by remains of the crop in the field after harvest. Soil organic matter is lost via erosion and decomposition. Via the decomposition of soil organic matter nutrients, of which N is the most important, needed for crop growth are released. The rate of decomposition of the accumulated organic matter in the soil is determined by the type of organic material and the environmental conditions (notably water and temperature).
Increasing the soil carbon content can be done by increasing the carbon input, decreasing the output or a combination of the two. For North West Europe the decomposition rate is approximately 2%. The fraction of carbon in soil organic matter is 0.58.

4.1 Increasing the input to the soil

To increase the carbon input in agricultural soils there are two main sources: crop residues and organic fertilizer application.
Leaving behind cereal straw in the field is a simple option to increase inputs. In cereals, the straw that is usually harvested for several purposes may be left in the field to increase the amount of soil organic matter. The average effect on the amount of soil organic matter

depends on straw yields but also on the proportion of cereals in the crop rotation. In general the harvested product is removed for direct consumption or processing the remainder of the crop (roots, straw, etc.) can be left behind in the field. The Harvest Index is the fraction of the economic yield of the above ground biomass. A typical Harvest Index for wheat (wheat is used as a proxy for cereals) is 0.4 but may range from 0.35 – 0.45. 15 % of the total biomass in cereals is below ground (roots) and is directly added to soil organic matter pool.

The application of organic fertilizers (e.g. manure, slurry) aiming to supply nutrients to the crop also increases or maintains the soil organic matter content.
The simplified approached followed here assumes that a constant fraction of the added organic material (biomass, manure) that remains after a year and contributes to soil organic matter. This fraction is called the humification coefficient. A typical humification coefficient is 0.3 but may range from 0.1 to 0.9 depending on the physical and chemical composition of the organic material. In this study a humification coefficient of 0.3 is used for the root biomass and 0.5 for the straw. The carbon fraction in biomass is around 0.45

4.2 Decreasing the output from the soil

Soil tillage stimulates the decomposition of soil organic matter, mainly because of aeration of the soil. Reducing soil disturbance by shallow tillage or no tillage, therefore, decreases the decomposition rate of soil organic matter. Reduced tillage may lower the decomposition rate of soil organic matter by 25%.

5. Carbon balance and soil fertility

5.1 The input to the soil

The total production in 2003 was 21.507.080 ton grain on a total area of 7.806.920. With a moisture correction of 15% this is 18.281.018 ton grain which is about 2.340 kg per ha. These reported yields are very low and indicate a low input farming system.

Assuming a harvest index of 0.4 the grain production equals a total above ground biomass production of 5.850 kg per ha. 15% of the total biomass or 1030 kg is below ground and is directly added to soil organic matter pool. Straw production in 2003 was 3.510 kg per ha.

Given a fraction carbon in the biomass of 0.45 a total of 460 kg C is added to the soil organic matter pool via the root system. With a humification coefficient of 0.3 the roots contribute some 140 kg C per ha to the buildup of soil organic matter. Straw represents a carbon stock of 3.510 kg C per ha., via straw, with a humification coefficient of 0.5, 790 kg C per ha can be added to the soil organic matter pool.

5.2 The output from the soil

Via decomposition of organic matter nutrients are released, on average 2% of the soil organic matter decomposes. How much organic material should be added to compensate the loss depends on the amount present and lost and the amount taken up by the crop. A soil with 34.800 kg C per hectare (about equivalent with 2% organic matter over 25 cm soil depth and a bulk density of 1.200 kg per m3) about 700 kg C is lost via decomposition per year.

5.3 The balance

To compensate the 700 kg C lost from the soil organic matter pool per ha the roots already provide 140 ton C per ha to the soil organic matter pool. So some 560 kg C per ha should be compensated via the straw production. The pool available via straw is about 790 ton C per ha.

The soil contains 3.480 kg N (assuming a C/N ratio of 10) of which 2% or 70 kg is released via mineralization. Assuming a nutrient use efficiency rate of 0.5 (this may range from 0.2 to 0.5) some 35 kg N is taken up by the crop. Given that 60 kg grain is obtained per kg N, with 35 kg N a yield of about 2.100 kg grain per hectare is possible without fertilizer input. The average yield for cereals is about 2.340 kg grain per ha, which would indicate an N uptake of 39 kg N per ha. These differences are small compared to the ranges in the used parameters, so it seems indeed hardly any manure is used.

So we assume no organic fertilizer is used and the loss of soil organic matter is to be compensated via crop residues. The straw that can be removed from the field amounts to 230 kg C per ha which was available to contribute to the built-up of soil organic matter. This is equivalent to 470 kg C in the biomass or about 1.040 kg straw per ha.
For Poland this would mean a straw removal of 8,111,214 ton.

6. Logistics and economics

The main cost of removing straw will lie in baling and transport followed to a storage and transport to a conversion facility. The efficiency of such a system will depend on the density of biomass at the field level and at the regional level. This is illustrated by figure 1 which shows the how fuel use increases as the amount of removable biomass per ha decreases.

The cost per tonne of straw will include the cost of collection, storage and regional transport, compensation for extra fertilizer (N, P and K) and a profit for the farmer. Determining the total cost for Polish conditions is not possible here. An indication can be gotten from other cases like corn stover in the USA. Where the cost for delivery of have been estimated at 32$(US) per tonne delivered in a 80 km radius (Glassner and Hettenhaus 1999).

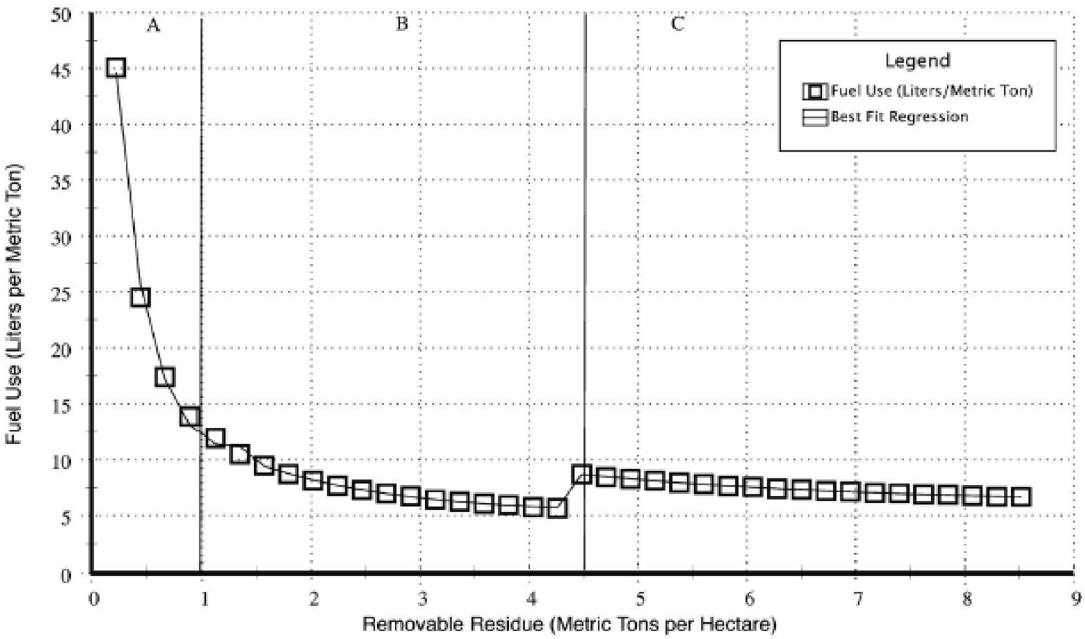
7. Results and discussion

This study is a quick scan which gives a first indication of what under current conditions in Polish agriculture can be removed. The parameters indicate an order of magnitude and direction of the amount of straw that can be removed. In the calculation we took the average of all cereals (except maize) grown in Poland. The range of production levels, fertilizer input and management will vary strongly between the different crops.

Crops are grown in rotation. In this study a single crop type was taken. The effect of soil type and management were not taken into account.

Adding fertilizer to the soil is a very common practice. Adding fertilizer will increase production levels and consequently allow more straw to be more removed, but also fraction of straw that can be removed will be higher simply because of the increase in root biomass.

Figure 1. Relation between straw residue per ha and the fuel use per tonne of residue (Glassner and Hettenhaus 1999)



Using organic manure will also directly contribute to build up of soil organic matter. A relative low input of 4 ton manure per ha with a C content of 5% and a humification coefficient of 0.5 already 100 kg C is added to the soil organic matter pool. Which in the presented example is equivalent to about 440 kg straw biomass per ha or 3,435,045 ton straw for Poland.

A tool that combines the knowledge about soil carbon loss and uptake mechanisms with spatial information on soil characteristics and farming systems should make it possible to evaluate the amount of biomass that can be removed from agricultural systems in a sustainable way in Europe. This would greatly help scenario forecasting and design of sustainable biomass delivery chains in Europe.

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5

SUSTAINABLE IMPORTS OF BIOMASS FROM LARGE SCALE TREE PLANTATIONS IN BRAZIL

Definition of the problem
The large scale production of biomass in fast growing, short rotation tree plantations, e.g. in Brazil, is considered an option to meet the ambitious targets of the Dutch renewable energy policy. The production and trade in biomass will have to be in line with social, economic and environmental criteria of sustainable development, which should be worked out and tested in close cooperation with local stakeholders.

Questions
1. For which countries such certification systems can be worked out (e.g. Brazil)
2. How can the participation of local stakeholders be organized to prevent unwanted competition with other forms of land-use?
3. What will be socio-economic and environmental impacts of large scale biomass plantations?

Leen Kuiper, August 2004. Report on BUS ticket no. 23, Probos

Summary
The large scale production of biomass in fast growing, short rotation tree plantations, e.g. in Brazil, is considered an option to meet the ambitious targets of the Dutch policy on bio-energy and of the gradual transition towards a more bio-based economy. To release the pressure on existing forests, which serve multiple functions, the only way to increase biomass production on the long-term is through the establishment of fast growing tree plantations. Inevitably, this could have a large impact on the natural resources in the exporting countries, the exact consequences of which need to be analyzed in close cooperation with the local population and other stakeholders. Most actors agree that the production and trade in biomass will have to be in line with social, economic and environmental criteria of sustainable development. Important lessons can be learned from the current opposition in Brazil against the expanding area of Eucalyptus plantations to provide wood for charcoal production and for the pulp- and paper industries and from the ongoing 'soybean debate' (Annex 1).

Benefits
Tree plantations offer numerous advantages when it comes to wood production. They are an efficient user of space and inputs in terms of the production of industrial wood per ha, offering easy harvest, allowing improved varieties, modern management practices, and shortened rotation periods, which make it a cheap production system (i.e. when not accounting for the loss of means of livelihood for local communities, in terms of conservation of flora and fauna, in terms of water resources and in terms of feeding local populations). Industrial plantations can produce a significantly larger volume of timber of more homogeneous quality, than natural tropical forests, but of course the quality of the wood is completely different. That is why natural forests continue to be exploited for a type of wood that is not available in plantations. Plantation timber is more adaptable to established industrial processes, particularly in the pulp and paper sector.[6] Aracruz Celulose in Brazil e.g records average growth rates of Eucalyptus plantations of 43m^3 per hectare per year on six-year rotations[7]. The importance of plantation timber to world markets is enhanced by the expected global shortage of industrial wood in the near future (which, by

[6] http://www.cifor.cgiar.org/publications/Html/AR-98/Plantation.html
[7] Christian Cossalter and Charlie Pye-Smith 2003. Fast wood forestry: myths and realities, Bogor, Indonesia

the way, is based on current over consumption patterns which hardly can be considered sustainable).

An indirect positive effect of tree plantations on biodiversity is the assumed reduction of the pressure on natural forests. However, in reality this is not true: in many cases natural forests have been cleared to give way to plantations – particularly in Brazil. No matter how many hectares are planted with trees forests continue to disappear because the main cause of forest destruction is not primarily wood exploitation but land clearance for export-oriented agriculture (e.g. soy beans for The Netherlands), cattle-raising and for dams and mining. The main land base for biomass plantations is primarily cleared and degraded forest lands, forest lands occupied by low-value commercial species or brush, marginal forest lands that have many physical limitations (e.g., poor soils, low rainfall, high elevations and steep slopes) and non-forest land, including extra-marginal cropland, savannah, and arid wastelands, which, by the way, can be of great value to local populations living in the area and for nature conservation. On the one hand, growing population pressure and increasing needs for food production makes it unlikely that biomass plantations will be grown on good cropland[8], but on the other hand plantation companies do not occupy lands with the type of physical limitations as described above: either the trees do not grow well in those environments (poor soil, low rainfall) and are prone to pests and diseases, or because they constitute a limitation to mechanisation (high elevations and steep slopes). Consequently, there are comparatively few cases where large-scale tree plantations have been established on degraded land[9].

Worldwide about 10 million ha can be classified as fast growing, short-rotation tree plantations for the production of biomass, supplying pulpwood to the pulp- and paper industries, charcoal for the steel industry and wood fibres to the panel and board industry. Annually, this area increases with 0.8 to 1.2 million hectares each year[10]. However, Ranney (1994) notes that less than half of this planted area could be considered successful or commercially viable[11]. In his opinion, successful biomass plantations are characterised by:

- more than 80% survival of planted materials;
- annual productivity greater than 10-12 dry tonnes/ha of harvested wood and bark;
- uniformity in diameter, height and straightness;
- less than $50/dry ton in delivered cost.

Eucalyptus plantations, totalling 3 million hectares at present, make up 40 percent of all tree plantations in Brazil. Eucalyptus for pulp is grown in Brazil in 5 to 7 years rotations. Annually the Brazilian forest industry is planting over 300 million trees for the pulp and paper industry only.

Negative impacts

An increasing demand for biomass from industrialized countries could lead to increased production levels and exports of raw materials in Brazil, in a market situation, which is characterized by very few - if any - regulations. In the worst case scenario (which, unfortunately, is basically the most common scenario), it would imply an unequal development scheme imposed on the local populations, which could enhance existing conflicts in land use, depriving rural populations of a sustainable means of livelihood and traditional sources of income, disrupting the local economy and changing the delicate power balance. Favoring export-oriented biomass production systems in the form of large

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[8] Couto, L and. Betters, D.R. 1996 Short-rotation eucalypt plantations in Brazil: social and environmental issues

[9] http://www.sinkswatch.org/plants.html

[10] Christian Cossalter and Charlie Pye-Smith 2003. Fast wood forestry: myths and realities, Bogor, Indonesia

[11] Ranney, J. W. 1994. "Short-rotation Wood Energy Crop Improvement and Commercialization in Tropical and Temperate Zones," presented at meeting on *The Potential of Biomass Products, Energy Utilization Forum,* June 10-12, Taipei, Taiwan.

scale, short rotation tree plantations (dedicated woody energy crops), by substituting areas previously used for agriculture, could have a negative impact on the availability of water, soil and the biodiversity of local ecosystems (flora and fauna). The most frequently cited negative environmental impacts are:

- reduced soil fertility
- increased erosion and compaction of the soil
- loss of natural biodiversity
- reduced groundwater reserves and stream-flow
- increase in fires and fire risks

Many environmental groups are concerned too about the use of fertilizers, chemical weed control and pesticides, applied to guarantee the productivity of monoculture tree plantations, causing e.g. contamination of water sources. The fast growth rate of Eucalyptus species tends to impose a high overall demand on water resources. Short rotation plantations of Eucalyptus, therefore, must carefully match water demand to availability, in order to avoid irreversible degradation of the sites. One of the most serious disadvantages of monoculture tree plantations is the danger of pest and insect attacks, as well as their susceptibility to fire. To some degree, pests and diseases can be controlled through proper planning and management: creating enough diversity is normally the best way to minimize this threat, but these measures are no remedy for the other social and environmental impacts.

Tree plantations usually create less jobs than the agricultural activities which they substitute. From a social point of view, in some countries large-scale industrial tree crops have already resulted in fierce opposition at the local level, mostly arising from pre-existing conflicts over land tenure. Besides, tree plantations may discourage more environmentally and socially acceptable forms of land use such as community based (agro) forestry.

Opposition by local populations

Local populations are at the forefront of most struggles against plantations, whereas NGO's play an important role in disseminating information and providing analyses for local populations. The Third World Network is campaigning against industrial tree crops in all cases where they are considered to be incompatible with improving the quality of life of local populations. Another example is the World Rainforest Movement, which in 2003 has issued a book on "Certifying the uncertifiable"[12]. The Brazil case study in this book stresses the concern of many NGO's about FSC-certification of large-scale tree plantations in Brazil. The Montevideo Declaration of June 1998 was a call for action to defend forests and people against large-scale tree monocultures, expressing the concern at the recent and accelerating invasion of millions of hectares of land and forests by industrial tree plantations. There are hundreds of NGO's who are actively opposing this plantation model. These environmental groups are now exerting considerable political pressure to make the establishment of Eucalypt plantations in Brazil unfavourable: a good example is the Alert Against the Green Desert Network, which was established 5 years ago, coordinating local communities and aid organisations in their struggle against the expansion of Eucalyptus plantations.[13] An example in South Africa is the Timberwatch Coalition, which has for years been involved in an anti-plantation movement in that country. The Latin America Network against Tree Monocultures, with focal points in all the countries in the region, was created in 2003 at the World Social Forum[14]. Other international actors actively opposing tree plantations are Friends of the Earth International, the Global Forest Coalition and Terra (in the Mekong delta).

[12] http://www.wrm.org.uy/actors/FSC/uncertifiable.html
[13] Overbeek, W. 2004. Brazil: more pulp for export means more exclusion. WRM Bulletin 83, June 2004
[14] www.wrm.org.uy/actores/FSM/Quito.html

Site selection for short rotation energy crops

One of the first challenges for any commercial activity requiring short-rotation energy plantations is to determine where suitable and available lands are located. A favourable site may allow a project to survive initial mistakes or miscalculations, while an unfavourable site requires great technical expertise, and even simple errors can result in major setbacks or failure. Unfavourable, low productivity sites usually lead to increasing expenses for road and harvesting infrastructure, increasing transport distances, less efficient harvesting, and greater potential impacts on the environment, society, and biodiversity.

Site selection and planning at the national, regional, and local level requires geographically located information on soils and geology, natural vegetation, current land uses, topography, watershed boundaries, stream/river systems, roads, local political jurisdictions, land ownership and tenure information, location of cultural and historical resources, location of nature preserves and rare habitats and species. It is also very valuable to have site-specific research data on the yields that can be expected from the preferred species. Inadequate site preparation is the most common mistake made by companies and researchers initiating a new short-rotation tree crop project.

Key to producing low-cost biomass form energy plantations is the land base and the quality of sites, which determine to a significant extent the degree of site preparation necessary; the choice of species, spacings and cutting cycles; required cultural management and soil amendments (fertilization, weed control, animal control, and pest management); and fuel transport and logistics.

Economic studies have showed that the use of good cropland for energy plantations is more cost-effective than using marginal cropland or poorly stocked forest land. The additional cost of the land will be offset by lower establishment costs and, more importantly, higher biomass productivity. This is clearly the decision that investors would make, but it would be the worst decision from a social and environmental perspective[15].

The costs of plantation establishment in Northeast Brazil ranged some ten years ago from about \$580 to \$1170/hectare with maintenance costs varying from about \$140 to \$860/hectare over a seven-year rotation. [16] Much of the variation in establishment costs is due to planting costs. Carpentieri et al. (1993) cite planting costs ranging from \$371 to \$811/hectare for Northeast Brazil[17]. Localized variation in delivered feedstock costs can be illustrated by the data from Northeast Brazil, where average wood costs range from a low of about \$1.00/GJ to \$4.60/GJ, based on the use of high and low estimates for land, planting costs, and productivity differences, which in reality ranged between 3 and 21 dry tonnes/ha.(Carpentieri et al. 1993). The wood supply situation in north-eastern region of Brazil, has a potential of transforming 197 million stères of roundwood each year into 19 thousand megawatts of energy per year, which is a tremendous potential[18].

The increasing price of the land and some new restrictions on plantations in south-eastern Brazil stimulated forest companies to begin local tree farmer programs to reinforce wood supplies. These programs, however, were not readily accepted by local farmers. Today, most of the forest companies in Brazil are adopting agro forestry as an alternative land use, mainly for their tree farmer programs. Agro forestry is likely to become a key point of plantation programs oriented toward the small farm operation.

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[15] Personal communication from Ricardo Carrere, coordinator of the World Rainforest Movement

[16] Couto. L., et al. 1993. "Agroforestry as an alternative to reduce establishment costs of short-rotation eucalyp plantations in southeastern Brazil," in *Opportunities for Agroforestry in the Temperate Zone Worldwide*, proceedings of Third North American Agroforestry Conference, August 15-18, , Iowa State University, Ames.

[17] Carpentieri, A. E., E. D. Larson, and J. Woods, 1993. "Future Biomass-Based Electricity Supply in Northeast Brazil," Biomass and Bioenergy, 4:149-174.

[18] Couto, L and. Betters, D.R. 1996 Short-rotation eucalypt plantations in Brazil: social and environmental issues**.**

Transports
Long distance transports of large amounts of woody biomass produced for export purposes to Europe, will place a major stress on Brazil's transportation system. However, it is certainly possible and very similar to other export commodities such as soy beans (see annex). A recent PhD study from the University of Utrecht indicates that imports of biomass from South-America to The Netherlands is economically more viable than importing it from other countries in Europe, in spite of the considerable transport distances (and without accounting for the externalities): on average the total production and transportation costs amounted to 40 euro per dry ton from Brazil against 70 euro per dry ton from Europe[19]. Alternatively, the biomass could be converted into energy carries with a higher energy content, such as ethanol, methanol, hydrogen or Fischer-Tropsch diesel, prior to their shipment to Europe. This would further reduce transportation costs.

Conclusion
When planning to establish large areas of fast growing, short rotation tree plantations in Brazil for the production of biomass for export purposes, significant problems are likely to occur. The fact is, that each year the area of fast-growing tree plantations in the world expands by around one million hectares, whether we like it or not. It cannot be denied that the planting of large areas of eucalypts, acacias, pines and poplars has sparked off a lot of controversy. Some claim plantations have already destroyed the environment and displaced small farmers. Others say they will help protect natural forests and provide economic growth. No matter how good or how bad these plantations are going to be managed, even in a sustainable way, the controversy will remain. Given this delicate and complex problem which has not only a technical, economical and environmental aspects to it, but also an ethical, political and social dimension, the question is valid: would <u>you</u> like to become involved in large scale tree planting programmes in Brazil? It certainly is not easy to answer this question with a straight 'yes'or 'no'.

We hope that this 'quick scan' has presented some of the pro's and con's of the ongoing debate on fast-growing tree plantations. Focussing on a particular area in Brazil (case study) would be helpful to put the plantation issue into a practical and realistic perspective, allowing e.g the feed back of local governments and NGO's.

Follow-up?
1. Make a list of challenging statements on plantation forestry; ask for feedback from the BUS
2. Present these statements to a selected number of NGO's and invite them to react
3. Formulate a draft vision on tree plantations for the sustainable production of biomass for the export and discuss it with in a broader platform, e,g participants of the Transition on Biomass

[19] Carlo Hamelinck. 2004. PhD thesis, University of Utrecht, The Netherlands

Reaction from the World Rainforest Movement

Dear Leen,

Thank you for requesting our input regarding your quick scan on tree plantations for biomass.
Let me raise a crucial question first: has the Dutch government analysed all the possibilities for reducing energy consumption, improving energy efficiency and developing alternative energy sources in The Netherlands itself, or is it simply trying to access cheap energy (externalizing costs to other countries) while portraying itself as environmentally-friendly (using biomass instead of fossil fuels)?
From your draft it becomes apparent that the real motivation for this idea is simply economic: accessing vast amounts of cheap and homogeneous raw material. This is exactly the same motivation of the pulp industry's plantations in developing countries and – if implemented - would exacerbate the current struggles against plantations in Brazil, or in any other country.
The idea is simplistic and looks at only one issue – the substitution of fossil fuels by biomass - while ignoring all the social and environmental problems it would generate if implemented at the necessary scale to meet an important part of the energy currently being used in The Netherlands. It would imply the appropriation of large areas of land in a country like Brazil, which already has acute land tenure problems and where both landless peasants and indigenous peoples are claiming for lands. For such a scheme to be successful (from an economic perspective), those plantations would need to be established near the coastal areas (because the wood or the transformed energy would be aimed at export and transport costs would need to be kept low). These are precisely the areas which are being claimed by large numbers of landless people. Additionally, those plantations would generate less jobs than any other possible uses of the land – as already proven in existing pulpwood plantations- and would therefore result in the further expulsion of rural populations.
From an environmental perspective, large-scale tree monocultures have already proven to be – in Brazil and in every single country where they have been implemented - detrimental to local biodiversity and have depleted water resources. Would this be considered as "environmentally-friendly"?
From all the accumulated experience regarding large-scale, fast-growth tree plantations, the only possible suggestion on this plan to produce biomass abroad based on this type of plantations is that it should *never* be implemented.
It is, therefore, fair to raise the question: Why is the Dutch government not planning to cover degraded land in the Netherlands with fast-growing tree plantations to provide biomass? I'm sure we could find a couple of experts from Brazil who would find that around 75% of the countryside in the Netherlands is, in fact, degraded and therefore more suitably used for fast-growing tree plantations (the logs could perhaps be shipped to Brazil to feed Brazil's pulp mills). This would of course sound ludicrous to most Dutch people … and the same can be said about how your idea can sound to Brazilian people.

Ricardo Carrere, coordinator World Rainforest Movement
Date: August 18, 2004

Annex 1
The soybean debate

When considering the potential development of large areas of energy crops supplying the export market, there are lessons to be learned from the development of soybean production in Brazil over the past decades. Apart from technical barriers related e.g. to production and transportation, Brazilian soybean production is facing increasing opposition from NGO's, who question the large scale land clearing and its negative socio-economic and environmental impacts for the local populations[20]. The same problems may be expected when trying to establish hundreds of thousands of hectares of fast growing, short rotation tree plantations for biomass production[21].

Brazilian's soybean production potential
In the seventies major soy importers - Japan and Europe - began seeking alternative sources of animal feed protein. Attempting to encourage the growth of soybeans in Brazil, Japanese investors bought land in Brazil for soybean production. Since then, soybean production has increased from 5 million metric tons in 1973 to about 38 million metric tons in 2001 (table 1). Today, Brazil is the world's second largest soybean exporting country. In 2004 the Brazilian soybean production exceeded 60 million tons, which may very well double in little more than 10 years time, just as it did in the past 3 years.

Table 1: Top Producers of Soybeans in 2001 (million metric tons)

USA	Brazil	Argentina	China	India	Canada
79	38	26	15	6	3

Soybean production in 1970 was predominantly in the southern states of São Paulo, Paraná, Santa Catarina and Rio Grande Do Sul. Increases in soybean areas in these states has come at the expense of rice, peanuts, potatoes, corn, cotton, coffee, and grazing land. The most spectacular growth in Brazilian soybean areas has occurred in the state of Mato Grosso and the cerrado area of central Brazil.[22] The Brazilian cerrados are responsible for half of the current production, making a whole region dependent on a single crop.
The cerrado area often is defined as a wasteland with stunted twisted trees. The cerrados are not rainforests. The soils of the cerrado are highly acidic, saturated with aluminium, deficient in phosphorous and have low water-holding capacity. However, the soils in the cerrados proved to be deep and well drained with excellent physical characteristics suitable for mechanized crop production.

About 46 percent of the cerrados (234 million acres) are suitable for large-scale crop production.
The rapid growth in soybean production in the cerrados has been made possible by modern mechanical, chemical and biological technologies. The mechanical technologies allow relatively inexpensive clearing of virgin cerrado land for crop production and for low-cost soybean planting, cultivation, harvesting, and drying. On average, virgin cerrado land can be put into production for about U.S $620,- per hectare. Fertilisation has corrected the low fertility, high acid soils through the application of limestone, phosphate fertilizers and trace minerals. However, correcting these soil deficiencies is relatively expensive.

Transportation problems
While Brazil has a large advantage in soybean production over the US, its transportation costs will likely remain much higher than U.S. transportation costs. Brazil's distribution

[20] Seminar on Sustainable Production of Soy: a View on the Future Industry - NGO dialogue on soy production initiated http://www.aidenvironment.nl/?uodPage=newsitem&uodNewsitem_Id=news_7
[21] http://www.wwf.ch/default.cfm?contentstring=4111&spr=de
http://www.omroep.nl/rvu/sites/nep/2003/groenegoud.html
[22] http://www.extension.iastate.edu/agdm/articles/others/McVOct00.html

system is antiquated by U.S. standards: about 80 percent of Brazil's soybeans are trucked to market. Trucking distances can range up to 800 miles to the market. The quality of most roads is poor and a substantial portion of the nation's highways are dirt surfaced. Brazilian railroads too are in poor physical condition after years of neglect under government ownership. Even though it is modernizing, Brazil's railroad system is likely to remain a limited capacity, high cost mode of transport for years to come. The development of the three navigable rivers (the Rio Madeira, the Hidrovia Paraguay – Parana, and the Hidrovia Araguaia – Tocantins) may solve many of the transportation problems facing Brazil's soybean industry.[23]

The Rio Madeira offers the best hope for improving grain transportation in Brazil, because it is a free-flowing navigable river that is already in full operation. Nine-barge tows move up and down the Rio Madeira, each barge carrying 2,000 tons. A modern barge loading facility is located at Porto Velho and a small, but modern barge-to-ocean vessel transfer facility is located at Itacoatiara on the Amazon River. The Madeira waterway has a capacity to move between 2 and 3 million tons annually without investments in the river. Thus, the Rio Madeira has opened the *New Frontier* in Mato Grosso to world soybean markets. Sapezal is the center of the new soybean producing area in Mato Grosso. Soybeans have to be transported to Itacoatiara on the Amazon River where the soybeans are loaded into ocean vessels. These vessels must travel up to 1,000 miles to reach the Atlantic Ocean. Almost all of Brazil's soybean exports go to Western Europe.

Increased soybean supplies will place a major stress on Brazil's distribution system, but despite these transportation problems, Brazil's land clearing and soybean production will likely continue at a high rate and Brazil's soybean exports will continue to grow.

Viewpoint of NGO's

The Dutch NGO's Both Ends and Aid Environment have done a lot of work on assessing the pro's and con's of soybean production in Brazil. In this so called 'soybean debate', which has been going on over the last decade, numerous barriers have been identified, partner organisations have been consulted, discussions have been set up about trying to bridge the gap between the poor and the rich and to solve the controversy between the agricultural use of land and nature conservation. The increased competition for productive land is a very complex problem involving many stakeholders. Frequently, local farmers have lost their livelihood and employment because soy bean companies have bought the lands where they used to work and live. Many studies have recorded the social and environmental impacts of large scale soybean production schemes.

Conclusion

For dedicated energy crops, which are likely to be established on a large scale in Brazil to supply the export market for Europe, similar barriers and problems may be expected. It would be very unwise to neglect the ongoing discussions and campaigns against industrial monoculture crops, which involve intensive land clearing, preparation of the soil, fertilisation, chemical weeding, use of pesticides, mechanized harvesting and long distance transports. The more so, when they prove to be incompatible with improving the quality of life of local populations.

[23] http://www.extension.iastate.edu/agdm/articles/others/McVeyNov00.html

6

SALT WATER FORESTRY: CASE STUDY OF MANGROVES

Definition of the problem
One of the proposed Biomass Transition paths (i.e. Biosaline biomass) suggests to establish tree plantations on salt affected areas: this could be relevant for about 100 million ha.

Questions
1. Which tree species are salt tolerant? (literature review)
2. Which biomass production levels are to be expected in semi-arid zones, with and without irrigation?
3. Are there any experiments with dedicated short rotation coppice on salt affected soils?

Leen Kuiper, August 2004. Report on BUS ticket no. 24, Probos.

Salt tolerance

Halophytes are defined as salt tolerant plant species which can complete their life cycle and reproduce themselves under salt water conditions, characterized by an electrical conductivity of 8 dS/m or higher, which corresponds with a salt concentration of > 6000 ppm (parts per million). Seawater e.g has a salt concentration over 28,000 ppm and an electrical conductivity of > 40dS/m. Under saline conditions most halophytes show reduced growth compared to non-saline conditions. Therefore, salt tolerance often is defined as the salinity level at which a 50% growth reduction occurs. However, approximately 10% of all halophytes have the ability to grow on seawater, which makes them highly salt tolerant. A complicating factor is the variability of salt tolerance during the progressive stages of plant growth. During the germination phase salt tolerance usually is lower than during later stages of plant development.

Salinity problem

The area salt affected land amounts 955 million ha worldwide, which increases annually with 10 million ha. In semi-arid areas, at present about 30% of all irrigated land (i.e 100 million ha) suffers from salinisation, of which 30 million ha is severely affected. Apart from these cultivated lands, other dry land areas in the semi arid and arid Tropics frequently suffer from salinisation too. These include e.g. 2 million ha of the wheat belt in western Australia, which is seriously affected by salt (in combination with water logging); various inland salt deserts, usually with brackish ground water or surface supplies of salt water, or desserts which are being infiltrated with saline affluent water, and coastal deserts presently not used for agriculture or tree planting, but which are located within the reach of seawater for irrigation. A tentative estimation of the total area potentially available for biosaline agriculture and forestry[24] is 125 million ha worldwide[25]. Most of this area could potentially be used for the production of biomass, without competing with the production of food crops.[26]

Various halophitic trees and shrubs (Acacia sp, Atriplex sp., Casuarina sp., Prosopis sp., Eucalyptus sp. Populus sp. Sarcocornia sp., Tamarix sp.[27]) can e.g. be used as fodder and

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[24] The term "biosaline agriculture and forestry" refers to the dedicated cultivation of salt tolerant plant species with the help of salt or brackish water on saline soils, unsuitable for conventional crops. See e.g. http://www.oceandesertenterprises.com/
[25] University of Arizona 1991. Seaweed and halophytes to remove carbon from the atmosphere, Electric Power Research Institute, Report EPRI ER/EN-7177
[26] NRLO 2000. Bio-productie en ecosysteemontwikkeling in zoute condities. Rapport 2000-11, NRLO
[27] Trees and shrubs for salt land in western Australia: http://agspsrv34.agric.wa.gov.au/progserv/natural/trees/uses/SALTAPP.HTM#extsal

thus may play a role in rangeland improvement, and provide a source of wood as well. These species can either be introduced (as exotics) or selected from natural ecosystems.

Mangroves represent vary valuable ecosystems rich in biodiversity, which are comprised of diverse, salt-tolerant tree and other plant species which thrive in inter-tidal zones of sheltered tropical shores and estuaries. Tens of millions of people around the tropics and sub-tropics depend on mangrove forests as a source of fuelwood, charcoal, timber, and other non-timber products. Mangrove trees have specially adapted aerial and salt-filtering roots and salt-excreting leaves that enable them to occupy the saline wetlands where other plant life cannot survive. Mangroves include approximately 75 different tree and shrub species. The natural environment of mangroves is characterised by the sea level and its fluctuations, air temperature, salinity, ocean currents, storms, shore slope, and soil substrate. Most mangroves live on muddy soils, but they also grow on sand, peat, and coral rock.

Distribution of mangroves

The majority of the subtropical and tropical coastline is dominated by mangroves, estimated to cover an area of 22 million hectares[28]. The FAO estimates are somewhat more conservative: a present (2003) some 15 million ha of mangroves exist worldwide[29]. About 55 percent of the world's population inhabits coastal areas and draws heavily on coastal and marine ecosystems for food, housing, industrialization, transportation, recreation, waste disposal and reclamation for other uses.

Consequently, mangrove deforestation is continuing, albeit at a slightly lower rate than in the 1980's. This reflects the large-scale conversion of mangroves for aquaculture and tourist infrastructures. The FAO is preparing a second edition of the world atlas of mangroves[30].

Biology of salt tolerance

The roots of mangroves contain many small "breathing" pores, called "lenticels." These allow oxygen to diffuse into the plant, and down to the underground roots by means of air space tissue in the cortex, called "aerenchyma." The lenticels are inactive during high tide. Lenticels in the exposed portions of mangrove roots are highly susceptible to clogging by crude oil and other pollutants, attacks by parasites, and prolonged flooding from artificial dikes or causeways. Over time, environmental stress can kill large numbers of mangrove trees. In addition, the charcoal and timber industries have also severely impacted mangrove forests, as well as tourism and other coastal developments. The rapidly expanding shrimp aquaculture industry poses the most serious threat to the world's remaining mangroves. Literally thousands of hectares of lush mangrove forests have been cleared to make room for the artificial shrimp ponds of this industry. Globally, as much as 50% percent of mangrove destruction in recent years has been due to clear cutting for shrimp farms.
Certain species of mangroves exclude salt from their systems, others actually excrete the salt they take in via their leaves, roots, or branches. In salt excluding mangrove species, the mangrove root system is so effective in filtering out salt that a thirsty traveler could drink fresh water from a cut root, though the tree itself stands in saline soil.[31] Saltwater is not necessary for the survival of any mangrove species, but it does give mangroves a competitive advantage over other plants that do not tolerate salt (Mitsch and Gosselink, 1993). The mangrove vegetation uses three different mechanisms which cope with excess salt.

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[28] http://www.earthisland.org/map/mngec.htm

[29] State of the worlds forests 2003 ftp://ftp.fao.org/docrep/fao/005/y7581e/y7581e01.pdf

[30] ttp://www.fao.org/forestry/foris/webview/wmatlas/index.jsp?siteId=5321&sitetreeId=20068&langId=1&geoId=0

[31] Lugo, Ariel E., and S. C. Snedaker,1974 "The ecology of mangroves", Annual Review of Ecology and Systematics 5:39-64

(1) The roots of salt-excluding species of *Ceriops*, *Excoecaria* and *Rhizophora* can absorb freshwater from the saline water through a process of ultrafiltration (Scholander, 1968).
(2) Species of *Avicennia* and *Sonneratia* can regulate the salt content of their tissues by glands in their leaves.
(3) *Xylocarpus* sp., *Lumnitzera* sp. and *Sonneratia* sp. deposit salt in older leaves, roots and bark (Josh), Jamale and Bhosal, 1975).

Mangroves grow faster in areas with plenty of fresh water such as in riverines and estuaries. Generally, more species can be found in areas with low salinity or in the landward zone, than in areas with high salinity or the seaward zone[32]. Mangroves have been useful in treating effluent, as the plants may absorb excess nitrates and phosphates thereby preventing contamination of nearshore waters.

Certain mangrove species can propagate successfully in a marine environment through "viviparity," which is embryo germination, which begins on the tree itself, or through "propagules" which hang from the branches of mature trees. The tree later drops its developed embryos or propagules, which may take root in the soil beneath.

Mangrove nursery
A mangrove nursery is an area where seedlings of different mangrove species are grown until they are ready for planting in the field. The nursery should ideally be on dry land near a river for ease of transport and watering. What are the criteria for a good mangrove nursery?

- Brackish water supply
- Accessibility
- Central location
- Open area with adequate sunlight
- Drainage
- Low risk of flooding by tide
- Slightly sloping terrain

Practical experiences with mangrove plantation management
In a recent World Bank experiment in Bangladesh[33], so far about 130,000 ha of mangrove plantations have been planted, which included commercially important mangrove species, *Sonneratia apetala, Avicennia officinalis, A. marina, A. alba, Amoora cucullata, Bruguiera sexangula, Excoecaria agallocha, Xylocarpus mekongensis, Heritiera fomes, Ceriops decandra* and *Nypa fruticans. Sonneratia apetala* proved itself to be the most successful one. Both *Sonneratia apetala* and *Avicennia officinalis* are pioneer species in the ecological succession in the natural mangroves of Bangladesh. They are strongly light demanding. Soil texture ranged from silty loam to silty clay loam. pH varied between 7.5 and 8.2. In most instances very limited (if any) site preparation is necessary, and propagules or pre-germinated seed and seedlings can be easily collected from nature and planted to achieve good results. In Bangladesh mature fruits collected directly from the trees are dumped in 0.6 to 1.3 m deep pits and are covered with thick brushwood and watered with saline water regularly for four to seven days. The fruits are then taken out, bruised lightly by hand and washed in river water to obtain white-coloured pre-germinated seeds, which are immediately broadcasted in seed beds or sown in plastic bags. Most mangrove species have an elaborate root system and root development is much faster than the shoot development; as a result, roots in plastic containers may develop into balls and, when the plant is transplanted, its growth may be hampered. Seedlings raised in soft nursery beds can be easily pulled out without any damage to the roots. The Bangladesh Forest Research

[32] http://www.pemsea.org/young%20environ/ye101/mangrove5.htm#12Can
[33] http://banglapedia.search.com.bd/HT/C_0298.htm

Institute (BFRI) has contributed significantly on the artificial regeneration of mangrove species and the establishment of man-made mangrove plantations.

Weeding usually is not required as the initial growth of seedlings is quite fast. However, depending on the abundance of weeds, one to three weedings are generally carried out every year during the first two to three years. In the earlier experiments, trees were spaced 2.4 m x 2.4 m. A greater proportion of plantations was raised at a spacing of 1.2 m x 1.2 m. Presently, a spacing of 1.5 m x 1.5 m is recommended for *Sonneratia apetala* and 1 m x 1 m for *Avicennia officinalis*. The growth of *Sonneratia apetala* varies greatly from place to place. Productivity tends to increase from east to west of the coastal belt. On a good site a stand may attain an average height of about 20 m with a diameter of 20 cm at breast height in 20 years. Productivity may be up to 10 m3/ha/year. A rotation age of 12-15 years has been found suitable.

It should be noted, however, that these growth rates found under more or less natural conditions, may be enhanced by a factor 3 to 4 by means of modern cultivation methods and the proper selection of fast growing cultivars. The traditional Dutch willow coppices ('grienden') e.g. used to produce about 3 oven dry tons/ha of biomass on average. By the use of modern cultivation techniques (including fertilisation) and the selection of fast growing willow varieties, dedicated energy coppices of willow now produce 10-12 odt/ha annually, which is a 4 fold increase in 20 years time. Similar improvements may be expected in biosaline forestry management.

Traditionally, mangroves produced fuelwood, charcoal and bark (for tannins). Mangrove wood was the main fuel in the Philippines until World War II (NAS, 1980a). A great advantage is the ease with which the wood is split. It makes an excellent charcoal, rather high in sulphur. In Bangkok, mangrove charcoal, which burns steadily, giving off intense heat without sparking, sells for twice the price of other charcoal (NAS, 1980a). With a calorific value higher than oak, it burns with even heat. [34]

Only in Asia, mangroves forests have been under management for a long time, sometimes over 100 years. Silvicultural systems have been developed based either on selection or clear-felling. Mangrove plantations were also established, either enrichment planting in areas under clear-felling management or as reforestation or afforestation[35], [36]. [37] In the Philipines, planted mangrove forests 40 years old are projected to yield 400 m^3/ha, an average of only 10 m/ha/yr. In Tamil Nadu, *Rhizophora mucronata* plantations for fuel are managed on 30-year rotations. The wood, which is quite durable except when exposed to ground, and difficult to saw, is used for construction, fish traps, house frames, piling, and poles. Thousands of tons of mangrove woodchips are exported annually from Indonesia, Sabah, and Sarawak for pulp manufacture.[38]

By sustainable forest management and community forestry people are encouraged to harvest the by products of that forest, rather than cut the trees themselves. No cutting of mangrove trees is allowed beyond a certain limit-- just enough to meet one's needs. Mangrove forest by products could include limited fuel-wood gathered from fallen or dead branches, fruits or leafy plants from the forest, medicinal herbs, sturdy poles for building, and other useful materials that the mangrove forest produces.[39]

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[34] http://www.hort.purdue.edu/newcrop/duke_energy/Rhizophora_mucronata.html#Energy
[35] http://www.tropenbos.nl/DRG/dry.htm
[36] http://www.fao.org/docrep/v5200e/v5200e09.htm#silviculture%20of%20mangroves: Unasylva no. 181
[37] http://www.specola.unifi.it/mangroves/human/restoration1.htm
[38] James A. Duke. 1983. Handbook of Energy Crops. Unpublished
[39] http://wwwscience.murdoch.edu.au/centres/others/mangrove/

The Manzanar Project in Eritreia
Desert and saltwater are two things Eritreia has plenty of: they are spread out along a coastline of some 1,200 km. The basic assumption of the Manzanar project is that the vast deserts, readily available seawater, and abundant sunshine can be utilized to grow plants that can be irrigated with seawater. About 15 percent of Eritrea's coastline is covered with mangroves with the trees found in areas where flash floods occasionally flow across the sand and into the sea. To make them grow in new locations, each tree needs to be provided with fertiliser in the form of a half kilo plastic bag containing nitrogen and phosphorus and buried at the tree's roots, which eliminates run-off of nutrients into the sea.[40], [41]

Follow-up?

A number of biological and technical problems still needs to be addressed:
1. Species selection for different geo-climatical zones; ranked by salt tolerance
2. Inventory of lands suitable for biosaline plantation forestry
3. Feasibility study for pilot areas: what yields are possible, what are the production costs? What will be the environmental impacts?[42]
4. Bridging the gap between scientific research and forestry practise by means of demonstration projects on integrated salinity management and dissemination of research findings
5. Relevance for The Netherlands: how can we be (and do we want to be) involved in the development of biosaline agriculture and forestry; who are the main stakeholders?

Furthermore, the development of biosaline forestry will face various social and economic problems (e.g. related to sustainability and market development), which need to be approached in a multiple disciplinary way.
6. A integrated vision on the role biosaline forestry may play in the provision of biomass in very near future will be very helpful[43], which should include (but not limit itself to) the status and trends in the extent of mangrove forests worldwide;
7. The development of appropriate silvicultural systems for (irrigated) biosaline plantation forest management adapted to inland and coastal deserts, which could provide a variety of products and services (multiple-use forestry; agro-forestry).

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[40] http://forests.org/articles/reader.asp?linkid=26137
[41] http://www.rolexawards.com/laureates/pdf/laureate0069.pdf
[42] Mangrove ecosystems of Australia: http://www.deh.gov.au/coasts/publications/somer/annex1/mangrove.html
[43] At the moment, Ocean Desert Entreprises is investigating the possibilities and the main barriers to the deployment of biosaline biomass, for which a grant has been given by the Ministry of Economic Affairs within the framework of the Biomass Transition.

Joshi, G.V., Jamale, B.B. & Bhosal, L.I. 1975. **On regulation in mangroves**. In G.E. Welsh, S.C. Snedaker & H.J. Teas, eds. Proceedings International Symposium on Biology and Management of Mangroves. Gainesville, USA, University of Florida Press.

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7

OBSTACLES TO IMPORTS OF BIOMASS, A STAKEHOLDER APPROACH

Definition of the problem
In the discussion on imports of biomass a number of obstacles are mentioned. It is very important to know these barriers and to find out how they may be overcome.

Questions
1. Which are the main objections against import of biomass (negative impacts on biodiversity, competition with the production of food, disbalance of nutrients, etc)
2. Is it possible to quantify these objections?
3. What are the possibilities to overcome these barriers?

Marieke Meeusen, Klaas Jan Kramer and Theo Vogelzang, August 2004. Report on BUS ticket no. 26, WUR-LEI

Summary
Several sustainability-related issues are associated with the importation of biomass. These include food production, nature conservation, biodiversity and respect for local economies. The main concerns are preventing emissions, preventing competition with food production, the protection of biodiversity and respect for local economies. The issue of importing biomass has prompted a whole range of stakeholders to put forward a whole range of sustainability criteria. This memo describes a stakeholder analysis to deal with this issue. A brief stakeholder analysis involving three parties reveals among others: involvement of non-governmental organisations of biomass exporting countries, attention for socio-economic aspects and the need for a responsible organisation to lead the discussions and developments.

Introduction
The Dutch government has developed a policy vision in respect of biomass and its role in the energy supply in 2040. Devised with the co-operation of many organisations, this vision aims at achieving a 30 per cent share for biomass in the energy supply in 2040. Biomass can serve as the basis for the production of electricity, heat and transportation fuels, and also as a raw material for the chemicals industry.

Dutch demand for biomass will be greater than the amount the Netherlands can produce. To meet the desired structure of the energy supply in 2040, the Netherlands will have to import biomass. However, not all imported biomass is "automatically" sustainable. Several preconditions therefore have to be formulated in order to make the import of biomass genuinely sustainable. The policy in respect of these conditions must be transparent and implemented with the aid of quality marks and certification programmes.

Current status of the "Biomass Transition"[44]
Within the context of the Biomass Transition, 30 representatives from business, government and nature and environmental organisations met in 2003 to consider the sustainability criteria required for the use of biomass. A working group, made up of members of the Transition team, is now formulating and organising these requirements.

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[44] NN, 2004, *Transitie nar een duurzame energiehuishouding: Duurzaamheid van biomassa in de energietransitie* ("Transition to Sustainable Energy Management: sustainability of biomass in the energy transition") – starting document for the second phase of the Biomass Sustainability Criteria Working Group.

Those for biomass production and use should guarantee a certain level of sustainability. The working group has identified three aspects which sustainability criteria should address.

- CO_2 balance in biomass production chains.
- Other emissions in biomass production chains
- Large-scale imports of biomass

The working group enters the second phase of its activities in 2004. This year it will develop a methodology based upon its own discussions. Initial debate about sustainability requirements for imported biomass has resulted in a "longlist" of themes. This now needs to be further refined for the different types of biomass and the different exporting regions. Once local criteria have been determined, the next step is for the system to be tested by an independent control institute or agency. This will be followed by pilots, to be conducted in 2004 and 2005. It is during these that the final criteria for sustainable imports will be formulated, jointly with all the stakeholders.

Purpose of this paper

Various studies have examined the obstacles surrounding the importation of biomass from a sustainability perspective. This paper summarises the objections – or, rather, the challenges. It then looks how to deal with them. Elberson's contribution[45] mentions the need to create coalitions in respect of particular bio-energy chains. That recommendation has been taken as the starting point for this paper. After all, only when society's wishes with regard to the import of biomass for energy – and its sustainability – are known can they can be taken into account. The question is how to find out what society wants. For biomass to be applied successfully in the production of energy and/or raw materials, it is important to know who the stakeholders are and what opinions they hold about the large-scale importation of biomass. This paper describes an approach to identifying the main players involved in the import of biomass, as well as an producing an inventory of opinions and obstacles which can serve as the basis for formulating a set of requirements for the development of bio-energy projects.

Interested parties

Any transition involves four groups of interested parties, which together make up the "transition coalition". Each of these views the issue from a different perspective. All four of these groups are active in the debate about biomass, with the following organizations amongst those involved.

Government

The government is expected to promote the interests of the community as a whole. In the case of bio-energy, the departments of Economic Affairs, of Housing, Planning and the Environment and of Agriculture, Nature and Food Quality play an prominent role, as does the Treasury. In respect of sustainability, the Directorate-General for International Cooperation (DGIS) of the Department of Foreign Affairs takes the lead. But other levels of government also have their part to play. They, after all, create the preconditions which actually make bio-energy policy – for example, by granting or refusing licences.

Business

The ultimate decision as to whether or not to take part in a bio-energy chain lies with the business community. Important considerations in that decision are continuity and the contribution which participation will make to achieving financial objectives. In the case of the bio-energy chain, the businesses involved range from producers to end suppliers. They include farmers, agribusinesses, the Forestry Commission and energy suppliers like Essent, Nuon and Shell. When biomass is imported, there are also importers and exporters to consider.

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[45] Elbersen, H. W. (2004), *The Sustainability of Biomass for Bio-Energy*, BUS report, Wageningen.

Non-governmental organisations
The non-governmental organisations involved usually represent a particular interest. In the case of bio-energy, they are groups concerned with nature and the environment – like the WWF, Greenpeace and the Netherlands Society for Nature and the Environment – as well as "Third World" organisations.

Research institutes
The research institutes should encourage the debate about biomass and bio-energy from a independent perspective. They "feed" that debate. In the case of bio-energy, important institutions include Copernicus, Probos, Wageningen University and Research Centre, the Energy Research Centre of the Netherlands (ECN) and CE.

At the moment, the Netherlands Society for Nature and the Environment is taking the lead in respect of sustainability. It sees a prominent role for the business community, in partnership with non-governmental organisations. Once these parties reach a consensus, "the government will follow of its own accord".

Obstacles to biomass imports: overview of the current situation
A number of studies and paper have shed light upon the obstacles to biomass imports. Particularly worthy of mention are those by Meeusen et al. (2003), Elbersen and Kuiper. Their results are summarised below.

Planet (the environment)
- CO_2 emissions throughout the entire chain ("C balance").
- Other emissions into the atmosphere, water and soil throughout the entire chain.
- Other environmental effects.
- Biodiversity.
- Land use.

This implies that the entire chain, from production to consumption, needs to be made more attractive in environmental terms. Attention must be paid to the use of plant protection products, fertilizer, water and energy during the production phase. Environmental effects must not be examined at the local level alone, but also on a global scale. In the case of land use, competition with other activities needs to be considered: production of food versus production of biomass for the national energy supply.

People (society and culture)
- Rural development and employment.
- Information transparency and validity in the chain.
- Individual and corporate responsibility for climate change and emissions.

In "people" terms, the potential contribution to rural development is most frequently mentioned. Bio-energy is regarded as attractive when it fosters employment, both quantitative and qualitative.

Profit (the economy)
- Energy prices.
- Security of supply.
- Incomes and standards of living for the links in the chain.
- Creation and development of knowledge.
- Innovation.

Sources: Meeusen et al. (2003), Elbersen (2003)[46] and Kuiper (2004)[47].

Although imports of biomass were not the principal subject of the stakeholder analyses, some do pay particular attention to the issue. The main opinions are outlined below.

[46] Elbersen, H. W. (2004), *The Sustainability of Biomass for Bio-Energy*, BUS report, Wageningen.
[47] Kuiper, L. (2004), *Sustainable Imports of Biomass from Large-Scale Tree Plantations in Brazil.*

- *Department of Economic Affairs*
  For the Department of Economic Affairs, it is important that the use of biomass result in a reduction in CO_2 emissions and other environmental effects, as well as a reduction in the use of land and encroachment upon nature. Moreover, the use of biomass must have no negative social impact in other parts in the world, particularly in developing countries.

- *Department of Health, Planning and the Environment.*
  The Department of Housing, Planning and the Environment (VROM) hopes to achieve sustainable production of biomass with due consideration for the economic, social and economic impact of its use at all levels: global, regional and local. VROM wants particular attention to be paid to the effects of biomass imports upon biodiversity and the distribution of welfare.

- *Netherlands Society for Nature and the Environment (Stichting Natuur en Milieu)*
  The Netherlands Society for Nature and the Environment (SNM) opposes the worldwide trade in biomass, instead favouring commerce in semi-manufactures. Moreover, any international trade in biomass must contribute to the sustainable development of developing countries and to a reduction in CO_2 and other emissions.

Once all the objections and obstacles have been identified, the next question is how they should be dealt with. Which are decisive in their significance? And how can the objections be overcome, particularly the most important ones? This brings the process-related side of the sustainability debate to the fore. This paper proposes stakeholder analysis as a tool.

Which stakeholders are relevant?
In general, different players have different observations, views, objectives, ambitions, problems, priorities, needs, standards and values, and they tend to interpret the subjects or systems being looked at in different ways. The first question requiring an answer is: which key players or stakeholders can be identified in respect of the topic "biomass imports" and what are their roles? There are many stakeholders with views on the issue, but which of them are important to the success of new chains? That selection can be made based upon the roles played by the stakeholders. Roles which can be expressed as (a) the extent to which they have an interest in bringing about the import of biomass for bio-energy and (b) the extent to which they can influence that process. The table below places the stakeholders in the so-called "interest and influence" matrix.

	Little influence	Great influence
Little interest	A	B
Great interest	C	D

Cell A contains those stakeholders with little interest in bringing about the import of biomass and with little influence upon that process. *Cell B* contains those with little interest but a lot of influence. *Cell C* contains those with little influence but a great interest in the issue. And *cell D* contains those with both a lot of interest in the issue and the ability to exert great influence. The opinions of those stakeholders in cells B, C and D need to be taken into account. They are the groups, which have either a considerable interest in the process and/or actual operations or can exert a lot influence over them, or both. It is therefore important to listen to them.

It should be pointed out that this paper does not assess the role played by every stakeholder in the above terms. Rather, a small number of those stakeholders were selected and asked for their opinions. They were: (a) the Centre for International Co-operation (COS Netherlands); (b) the Netherlands Society for Nature and the Environment (SNM); and (c) the Product Board for Margarine, Fats and Oils (MVO).

What information is required?
The following information is relevant to those who attach great importance to biomass or exert considerable influence in the field, or both.

- An inventory of the parties involved.
- Investigation of elements for success.
- Investigation of possible problems.
- Investigation of stakeholder expectations.
- Determination of responsibilities.
- Investigation of possible solutions to problems found.
- An inventory of missing elements in the decision-making process.
- Leading parties.
- An inventory of research questions.

A short explanation. The stakeholders were asked which parties they believe are, or should be, involved in the issue. A second aspect is identification of elements for success. Such an element actually contributes towards that success if it can count upon broad support, which in turn implies that other stakeholders are also positively inclined towards it. Elements for success are therefore identified and their importance assessed. The stakeholders were then presented with the list of those elements and asked what their attitude is to each of them. A stakeholder analysis usually reveals that support for each element varies. The next question is why that is. What are the underlying factors or problems which cause that variation? In order to gain an understanding of these tensions, the problems at and between the stakeholders were outlined on an element-by-element basis. Stakeholders' expectations also play a part in this. What do they think the future holds, and what does their intuition tell them? This was followed by a determination of responsibilities, with the stakeholders stating what their own are. Finally, the problems identified were presented again to the stakeholders with a request to devise solutions to them.

Results
This section describes the results of applying the stakeholder analyses in interviews with three of them: (a) the Centre for International Co-operation (COS Netherlands); (b) the Netherlands Society for Nature and the Environment (SNM); and (c) the Product Board for Margarine, Fats and Oils (MVO). Those results obtained for the first time from the stakeholder-analysis approach are emphasised.

Inventory of parties involved
All three parties cite the four clusters already mentioned – business, government, non-governmental organisations and research institutions – as being relevant to the transition. The organisations specifically mentioned earlier in this paper are considered particularly important. In addition, certification bodies were cited during the interviews. Both the SNM and the COS point out that, in the business cluster, the exporters are playing little or no role in the debate at present despite having a significant involvement. The three organisations also mention that they miss contributions from non-governmental organisations concerned with nature, the environment and economic opportunities in the exporting countries. MVO suggests looking at the worldwide initiative Roundtable on Sustainable Palm Oil (RSPO). The RSPO is a global multi-stakeholder initiative on sustainable palm oil. The aim of the RSPO is “to promote the growth and use of sustainable palm oil thorough co-operation within the supply chain and open dialogue between its stakeholder”.
One interviewee further points out that there is intensive involvement from only a limited number of research institutions. They call for the number of such institutions taking an interest to expand, with particular attention to the "people" component (information provided verbally by Hans Jager, Thijs de la Court and Frank Bergman, 2004).

Investigation of elements for success (eg. certification)
According to the COS, CE initiated the debate about biomass imports within the Department of Economic Affairs working group. The discussion focused mainly upon the *certification* of imported biomass, in a way comparable with the work of the Forest Stewardship Counsel (FSC). Certification should guarantee the sustainability of biomass imports. The working group was not very positive about certification but, in order for the discussions to continue, it agreed to continue with the process. Through case studies and in co-operation with national and international stakeholders, it is to develop criteria for certain types of biomass. Verifiability is an important issue in the successful importation and use of biomass.
In case of certification it could be interesting to look at the activities of the RSPO. The 2004 meeting of the RSPO will bring together important stakeholders along the palm oil supply chain in order to reach an agreement on credible criteria in achieving sustainable palm oil production.

Investigation of stakeholder expectations
The COS doubts that biomass can ever achieve a 10 per cent share in Dutch energy production, since the there is not enough physical space for that production. A higher share will lead to planning conflicts. Eastern Europe is not a producer of biomass, so it would have to come from Africa or South America. The SNM expects biomass to become an essential part of future energy supplies. Imports are necessary for its large-scale application in energy production, and for the production of raw materials for the chemical industry. Pilot projects should create transparency about the importation and use of biomass.

Determination of responsibilities
The COS and MVO see a task for the Dutch government is facilitating an open process of transition. Moreover, it is essential that non-governmental organisations representing every interest and subinterest be able to voice their opinions and ideas. As already stated, this contribution is regarded as inadequate at the moment. The research institutions are expected to provide "substantial" input from an independent position. The COS has criticisms in that respect. It also notes that, "at the moment, nobody is responsible for the process". Moreover, the lack of input from certain parties and the one-sided technocratic approach (information provided verbally by De la Court, 2004) are not being corrected. The SNM partially subscribes to this viewpoint. Important economic parties have taken the lead. The Society also agrees that technocrats are in the ascendant. Not enough attention is being paid to risk analyses or the socio-economic aspects of biomass and its importation.

Investigation of possible solutions to problems found
The COS asks why biomass has to be imported. The producing countries could use it themselves to meet their own energy needs. The Centre is seeking alternative solutions, including the use of rapeseed in the Netherlands and chain shortening. The SNM, however, thinks that the development of sustainability requirements will guarantee sustainable imports of biomass and the verification of its origin. MVO thinks that it is important that it is important to look at the development is other (European) countries, especially at legal instruction and financing.

Inventory of missing elements in the decision-making process
The interviewed organisations are uncertain whether the Department of Economic Affairs' biomass project will be continued. However, it is expected that most of the major commercial companies will carry on their biomass work. The MVO agrees with the COS and SNM that there is not a continuous process. This may be due to the fact that responsibility for the process has been transferred to the Directorate-General for International Cooperation (DGIS) of the Department of Foreign Affairs. The COS is no longer invited to discussions about biomass, which it says is a result of the way the project is currently organised. Participation by bodies like the COS is not considered.

Conclusions
The Dutch government wishes to achieve a substantial market share for bio-energy. The amount of biomass produced in the Netherlands, now and in the future, is generally regarded as in sufficient to meet this requirement.

Imported biomass is not "automatically" sustainable. This is what has prompted the debate. Sustainability criteria are being developed. The Transition Working Group is actively addressing the sustainability of imported biomass. That group enters the second phase of its work in 2004.

There are many issues involved in the sustainable importation of biomass. These relate both to "the planet" (CO_2 emissions, water consumption, energy consumption, biodiversity and so on) and to people (competition with other activities, producer incomes, rural development in exporting countries). Naturally, the chain should also provide economic advantage – a profit component – to all involved.

A variety of stakeholders are involved in the issue: governments, the business community, non-governmental organizations and research institutions.

The issue of importing biomass has prompted a whole range of stakeholders to put forward a whole range of sustainability criteria. The question is how to deal with them. One way is the use of a stakeholder analysis. First, all the stakeholders are identified. Then the role of each is analysed. These roles are then assessed in terms of (a) the importance attached to the issue by the stakeholder and (b) the influence exerted by the stakeholder. The ideas and opinions of those stakeholders with considerable influence or considerable interest, or both, are significant.

What information is then needed? See the list below.
- An inventory of the parties involved.
- Investigation of elements for success.
- Investigation of possible problems.
- Investigation of stakeholder expectations.
- Determination of responsibilities.
- Investigation of possible solutions to problems found.
- An inventory of missing elements in the decision-making process.
- Leading parties.
- An inventory of research questions.

A brief stakeholder analysis involving just three parties reveals that there is currently a somewhat one-sided emphasis upon technical aspects, with insufficient consideration of the consequences for people in the exporting countries.
- Involve non-governmental organizations concerned with "Third World" issues.
- Involve more research institutions in the issue. Seek more contributions addressing "people" aspects and socio-economic issues.
- Certification is regarded by some as being very important in guaranteeing sustainability.
- The responsibilities associated with the process are not being assumed adequately.

Insufficient consideration of the socio-economic consequences for producers in the exporting nations represents a risk factor in the importation of biomass.

The SNM and MVO more or less subscribes to this view: NGOs from exporting countries are absent in the stakeholder process. They recommend including these organizations in a follow-up of this project/initiative. The organization of the project is not transparent and focuses too much upon techniques. Socio-economic elements are missing. Knowledge and experience from other research themes are not being used.

- Elaborate the project group's ideas about this issue in conjunction with partners. Include organisations from developing countries.
- Include other research institutes.
- Include socio-economic research in the discussions.
- Use research done and/or experiences in similar projects or initiatives (like RSPO).

8

HOW TO GET MORE WOOD FROM THE DUTCH FORESTS?

Definition of the problem
In general, wood harvest in the Dutch forests is much lower than the annual increment, resulting in an increase in the growing stock of 800,000 tons each year. At present, no extra wood is expected to become available from our woodlands for biomass-utilization. The wood is certainly there, but it doesn't come out of the forest. What is causing this? We have asked the forest owner and the forest manager!

Questions
Which categories of forest owners are most willing to increase their harvest and to provide (more) biomass?
Would it be possible to harvest more wood without jeopardizing the sustainability of the forest?
What is the forest manager's view on pre-commercial thinnings?
Which extra financial support is necessary to increase the amount of biomass to be extracted from the forest?

Leen Kuiper and Jan Oldenburger, November 2004. Report on bus ticket no. A4, Probos

1. Approach

By a quick scan, consisting of interviews and E-mail consultations, an attempt was made to answer the above questions. The following public and private forest owners and experts have been contacted: municipalities (4x), private forest estates (4x), other public forest owners (2x) and consultants (2x).

- Mr. W. Klein Thijssink, Municipality of Ermelo
- Mr. J. Floor, Municipality of Arnhem
- Mr. van der Els, Municipality of Someren
- Mr. van den Born, Municipality of Ede
- Mrs. Berger – van Rijckervorsel, Estate de Wamberg
- Mr. van Boetzelaer, Estate Eijkenstein
- Mr. Vernhout, Estate Vilsteren
- Mr. Gelderman, Estate Beekvliet Gelre
- Mr. P.A.M. van Winden, Ministry of Defence, Department Buildings, Operations & Fields of operations
- Mr. H. Wanningen, Staatsbosbeheer, Corporate services
- Mr. C. Balemans, Forestry group The Netherlands North-East
- Mr. G. Borgman, Borgman Beheer Advies

2. Results

2.1 The municipality of Ermelo

The forest of the community of Ermelo is subject to multiple purpose management in which wood production is considered an important feature. The Woodstock forest inventory has shown that it is possible to harvest more wood from Ermelo's forest. The harvest level can and will be increased by 15% to reach an acceptable harvest level of 75-80% of the annual increment. Selling fibre wood to a bioenergy plant instead of selling it to the paper- or boarding industry is no problem for mister Klein Thijssink, i.e. if the prices are the same. The forest manager is not willing to consider the removal of branches and treetops from the forest, because it would be a step back in time. Should dead wood be harvested from the forest, according to Mr Klein Thijssink, it will decrease the soil quality and reduce the availability of nesting places for birds. At the moment, the first thinning in the forests of the community of Ermelo is done after 20-25 years, producing mainly fibre wood. It is possible to thin earlier, but mister Klein Thijssink does not see the advantage of pre-commercial thinnings. He thinks it will have a negative impact on the amount of dead wood, the birds and the forest soil.

2.2 The municipality of Arnhem

The municipality of Arnhem is harvesting wood only in order to improve the quality of the forest and not because of the revenues. Enhancing the natural values is the main steering factor in forest management. The community of Arnhem definitely will not consider to harvest more wood; not even with a financial support. Harvest operations are performed only if they are profitable and the wood is sold to the highest bidder. Selling his fibre wood to a biomass energy plant instead of selling it to the paper- or boarding industry is no problem for mister Floor. Harvesting branches and treetops is not an option for the community of Arnhem. The first commercial thinning in Scots pine stands is, depending of the soil quality, performed after 30 years. Earlier thinnings are considered only if they are commercially viable and if the wood quality of the standing trees are to be improved. However, it will not be done if the natural branch removal is influenced in a negative way. According to mister Floor a pre-commercial thinning can only be performed with a harvester, because otherwise the costs would be too high. During the first pre-commercial thinning the harvester makes felling tracks and removed badly shaped trees. Mister Floor agrees with the fact that an extra cubic meter of wood could be harvested from the forest without affecting the sustainability of the forest. However, it would not be profitable, because labor costs for this extra cubic meter of wood would be too high. Mister Floor is not in favor of trying to subsidize this.

2.3 The municipality of Someren

Wood production is important in the forest of the municipality of Someren. The management is performed according to the principals of nature-oriented forest management. According to mister van der Els already the maximum amount of wood is harvested in the forest of the community of Someren. An extra financial incentive would not change this. Mister van der Els doesn’t see any problems if his fibre wood would go to bioenergy plants. The highest bidder gets it. Mister van der Els has objections against the removal of branches and treetops from the forest, because it will reduce the amounts of dead wood. However, after explaining that only thick dead wood has a significant advantage for biodiversity, mister van der Els thinks that it might be an extra source of income. The production of high quality wood (a branch free part of the stem of 8 to 10 meter) is one of the aims in forest management of the community of Someren. For this reason the first thinning is performed after 20 to 25 years. An extra financial incentive to perform pre-commercial thinnings would not result in a change in management. Mister van der Els supports the idea that an additional cubic meter of wood could be harvested from the forest without impacting the sustainability of the forest, but he does not think it is feasible, because one cubic meter of wood is too small an amount.

2.4 The municipality of Ede

Wood production is not important in the forests of the municipality of Ede, because wood is only harvested in order to increase the nature values of the forest. Increasing the harvest level, therefore, is no option. Selling his fibre wood to a biomass energy plant instead of selling it to the paper- or boarding industry is no problem to the forest manager, Mr. van den Born. Harvesting branches and treetops is no option in the forest of the community of Ede. The age at which the first thinning is performed is 20-25 years. Pre-comercial thinnings are not considered at present. The yield from first thinnings could be used for biomass purposes, i.e. if at least the harvesting costs are being covered. This would imply that the wood from precommercial thinnings should be sold together with wood from commercial thinnings, otherwise it would not be viable to perform these pre-comercial thinnings. Mister van den Born agrees with the fact that one extra cubic meter of wood could be harvested from the forest without affecting the sustainability of the forest.

2.5 Private estate de Wamberg

Wood production is very important within the estate de Wamberg, which has a forest area of 90 hectares. The production forest is harvested with a cutting cycle of 6 years. If an extra financial incentive would become available, the current harvest level could be increased. If the same amount of money is paid, mrs. Berger - van Rijckervorsel doesn't see any problems if her fibre wood would go to the energy plant. It would not be a problem either to harvest branches and treetops, because this has been done in the past. No precommercial thinnings are performed at the Wamberg, because only a small part of the forest consists of young forest stands.

2.6 Private estate Eijkenstein

The private estate Eijkenstein consists of 140 ha of woodlands in which wood production is considered very important, but the nature values are also taken into account. At the moment thinnings are performed regularly and according to mister van Boetzelaer it is not necessary to increase the harvest level. A financial incentive to increase the amount of harvested wood would, will have a negative impact on the aim of the subsidy for nature conservation and is, therefore, not to be recommended. Selling his fibre wood to a biomass energy plant is no problem for mister van Boetzelaer, i.e. if the same amount of money is being paid. According to mister van Boetzelaer the marketpotential for energy wood is still insufficient for small freights of wood. Harvesting branches and top wood is no problem for mister van Boetzelaer. However, he has a problem with such a harvest if it would imply more heavy machinery in the forest, because these (heavy) machines may damage the soil and the paths. Pre-commercial thinnings are not performed, because they do not deliver revenues. However, Mister van Boetzelaer would consider to do pre-commercial thinnings if being subsidized. In the past volunteers performed these management activities, but they are no longer available. Mister van Boetzelaer agrees to the fact that more wood could be harvested from the forest without a negative impact on the sustainability of the forest ecosystem. However, the resistance and resilience of the forest against storm damage should be kept in mind.

2.7 Private estate Vilsteren

The rural estate Vilsteren has a forest area of 400 ha. This is less than half of the total estate. Wood production is important in forest management. The forest is devided into parts with different accents (wood production, culture, nature and recreation). Once in every 5 years the amount of wood that has to be harvested according to the accent in a certain part of the estate is determined. In certain parts of the estate more wood could be harvested from the perspective of wood production, bus this is not done because it is not necessary for the accent in that part of the forest. Selling his fibre wood to a biomass energy plant instead of selling it to the paper- or boarding industry is no problem for mister Vernhout, unless the prices are the same. According to mister Vernhout it does not seem to be reasonable to harvest branches and top wood from the forest, because the estate is on poor sandy soils. The estate has its own employers, which makes it possible to perform the precommercial thinnings. An extra financial incentive is not necessary to perform them. Next to this mister Vernhout indicates that the relevance of this subject is reduced, because forest management is changed to nature-oriented forestry (geïntegreerd bosbeheer).

2.8 Private estate Beekvliet Gelre

Wood production is important in forest management of the estate Beekvliet. The forest consists of 10 hectares of alder (elzenbroekbos) and 50 hectares that are owned by Natuurmonumenten, but they do not manage the forest. The thinnings on the estate are behind schedule. This is mainly due to the low wood prices. A financial incentive would certainly help to stimulate the harvest. Selling his fibre wood to the biomass energy plant is no problem for mister Gelderman. If commercially viable the harvest of branches and treetops would not be a problem either. Pre-commercial thinnings will certainly be considered if the revenues from energy wood would pay the costs.

2.9 Ministry of Defence, Department of Buildings, Operations & Field operations

Wood production is not important in the woodlands of the Ministry of Defence. Harvesting more wood is possible if the harvesting operations will be financed, under the condition that they would not negatively influence the military function and the nature values of the forest. The Ministry of Defence doesn't see any problems if their fibre wood would go to a bioenergy plant. Removing branches and top wood and performing pre-commercial thinnings is no problem, as long as the sustainability of the forest ecosystem is not affected. According to the Department BO&F one extra cubic meter of wood could be harvested from the forest without negatively affecting the sustainability of the forest. According to the Department of BO&F the possible damage to the soil and vegetation caused by the harvesting activities is of greater concern to the sustainability of the forest ecosystem than the amount of wood harvested.

2.10 State Forest Authority, Corporate services

Each year**,** **'**Staatsbosbeheer Diesntverlening' asks their forest managers to indicate from which objects they expect to yield energy wood. The energy wood is mainly derived from pre-commercial thinnings, especially from those stands in which the quality of the wood is bad. The wood is skidded to the forest road, where it is being chipped. The trees are sometimes stored along the forest road for a while in order to reduce the moisture contents. Energy wood is also derived from forests that are being converted. The wood that is being removed from heather and other types of reserved natural areas is also sold as energy wood. According to SBB Corporate Services precommercial thinnings are no longer performed by SBB managers., because they cost money. If nevertheless, a forest manager wants to do a pre-ecommercial thinning, he has to pay for it himself. The forest managers of SBB earn between 0 and 3 euro per cubic meter of standing volume. The policy of SBB is to look for a value-added utilisation of the wood before it is used for energy purposes. Mister Wanningen indicates that the demand for industrial fibre wood has increased recently, which is due to the lower quality requirements for the delivered wood by the board industry. It is now possible e.g. to deliver the wood in different lengths and also temperate hardwood is accepted. The wood from pre-commercial thinnings can go to a new OSB plant in Belgium and the forest owner will still earn a few euros for his wood. The branches and top wood are only harvested if a calculation shows that this can be done cost efficiently. If the calculation indicates that the harvesting operation will cost money, the operation is only performed if the forest manager pays the deficit.

2.11 Forestry Group North-East

As a consultant this Forestry Group is involved in forest management planning within the framework of FSC group certification. From these management plans it can de derived that most private forest owners frequently harvest less than would be possible. The forestry group advices to harvest 70% of the annual increment. Consequently, most private forest owners indicate that they will increase their harvest in the near future. This illustrates the needs to inform forest owners about the benefits of increasing harvest levels. In order to facilitate this awareness process, the writing of forest management plans should be subsidized, for instance by the provinces or municipalities. If forest owners would get higher revenues for their wood, more wood would likely be harvested. At present, the diameter at which the top of the stem is cut off frequently is 12 cm, although it should be no more than 8 cm. According to mister Balemans it would be a step back in time if branches and top wood would be harvested. For this reason he doesn't think it's a good idea. With proper financial incentives pre-commercial thinnings and coppice management will certainly stimulate the production of biomass for energy purposes. Mister Balemans agrees with the fact that harvesting more wood is possible without jeopardizing the sustainability of the forest.

2.12 Borgman Beheer Advies

Mister Borgman was asked to estimate the exploitation costs of a precommercial thinning, which amount to about 15 to 20 euro per m^3, based on a harvested volume of 35 to 40 m^3 per hectare, at an age of 30 years. A pre-commercial thinning in a Scots pine stand of 15 years produces 10 to 12 m^3 of wood. Preferably, precommercial thinnings are performed together with commercial thinnings in order to compensate the costs. According to mister Borgman, pre-commercial thinnings for energy purposes should be viable from a financial perspective. The price paid for energy wood chips is 30 euro per metric ton at the gate of the energy plant. (Two cubic meters of coniferous woodchips go into one metric ton). According to mister Borgman, the establishment of three to four additional bioenergy plants would solve the problem of finding an outlet for the wood from pre-commercial thinnings, if these energy plants will pay the cost price of the wood. According to mister Borgman the bioenergy producers will import shiploads of cheap biomass from Chile if the price of biomass in the Netherlands is to high. The biomass price is further kept low by the low prices for energy wood from abroad.

3. Conclusions

1. If forest managers will get then same price, they do not have any problems with their fibre wood going to bioenergy plants instead of going to the paper- or board industry.
2. The willingness of forest managers to increase their harvest levels mainly depends on the role of wood production in forest management and on the type of forest owner. Private forest owners will be more willing to increase their harvest (provided they get an extra financial incentive) than public forest owners, such as local communities, ministry of defense, state forest service. Hence, the most effective strategy to enhance biomass yields from Dutch woodlands is to focus on private forest owners.
3. Forest managers who aim at the conservation of natural values of their woodlands will not be inclined to harvest more wood, unless the natural values of their forests clearly benefit from it.
4. The removal of branches and treetops is not considered a viable option, because it is seen as a step back in time. Forest owners have just got used to the idea that they should leave the branches and treetops in the forest to enhance biodiversity. It will be difficult to convince them with an opposite message.
5. An increase in pre-commercial thinnings is conceivable, but this will only happen with the proper financial incentives.
6. The costs of pre-commercial thinnings (excluding the costs for chipping or shredding) amount to 15 to 20 euro per m3 , when assuming 40 m3 of wood is being harvested per hectare on average. The current price for wood chips at the gate of the energy plant is about 25-30 euro per ton of fresh chips (i.e 12-15 euro per m3 of solid stem wood). Thus the harvesting costs still exceed the price that is being paid for the wood chips, making it very unrealistic to happen without incentives (in the order of 20 euro per m3).

7. Many private forest owners are harvesting less wood than they could. A better exchange of information (forestry extention) and a financial incentive for making forest management plans would help changing their attitude.

4. Follow up?

A number of questions still remain unanswered:

- How many private forest owners, owing more than 5 ha of woodland, which are currently registered at the Bosschap, could be stimulated to harvest more wood? How much extra energy wood would become available from these private forest owners?
- Which financial incentives are needed in order to enhance pre-commercial thinnings?

A follow-up is proposed, focusing on private forest owners which are actually harvesting far less wood than the sustainability of their forest holdings would allow. Probos suggests to divide this follow-up study into two phases:

(1) Analyse the available HOSP (Houtoogststatistiek en prognose) database to see if it could yield more detailed information on forest owners which currently are harvesting less wood than they actually could harvest. E.g. the category of private forest owners may be divided into a group of forest owners that own less than 100 ha of woodlands and a group of owners that owns more than 100 ha.
(2) Check the results of phase 1 (HOSP database) by a substantial number of telephone interviews with relevant categories of forest owners. In this way, representative information about the harvest level of the ‘most promising’ forest owners is derived. In addition, the willingness of forest owners to harvest more wood as well as the incentives needed, will be assessed.

9

SELF-SUFFICIENCY OF THE NETHERLANDS IN THE FIELD OF BIOMASS

Definition of the problem
Which influential studies address the question of how much biomass for energy The Netherlands is able to produce by itself. In the discussion on biofuels this is a recurring hot item.

Questions
1. What are the main assumptions and inaccuracies?
2. Which parties could jointly work together to give a conclusive answer on the self-sufficiency situation in The Netherlands?

Marieke Meeuwsen, November 2004. Report on BUS ticket nr. A22, WUR-LEI

1. Motivation

Various studies make judgments regarding the extent to which the Netherlands would be capable of producing biomass itself for energy applications. The results of these studies vary, thus giving us no clear picture of the availability of biomass in the Netherlands. There is therefore no adequate basis for businesses to take decisions on long-term or even shorter-term investments. This forms the motivation for SHELL to ask for greater insight into the studies that have been carried out in the field of the availability of biomass.

2. Objective

This memorandum aims to compile an overview of studies in which an assessment is made of the quantity of biomass for biofuel that the Netherlands is able to produce *itself* and – based on this – to provide an assessment of the extent to which these studies provide businesses with sufficient insight regarding the certainty of the supplies of raw materials. For this purpose, an inventory has been made of studies in the field of the availability of biomass. The inventory focuses on insight into (a) the estimated quantity of biomass to be produced by the Netherlands and (b) the applicable price for this, particularly with an eye to (c) the assumptions chosen in this regard and (d) the uncertainties stemming from these.

3. Potential availability of biomass

Van der Broek et al. (2003) provide the most complete and up-to-date overview of the quantity of available biomass in relation to need, reasoned from the perspective of the development of the market for biofuels. They have derived and made an inventory of the required quantities of biomass for six different biofuels[48] for the extent to which this biomass is actually available. A wide range of studies has been consulted for this purpose.[49] The added value of Van der Broek et al. (2003) is that all previous studies are brought together. They have carried out this analysis at Dutch, EU and global levels. The report

[48] The following fuels were examined: ethanol from sugar beet, wheat and residual biomass flows; ETBE (ethyl tertiary butyl ether), biodiesel from oilseed rape and methyl esters from residual biomass flows; options that could offer prospects in the medium to long term were not examined, namely lignocellulose ethanol and Fischer-Tropsch diesel.
[49] Including the following: Van der Broek (2001), Faaij (1997), Vis (2002), Van Vaals (2003), LEI (1999), VNPI (2003), Van der Voort (2003), Berkhout (2003), CBS (2003)

does not provide a detailed picture of the potentially available biofuels *per biomass flow*.[50] With regards to the Dutch situation, Van der Broek et al. (2003) conclude that the potential availability of biomass is 80% higher than the quantity needed to meet the target percentage of 2% in 2005. This is set to change in 2010, when the target percentage will rise to 5.75%. In this case, there will be a shortfall in the Netherlands.

Elbersen et al. (2004) also point to the large quantity of biomass "flowing through the Netherlands." The Netherlands has a surface area of 3.3 million hectares (of which approximately 2 million hectares are agricultural land), meaning 13 tonnes of dry matter per hectare per year "flowing through the Netherlands." This gives the Netherlands a high biomass flux, argue Elbersen et al. (2004).

Table 1: Quantity of biomass "flowing through the Netherlands," in millions of tonnes

Source	**Quantity**
Import of mixed feed	15
Grass production and conversion into feed	10
Production of arable and horticultural products	7
Wood and paper	5
Arable residual materials	4
Import of nutrients	2
Total	43

Source: Elbersen, et al. (2004)

Accordingly, various quarters point to the large quantity of *potentially* available biomass for bio-energy. Whether these flows *actually* become available, and to what extent, is less clear. Van der Broek et al. (2003) therefore issue their own warning. They point to the fact that the figures indicate sufficient biomass in theory, but that the actual availability is determined by economic limiting conditions that differ by source. The extent to which the potentially available quantity of biomass actually becomes available is therefore variable. Van der Broek et al. (2003) therefore expressly state that the inventory deals with the *potentially* available quantity of biomass.

A number of studies are covered in the following sections, describing the actual availability of the individual biomass flows. The corresponding assumptions and uncertainties are illustrated. After all, we are dealing with the question of which factors determine whether and to what extent the potentially available quantity of biomass is actually available for bio-energy.
The biomass flows – also distinguished by Van der Broek et al. (2003) – are defined as follows:

- Cultivated biomass;
- Residual flows from the food, beverages and tobacco industry;
- Residual flows from agriculture;

These flows will be dealt with separately.

4. Factors determining the actual availability

4.1. Cultivated biomass

Table 2 presents an overview of the area and the production of a number of crops suitable for bio-energy. In the year 2004, wheat is primarily sold as animal feed. Higher prices are paid in this sector than in the bio-energy sector. If these ratios change, the feed wheat could also be used for bio-energy purposes. After all, wheat is an important crop in the grower's

[50] Van der Broek et al. (2003) have taken the available quantities per sub-flow as the starting point and added them together; the presentation in the report provides little insight into the chosen starting points at the sub-flow level.

Table 2: Overview of the area and the production of a number of energy crops in the Netherlands in the period 1985-2003, in 1,000 hectares and in 1,000 tonnes

	1985	1990	1995	2000	2003
Area (x1,000 hectares)					
Wheat	128.1	140.6	135.4	136.7	133.0
Sugar beet	130.5	125.0	116.1	111.0	102.8
Oilseed rape	10.1	8.4	1.5	0.9	1
Production (1,000 tonnes)					
Wheat	851.1	1,075.9	1,166.7	1,142.7	1,228.3
Sugar beet	6,334	8,623	6,449	6,727	6,209.8
Oilseed rape	30.6	25.5	4.5	2.9	2.0

Source: LEI/CBS, 2004

cultivation plan for crop rotational reasons. Wheat is unlikely to be removed from the cultivation plan.

Sugar beet is cultivated for the production of sugar as a foodstuff. Only so-called “C sugar” would be available for use in bio-energy production, due to its low price.[51] C sugar is the sugar that is produced in excess of the quota set by the EU. Growers receive a fixed price for sugar that falls within the EU quota; the sugar that the growers produce over and above that quote (C sugar) is sold at the world market price, which is lower. The assumption that this sugar could be made available for bio-ethanol is understandable, but a point for attention is that this surplus quantity varies each year and is a residual item for growers, rather than a principle activity. As such, there is less certainty of supply.

Oilseed rape is cultivated in limited quantities in 2004. There should be growth opportunities for oilseed rape; this crop could possibly count on more interest now that the biodiesel market is picking up. For this reason, Janssens et al. (not yet published) have looked at the conditions under which Dutch farmers will cultivate oilseed rape for biodiesel. In the year 2004, the competitive position of oilseed rape is not very attractive for arable farms in relation to the alternative offering the lowest returns (winter wheat). Oilseed rape is only financially attractive on fallow land, on which generally speaking no marketable crops are allowed to be cultivated. This area is a maximum of 5,000 hectares. Janssens et al. demonstrate that this situation will not really change as a result of the proposed changes in the Common Agricultural Policy. Measures to increase yields and to reduce costs could encourage the cultivation of oilseed rape; these measures could make oilseed rape a more attractive option than wheat.
This example also illustrates the gap between potential availability and actual availability. Although the potential area is estimated at 71,000 hectares on the basis of technical and crop rotational factors (Van der Voort, 2003), this appears to be much less if one looks at the matter from an economic perspective.

An additional warning is hereby issued. If the competition at crop level is “won” by an energy crop, one should not draw the conclusion that energy crops will be cultivated from that moment on. After all, the important factor is the competition on the use of the land: which usage provides the highest profit? Accordingly: if one crop becomes more competitive than another, but the profit to be gained through this land use is lower than from a competing land application outside arable farming or even outside agriculture as a whole, then that crop will not be chosen for cultivation.

[51] Incidentally, the sugar policy of the European Union is currently undergoing reforms. The future sugar policy is very likely to be different from that of 2004. (de Bont et al., 2004)

4.2. Residual flows from the food, beverages and tobacco industry

Van der Broek et al. (2003) see a major role for the residual flows from the food, beverages and tobacco industry. These flows account for a large share of the potentially available quantity of biomass. Various studies – of which an overview has been compiled by Elbersen et al. (2002a) – have made an inventory of the quantity of residual flows from the food, beverages and tobacco industry. These studies examined the by-products, which are the products not given the label of main products. This implies products for which (profitable) purposes and sales are arranged. Elbersen et al. (2002a) show that the food, beverages and tobacco industry produces approximately 10 million tonnes of by-products. See table 3.

Table 3: Quantity of residual flows stemming from the food, beverages and tobacco industry, in 1,000 tonnes and in PJ

	Quantity (1,000 tonnes)	Energy (PJ)
Abattoirs and meat processing	1,426	18.3
Fish processing	76	0.5
Vegetable and fruit processing	1,162	3.8
Manufacture of margarine, fats and oils	3,783	59.0
Manufacture of dairy products	280	4.4
Manufacture of flour	1,793	17.4
Manufacture of sugar	1,095	8.9
Manufacture of other foodstuffs	128	1.4
Manufacture of beverages	754	3.8
Tobacco processing	2	<1
Other	192	4.4
Total	10,691	122.1

Source: Elbersen et al., 2002a

As already stated, the majority of these by-products have an application: more than three quarters are used as a raw material for animal feed, approximately ten per cent is sold as a soil improver and the remaining ten per cent is burnt, dumped or sold outside the agricultural sector.

The current sales pattern is in transition. In particular, the animal feed market is becoming less attractive for by-products. Food safety is a hot issue, increasingly setting boundaries for the opportunities for the sale of by-products in animal feed. The shrinking cattle population will also lead to fewer sales opportunities. By-product producers are therefore urgently exploring alternative applications in the non-food sector. In this regard, the overview provided by Elbersen et al. (2002b) is illustrative. Elbersen et al. (2002b) show the by-products for which alternative applications were being sought in 2001. More than half a million tonnes were involved (see table 4). In time, this would grow to double that quantity, as shown in table 5.

Table 4: By-products for which alternative applications were being sought in 2001, in 1,000 tonnes per year

By-product	Quantity
Animal residual flows	305
Fat residual flows and additional flows	25
Frying fat	130
Residual flows from the sugar industry	22
Other by-products	68
Total	550

Source: Elbersen et al., 2002b

Table 5: By-products for which alternative applications will need to be sought in due course, in 1,000 tonnes per year

By-product	Quantity
By-products from the grain-processing industry	479
By-products from the potato industry	234
By-products from the sugar industry	154
By-products from the dairy industry	28.5
By-products from the fermentation industry	7.5
Animal fat	54
Other by-products	119
Total	1,077

Source: Elbersen et al., 2002b

In the search for non-food applications, in which (by definition) food safety is less of a restrictive factor, the highest-quality applications are explored first. Naturally, one first looks at applications that bring high returns; processing technologies that make these markets accessible are assessed according to their returns. Elbersen et al. (2004) sum up a number of these applications: (pharmaceuticals), fermentation, fuel, fertilizers, fire, flare, fill. For a number of by-products, they also show the (technical) possibilities within these markets. Accompanied by a market analysis, this provides a picture of the actual possibilities in alternative markets. If these bring better returns for the seller of the by-products, less with remain for use in bio-energy. Therefore: the shrinking animal feed market does not automatically mean that the by-products will become available for bio-energy. Competition now begins with other non-food applications. However, this flow is expected to be an interesting prospect for bio-energy.

Goorden and Meeusen (1999) note that flows become available right across the country, and that the quality is often low and not constant, because these flows cannot find any other application elsewhere. Goorden and Meeusen (1999) therefore saw a major role for large-scale agribusiness, within which supply and demand can be attuned to each other. In this regard, the initiative of Nedalco and Cerestar is also illustrative.
Goorden and Meeusen (1999) as well as Sanders (undated) also point to the fact that the use of residual flows from the food, beverages and tobacco industry ties in with the proposal of bio-energy: sustainability. After all, the environmental impact is limited, as more products are obtained from the crop and the energy share is only 'responsible' for part of the environmental impact. Moreover, the production of biomass in this way does not take up any space that may otherwise have been needed for the production of food.

4.3. Residual flows from agriculture

Van der Broek et al. (2003) show that animal manure in particular has a large share in the potentially available quantity of biomass. This biomass is expected to be used for fermentation. The other biomass flow that they mention is straw, which can be used particularly for electricity and – in time – for biofuels. Where residual flows from agriculture are concerned, for biofuels in the short term, the foliage of potatoes and sugar beet is named as the most interesting option (said by Elbersen, 2004). The quantity would be 1.5 million tonnes. Elbersen foresees that this resource will grow in importance for bio-energy. These by-products currently remain on the land, where they release nutrients (particularly nitrogen) at times when the plants do not require them; they therefore have very little use as fertilizers. A bigger problem is the fact that they die off, resulting in the nitrogen being released in the form of nitrate. This could make potato and sugar beet foliage an even more interesting source of biomass for bio-energy. Naturally, the same principle also applies here: one first needs to seek economically attractive (or more economically attractive) options before taking steps along a particular route towards bio-energy.

5. Market prices of the biomass flows

SenterNovem has commissioned the development of a databank by Ecofys, the Commodity Board for margarines, fats and oils and Probos, within which the prices at which various biomass flows are offered and/or sold are recorded. (http//212.0.231.227/biomassa/prijzen/). The databank makes a distinction between the following groups: (a) fresh wood; (b) used wood; (c) wood from processing, (d) shells/pods/husks, (e) peel/skin, membranes and seeds/pips, (f) pulp, (g) fats and oils, and (g) other residues from the food, beverages and tobacco industry.

6. Conclusions

- A good overview is available of the potentially available quantity of biomass, but this is not sufficient …

There is a good overview of the potentially available quantity of biomass in the Netherlands. Van der Broek et al. (2003) provide a good impression of this. However, a picture of the *potentially* available quantity of biomass provides an insufficient basis for an industrial enterprise to gain insight into the biomass available to it at an acceptable price. After all, the actual available quantity of biomass is much less, and is strongly dependent on the prices and the market.

- Potentially sufficient availability

One can conclude that the potentially available quantity is more than adequate to satisfy the EU directives on biofuels on a Dutch scale with regards to 2005. The Netherlands produces sufficient biomass to be able to produce the desired biofuels. However, there will be a shortfall with regards to the targets set for 2010.

Feed wheat available for bio-energy when the price falls
In the Netherlands, feed wheat is cultivated for use in animal feed. Feed wheat could become available for bio-energy if the price is competitive; at present, this is not yet the case.

- C sugar is an interesting option with regards to price, but the supply is not constant or guaranteed

So-called C sugar, the sugar that is produced in excess of the price-guaranteed quota, comes onto the market at the lower world market price, and is thus a potential candidate for bio-energy. It should be noted that the supply of C sugar is variable, as it is a “residual product” for the grower.

- Oilseed rape offers opportunities if returns first improve

The actual available quantity of cultivated oilseed rape in the Netherlands appears to be limited for the time being, due to the low returns. Other crops still bring better returns for the grower, even under the most pessimistic scenarios of the Common Agricultural Policy. If the yields increase and/or the costs fall, there will be space for oilseed rape. There are optimistic noises from the practical sphere that this combination will make the cultivation of oilseed rape a more realistic prospect.

- Residual flows: an interesting prospect for bio-energy, but higher-quality applications are being sought first

Where the residual flows from agriculture and from the food, beverages and tobacco industry are concerned, the actual available quantity of biomass is greatly dependent on the alternative application possibilities. When these generate a higher yield price, the biomass flows in their direction and does not become available for bio-energy. It is a case of market effects, where the highest-quality application 'wins' as opposed to bio-energy. This can be seen particularly clearly in the residual flows from the food, beverages and tobacco industry of which, until recently, 85% was sold in the animal feed sector. Under the influence of the problems surrounding food safety, this has started to change, thus increasing the availability for bio-energy.

In short, the actual availability is much less than the potential availability
Our conclusion is that the potential quantity of biomass for the Netherlands is large, large enough to satisfy the demands of the biofuels directive. However, the actual quantity of biomass available for bio-energy is much less. Self-sufficiency at the Dutch level is by no means guaranteed.

7. Final remarks

The above conclusion shows that the availability of biomass for bio-energy is determined by market and economic forces. The actual availability of biomass is thus the result of these forces, which can develop in different directions. A study of the actual availability and market prices soon becomes outdated, simply because the market is constantly on the move. A '*tour d'horizon*' of possible development directions therefore complements this, indicating the directions along which biomass could become available. Meeusen et al. (2003) have looked at the forces with the most influence, within both the energy market and the agricultural market. The Memorandum on "Energy and Society" (*Energie en Samenleving*) and the study entitled "Interpretation of the IPCC scenarios for Dutch agriculture" (*Invulling van de IPCC-scenario's voor de Nederlandse landbouw*) for the RIVM (National Institute of Public Health and the Environment) include comparable factors for the energy sector and the agricultural sector that are influential and/or uncertain, namely:

- The degree of collaboration, and
- The economic development.

Both factors can develop in various ways, and four 'extremes' can be defined, within which the energy and agricultural sectors can operate. The four global scenarios are:

- Free trade
- Isolation
- Large scale solidarity, and
- Ecology on a small scale.

The situation for both the energy and agricultural sectors, as well as the combined production of energy from biomass is outlined in figure 1 for the four world views.

Figure 1: Overview of the four world views for agriculture, energy and energy produced from biomass

"Free trade": economics and money dominate, without national barriers *Biomass for energy in general* • All over the world, the production of and demand for biomass can be seen; there is a brisk trade in biomass for energy • The price of biomass for energy is low. • The Netherlands is a distribution country *Dutch agriculture* • The Netherlands produces in large-scale units, with the aid of the most advanced technologies, which increase production and reduce the cost price. This is a case of intensive production methods. • There is no longer any bulk production; the products must provide high added value.	Profit for here and now	"Isolation": gradual gain dominates within national and regional limits *Biomass for energy in general* • Aiming for self-sufficiency in order to be independent of others. • Local and regional energy provision • Sustainable energy thrives in order to reduce dependence on others. • Biomass for energy is limited – self-sufficiency with regards to food has a higher priority. • The environment in general is not important, though the local environmental impact is. *Dutch agriculture* • The EU continues to provide the agricultural sector with strong support in order to guarantee

• The Netherlands is characterised by large-scale underground greenhouses, dairy farming in industrial-style units where the cows remain indoors, and 'pig flats' (multi-storey pig accommodation). • The agricultural area is greatly reduced. *Biomass for energy in the Netherlands* Producing biomass at a very low price – competing with the world market price - in large-scale, intensive agricultural systems (particularly greenhouse horticulture, dairy farming and intensive livestock farming), making use of profitable technologies; public support for technologies does not play a role. Manure is available in large quantities and forms the most important basis for the production of bio-energy.		the self-sufficiency of food; • All sectors are declining, but that shrinkage is much less marked in arable farming, for example, than in the free trade scenario; • The emphasis is placed on the large, specialised, professional agricultural enterprises. *Biomass for energy in the Netherlands* Use of residual flows and manure from specialised agricultural enterprises and businesses from the agricultural sector to supply the rural community with energy with the aid of local/regional units.
Worldwide institutions		Local networks
"Large scale solidarity": global problems to be resolved together *Biomass for energy in general* • The Netherlands is a distribution country for energy. • The Netherlands is the world's chemical factory with a high level of attention for environmental management and energy efficiency. The use of renewable resources, including biomass, has largely replaced the use of fossil fuels. • Gaseous fuels that are attractive from an environmental perspective can be utilised easily and distributed within the remaining natural gas infrastructure. • Biomass produced in the Scandinavian countries on a large-scale. *Dutch agriculture* • The EU supports the preservation of characteristic European nature and landscapes by means of subsidies; • Multi-functional agriculture is supported; • Technology well accepted, as long as that technology contributes to sustainable agriculture; • More or less constant area of agricultural land; • Shrinkage in livestock farming. *Biomass for energy in the Netherlands* The agricultural residual flows from the chemical industry are used for gaseous fuels, distributed through the infrastructure formerly used for natural gas. The latest technologies are also used: technologies that fit in with economic growth and that contribute to sustainability. Sustainability is an important issue and new technologies are tested on this criterion first. Energy generated on the basis of grass on multi-functional dairy farms, where attention is devoted to nature and the landscape.	Profit for the world and for later	"Ecology on a small scale": global problems to be resolved locally *Biomass for energy in general* • Sustainable energy develops, as the Netherlands becomes more independent of others as a result. • Large-scale energy production units do not fit into the picture. • Biomass for energy is limited – and certainly not large-scale. • The natural gas network has been preserved. • The generation of energy must be sustainable and "socially responsible." *Dutch agriculture* • The production is extensive and organised on a small scale. A lot of attention is paid to aspects of landscape, nature and care; • No high-tech technologies; instead, clean technologies that fit in with the "natural character" of agriculture; • Slight decline in the area used for agriculture; most of the land remains in production on small-scale enterprises; • Extensification of production hinders the large-scale use of the agricultural land for non-food applications. *Biomass for energy in the Netherlands* Energy production on extensive, small-scale enterprises, supplying their own region. No new technologies will be used for this, only technologies that fit in with the concept of "natural agriculture." Residual flows are reused for energy production purposes; also on a small-scale, with clean technologies that have been labelled as "sustainable" in the social debate.

In the year 2004, a certain amount of attention has been devoted to the scenarios taking a globalised society as a basis. Large-scale production units are included, which need to be competitive. Biomass would be made available for bio-energy, alongside and in combination with "biomass for other applications" (food, animal feed); to this end, there are close interactions with the agricultural sector. In addition, a great deal of thought is devoted to the role of the Netherlands as an import country. New technologies may be helpful in this, particularly if the proposal is given a "sustainable" interpretation. The Shell Prize for Biofuels Research also fits into this picture, awarded to Swaaij (de Wit, 2004). Swaaij does not see much scope for the large-scale cultivation of energy crops within the Netherlands, and places the focus on technological developments and the organisation of the trade flows.

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10

TORREFACTION TO IMPROVE BIOMASS FUEL PROPERTIES

Definition of the problem
Torrefaction is a method for thermal pre-treatment of biomass, so that:
1. The calorific value per mass unit will largely be maintained;
2. The raw material gets a grinding quality similar to natural coal;
3. The raw material gets hydrofobic characteristics;
4. It is a method by which non-homogenic biomass streams gain more homogenic qualities;
5. It provides an extra step in the total conversion process because it involves a thermic pre-treatment at a temperatutre of 200 to 300 C.

Questions
1. Are the costs of an extra pre-treatment step in balance with the benefits?
2. In which sectots torrefaction can be applied?
3. Is it an interesting option to reduce biomass streams with a large diversity to a limited number of streams?
4. Will it facilitate the imports of biomass?
5. Which forms of cooperation are conceivable?

Jaap Kiel and Patrick Bergman, November 2004. Report on bus ticket no. A11, ECN

1. Introduction

Many (conventional) thermal conversion technologies require rather narrow feedstock specifications, which are difficult to meet by a wide range of biomass and biomass residue streams. For example, direct (co-) firing in pulverised-fuel boilers and entrained-flow gasifiers requires (sub-)millimetre-size feedstock particles. Size reduction down to this size is known to be difficult and expensive for many types of biomass, especially for (fresh) woody biomass due to its fibrous structure and tenacity. Furthermore, many biomass residues and biomass/waste mixtures do not meet the stringent chemical requirements set by conversion processes, e.g. with respect to alkali metals, chlorine or heavy metals.

In addition to the conversion process itself, also transport, handling and storage set certain requirements to biomass feedstock. In this respect, many types of biomass (residues) have inferior properties, such as low energy density, hydrophilic nature (high water uptake when stored in open air), poor flow ability, susceptible to rotting and heating.

ECN has identified torrefaction as being a biomass pre-treatment technique with a high potential for converting various biomass (residue) streams into biomass fuels, which meet the narrow specifications of different thermal conversion technologies. This concerns either torrefaction as such or torrefaction as one of the unit operations in so-called Multiple-Input-Specific-Output (MISO) concepts, by which a wide range of biomass (residue) streams is processes into a limited number of high and uniform quality biomass fuels. As a first step, it was decided to study the principles of torrefaction in more detail.

2. Torrefaction principles

Torrefaction is a thermal treatment at a temperature of 200 to 300 °C at near atmospheric pressure, in the absence of oxygen and at relatively long residence times (typically 1 hour). During the process the biomass partly decomposes giving off various types of volatiles. The final product is the remaining solid, which is referred to as torrefied biomass. The name torrefaction is adopted from the roasting of coffee beans (torrefier in French), which is however done at lower temperature while using air (oxygen). In the 1930's the principles of torrefaction were first reported in relation to woody biomass and in France research was done on its application to produce a gasifier fuel. Since then the process received only attention again when it was discovered that torrefied wood is a good reducing agent in metallurgic applications. This led to a demonstration plant, which was built in the mid eighties but was dismantled again in the beginning of the nineties.

Figure 1: Typical mass- and energy balance of the torrefaction process.
E = energy unit, M = mass unit.

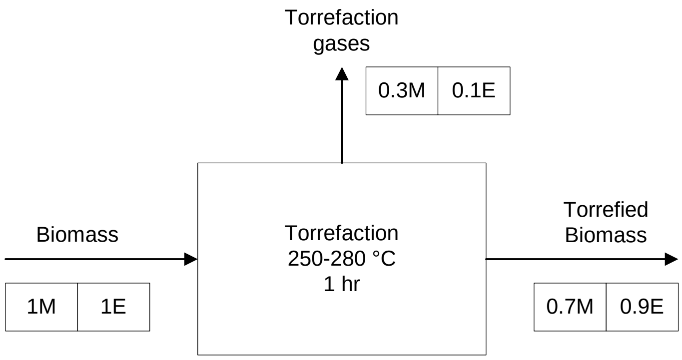


Figure 1 provides a typical mass- and energy balance of torrefaction. Typically, 70% of the mass is retained as a solid product, containing 90% of the initial energy content. The other 30% mass is converted into torrefaction gases, containing only 10% of the energy content of the biomass. Therefore, a considerable energy densification can be achieved, typically by a factor of 1.3 on mass basis. The energy yield in the solid product is considerably higher than for charcoal production or pyrolysis. The latter has a typical energy yield in the solid product of 55-65% in advanced concepts down to 20% in traditional ones.

Woody and herbaceous biomass consists of three main polymeric structures: cellulose, hemicellulose and lignin. Together these polymers are called lignocellulose. Hence the thermal decomposition of biomass is generally explained on the basis of these constituents. During torrefaction numerous reactions occur and different reaction pathways can be identified. However, all these reaction pathways can be grouped to a few main reaction regimes, as is shown in Figure 2.

For each polymer similar decomposition regimes can be defined. In temperature regime A biomass physical drying occurs. When the temperature is increased to regime C, depolymerisation occurs and the shortened polymers condense within the solid structure. A further increase of temperature to regime D leads to limited devolatilisation and carbonisation of the polymers and of the solid structures that were formed in the lower temperature regimes (*viz.* regime C). Again a further increase of temperature to regime E leads to extensive devolatilisation and carbonisation of the polymers and of the solid products that were formed in regime D. For lignin also a temperature regime is defined in which softening of this biomass constituent occurs, a phenomenon very beneficial in the densification of biomass, as softened lignin is a good binder agent.

Figure 2: Main physico-chemical phenomena during heating of lignocellulosic materials at pre-pyrolytic conditions (torrefaction).

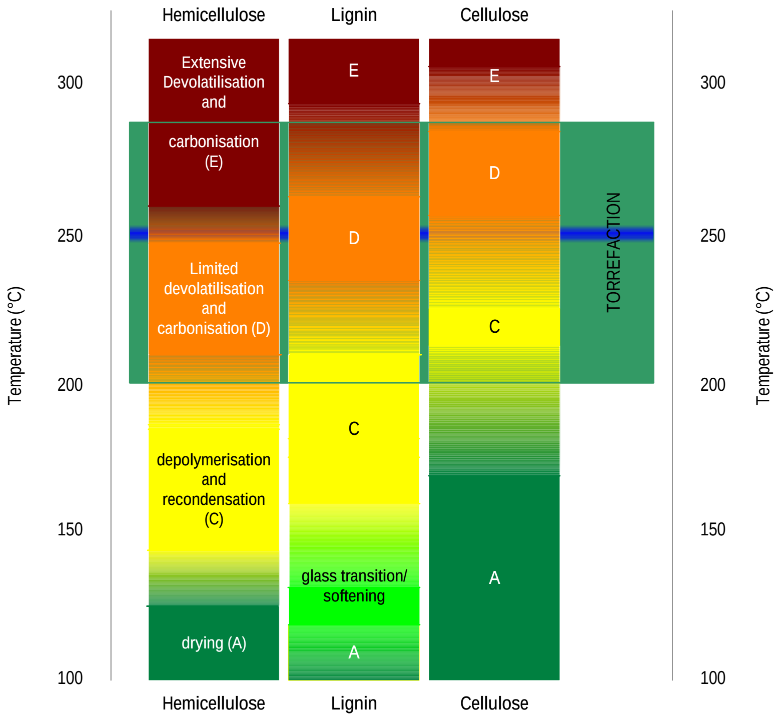
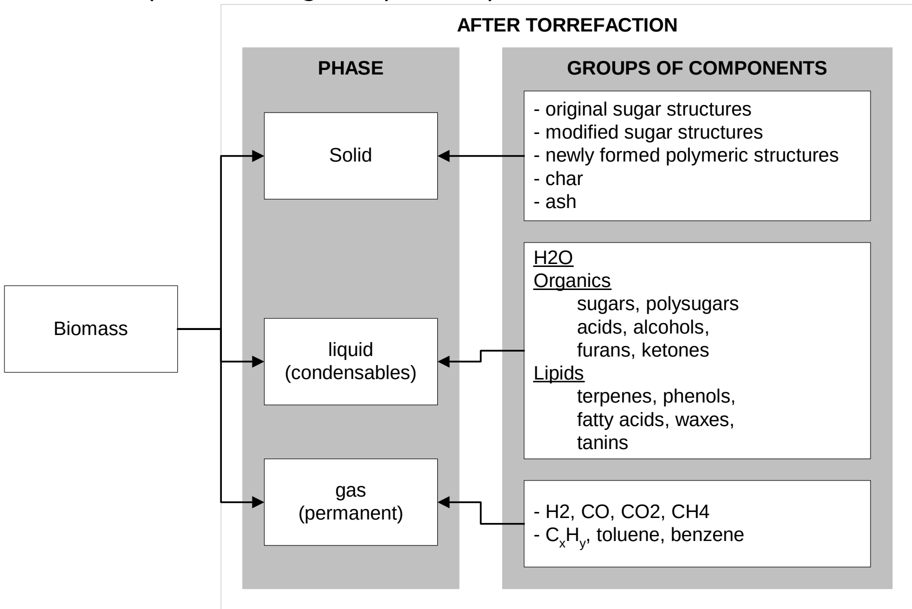


Figure 2 also includes the torrefaction temperature regime and the blue line splits it into a low (<250 °C) and high temperature regime (>250 °C). In general hemicellulose is the most reactive polymer followed by lignin and cellulose is most thermostable. In the lower torrefaction temperature regime the main biomass decomposition comes from the limited devolatilisation and carbonisation of hemicellulose. Minor decomposition is to be expected from lignin and cellulose except for changes, which do not lead to a significant mass loss. At higher torrefaction temperatures, decomposition becomes more vigorous as hemicellulose extensively decomposes into volatiles and a char-like solid product and also lignin and cellulose show limited devolatilisation and carbonisation.

During torrefaction numerous reaction products are formed. Their yield strongly depends on the torrefaction conditions (temperature, residence time) and on the biomass properties. Figure 3 gives an overview of the torrefaction products, classified based on their state at room temperature, which can be solid, liquid or gas. The solid phase consists of a chaotic structure of the original sugar structures and reaction products. The reaction products that remain solid are large modified sugar structures, newly formed polymeric structures with possibly a certain degree of aromatic rings, typical carbon-rich char structures and the ash fraction. The gas phase includes the gases that can be considered permanent gases. In general, these are compounds with a boiling point below –33 °C, but also light aromatic components such as benzene and toluene.

Figure 3: Products formed during torrefaction of biomass.



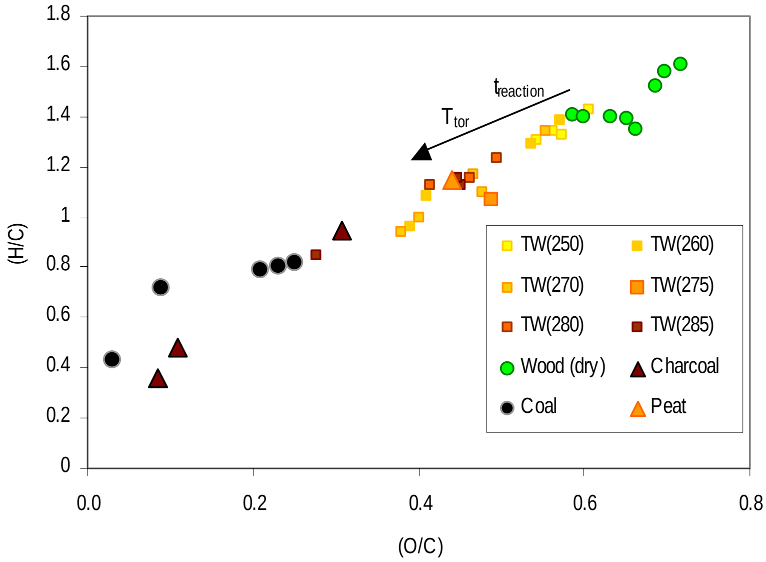
The condensables or liquids can be divided into three product groups. One group is reaction water as a product from the thermal decomposition (in addition to the freely bound water that has been released from the biomass by evaporation). The organics sub-group consists of organics that are mainly produced during devolatilisation and carbonisation (see Figure 2). The lipids are a group of compounds that are present in the original biomass and are therefore not really reaction products. This sub-group contains compounds such as waxes and fatty acids. Although these components are mainly liquids, some can be solid at room temperature.

One way to compare the characteristics of torrefied biomass with biomass and other conventional fuels is by using the Van Krevelen diagram, as shown in Figure 4. It can be seen that the highest H/C and O/C ratios belong to wood and the lowest belong to coal. Torrefied wood lies in between and the higher the torrefaction temperature (and/or the residence time), the more the composition moves from wood to coal. The elemental composition of torrefied wood produced in the higher temperature region is close to that of peat.

From Figure 4 it can be seen that, upon torrefaction, biomass loses relatively more oxygen and hydrogen than carbon. The main consequence of this is an increase of the calorific value. Depending on the torrefaction conditions, the net calorific value (LHV) is in the range from 18 to 23 MJ/kg (dry basis). For comparison, the LHV_{dry} of untreated wood, coal and charcoal is typically 17-19 MJ/kg, 25-30 MJ/kg and 30 MJ/kg respectively.

Another favourable feature of torrefaction is that the solid product becomes hydrophobic. Biomass is completely dried during torrefaction and after torrefaction the uptake of moisture is very limited (typically 1-6% wt). The main explanation for this is that, by the destruction of many OH groups in the biomass through dehydration reactions, torrefied biomass has lost the capability to form hydrogen bonding with water. In addition, more unsaturated structures are formed which are non-polar. The low water content and the hydrophobic nature largely prevent the torrefied product from rotting.

Figure 4: Van Krevelen diagram for torrefied wood (TW) produced under various conditions (torrefaction temperature indicated between brackets), untreated wood, coal, charcoal and peat.



3. ECN R&D programme

Although the principles of torrefaction are known, torrefaction of biomass for energy purposes has been applied only on demonstration scale and only for specific applications. Most attention was paid to its application in the metallurgic industry (mid. eighties) and to its application as a smokeless fuel in domestic uses (barbeque, cooking). Although this has led to a reasonable knowledge base and to the development of 'demonstration' technology, many aspects relevant to the application of torrefaction for upgrading biomass into biomass fuel for thermal conversion processes, such as co-firing in pf boilers, were not addressed. This includes:

- The scale of operation in relation to reactor technology and process layout. Given the required large throughputs (typically 50-100 kton/year), minimisation of the reactor residence time is an important objective. From literature, torrefaction is known to be a time demanding process (45-90 min), which inherently leads to high reactor costs and a limited scale of operation.
- The characterisation and quantification of product quality and how this relates to torrefaction process conditions. Especially the quantification of the grindability is an important, un-addressed topic, but also the combustion and gasification properties of torrefied biomass are not well known.
- The nature and quantity of possible emissions to air and water as a function of process conditions.
- The prospects of heat integration of process streams including the utilisation of the energy containing torrefaction gases.
- The economic viability of torrefaction as a biomass pre-treatment technique for bulk applications.

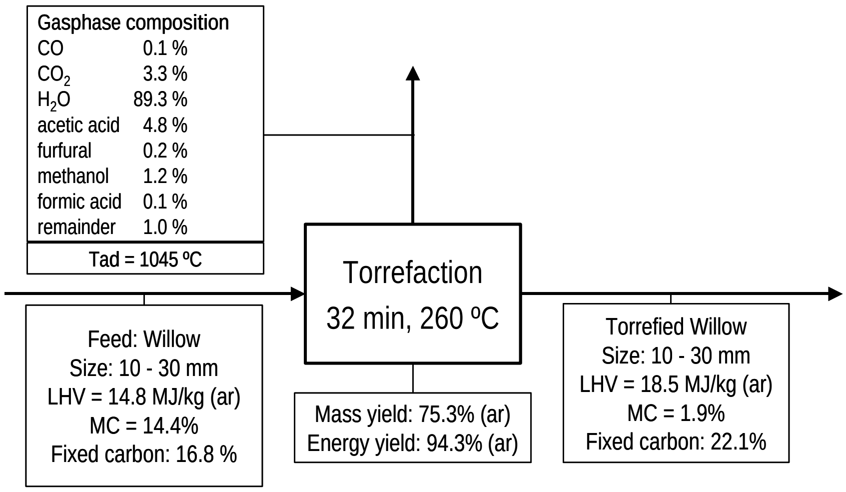
Therefore, it was decided at ECN to initiate an extensive R&D programme with the following main objectives:

- To determine the relation between product distribution, product quality and quantity, and important process parameters (e.g., temperature and residence time) through bench-scale parametric testing.
- To develop tools to characterise the solid and gaseous products.

- To characterise the combustion/gasification properties of torrefied biomass through lab-/bench-scale testing.
- To develop (optimised) reactor and process concepts and to perform detailed evaluations of the economic viability of torrefaction for various biomass (residue) streams and thermal conversion processes.

The parametric testing has been, and is being, performed in both a continuous, externally heated screw reactor and a bench-scale fixed-bed reactor, which is heated by a combination of trace heating and pre-heated nitrogen. The testing has resulted in a large data base on the torrefaction behaviour of a wide variety of biomass streams, including different types of fresh wood, demolition wood and straw, as a function of process conditions. Results of a typical torrefaction experiment are given in Figure 5, while and example of the liquid product yield is given in Figure 6. An important general finding is that the torrefaction residence time can be reduced substantially (down to 10 min.), while still achieving a good quality solid product. Furthermore, experiments with selected waste streams revealed the potential of torrefaction to improve the uniformity of the solid product and to reduce contaminant levels (e.g. chlorine and high-volatile heavy metals).

Figure 5: Results of a typical torrefaction experiment.



To characterise the grind ability of the solid product, a dedicated milling facility was set up, which allows the determination of the power consumption. In general, it appears for woody biomass, that the overall milling characteristics are largely improved by the application of torrefaction. Milling experiments showed that the power consumption can be reduced by 50-85%, depending on the applied torrefaction conditions (see Figure 7). Basically, in terms of required power consumption torrefied biomass becomes similar to coal. Simultaneously, the capacity of the mill increases by a factor of 2 to 6.5. Furthermore, these improvements are observed independent of the type of woody biomass (willow, larch, or beech). The improvements were related to the destruction of the hemicellulose by which the cellulose fibres in biomass become much more easily detachable. Moreover, the depolymerisation of cellulose shortens the length of the fibres. The largest improvements were obtained within the higher torrefaction regime (see Figure 2).

Figure 6: Liquid (condensables) product yield in torrefaction of willow at different conditions.

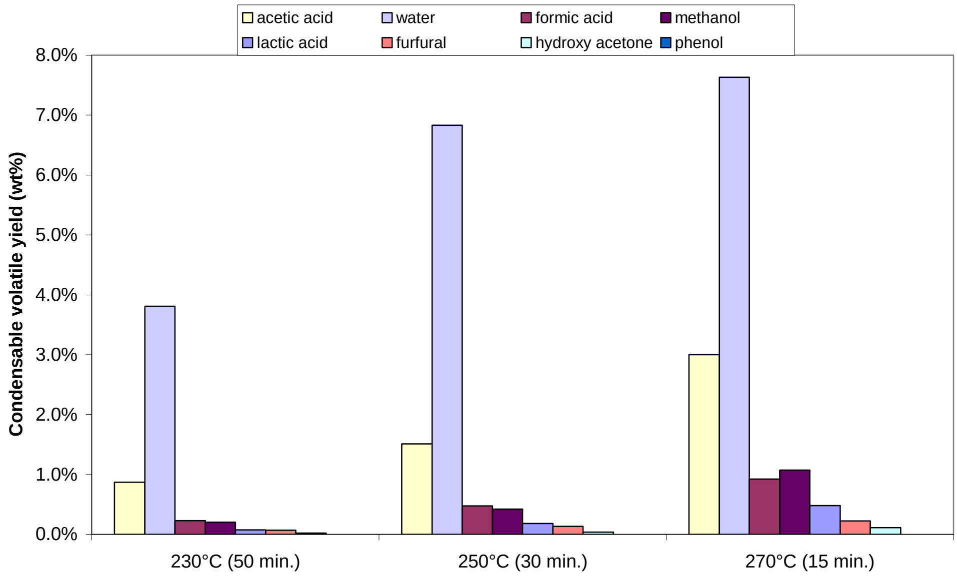
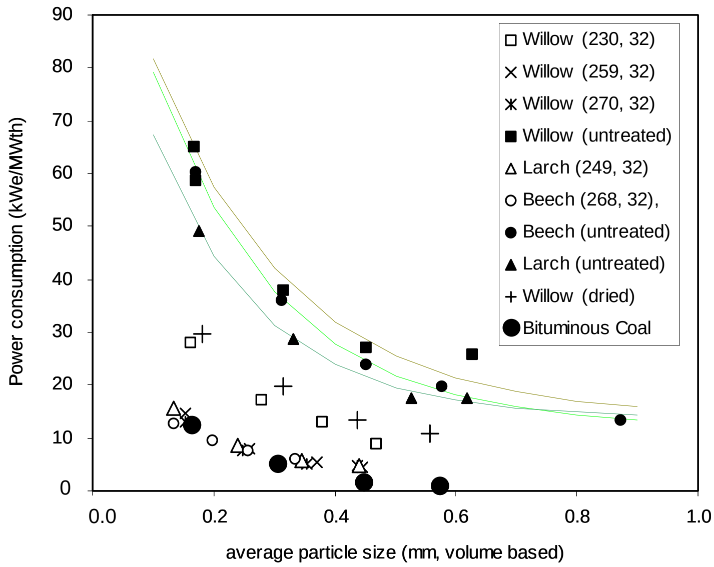


Figure 7: Specific power consumption when milling biomass, dried biomass, torrefied biomass and coal. For torrefied biomass, the torrefaction temperature (230-270 °C) and the torrefaction time (32 min) are indicated between brackets.

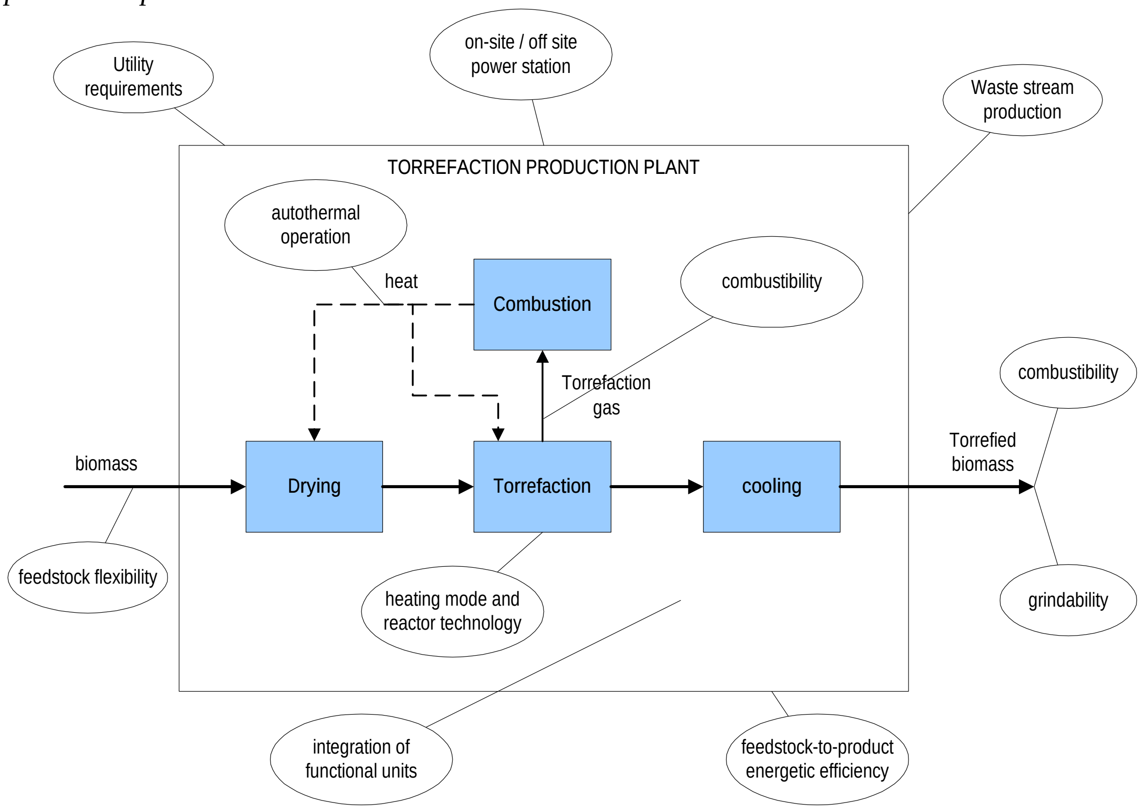


4. Reactor and process design

In parallel with the experimental work aimed at building up a quantitative knowledge base on torrefaction and new quantitative methods to characterise product quality, ECN focused as well on both reactor and process design. In general, given the bulk quantities that have to be processed, the torrefaction reactor should be rather simple and robust, and it should have a high throughput. Furthermore, particular attention should be paid to the heat input, with torrefaction being a slightly endothermic process. In the process design, proper treatment of the torrefaction off-gases and heat integration are main points of attention. However, actually a whole range of technical aspects has to be considered, as is shown schematically in Figure 8.

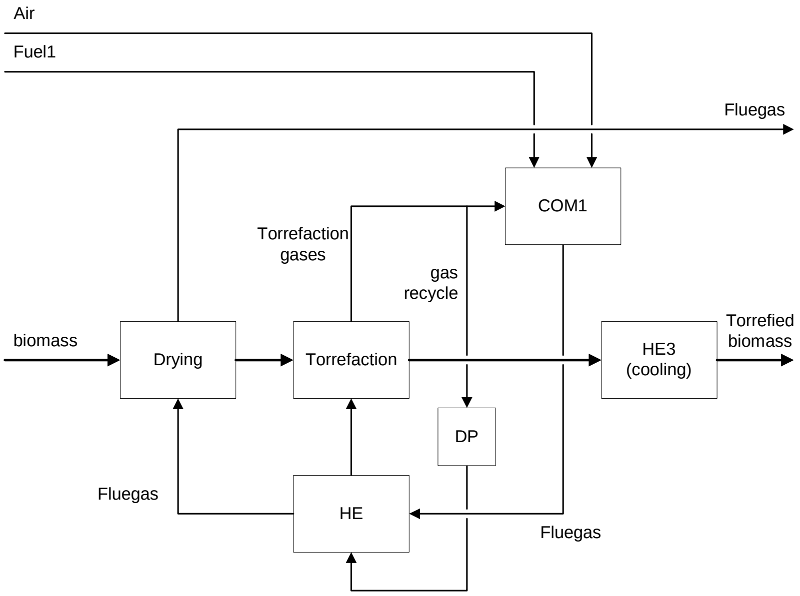
Taking into account this whole range of technical aspects has resulted in new reactor and process concepts, which are now ready for further evaluation and optimisation through pilot-scale testing. The reactor and process concepts are based on direct heating for the torrefaction step as being most energy efficient and leading to a more uniform product quality as opposed to indirect heating concepts. A basic process concept based on direct heating through a (hot) gas recycle is shown in Figure 9. The economic evaluation of torrefaction for different specific applications, based on these new reactor and process designs, has confirmed the large (economic) potential of this new pre-treatment technique.

Figure 8: Technical aspects to be considered for the proper design of a torrefaction production plant.



Finally, also work on the combination of torrefaction and densification (pelletisation) was started. Initial experimental work revealed that high quality pellets can be produced at similar cost than for conventional pellet production (although additional production costs are introduced by the torrefaction operations, considerable savings in the processing costs of size reduction, pelletisation and product storage are the result). The resulting pellets are of a higher quality in terms of calorific value, bulk density, energy density and hygroscopic nature (no water uptake, no swelling).

Figure 9: Basic process concept for torrefaction (and drying) based on direct heating.



5. Conclusions and further development (pilot-scale testing)

In conclusion, torrefaction has a high potential as a biomass pre-treatment technique in the production of biomass fuels for bulk applications (e.g. power production and the production of syngas as a feedstock for the production of transportation fuels and chemicals). Important advantages of torrefaction are:

- The grindability of biomass is largely improved (becomes similar to coal), allowing direct (co-) firing in pulverised-fuel boilers and entrained-flow gasifiers up to high percentages.
- The energy density on a mass basis, and in combination with a densification process also on a volume basis, is largely improved, which reduces transport, handling and storage cost.
- The product has low moisture content and has become hydrophobic, which allows open air storage and largely prevents it from rotting.
- The product is more uniform and contaminant levels can be reduced (e.g., chlorine and high-volatile heavy metals).
- Torrefaction in combination with pelletisation leads to high-quality pellets at no or hardly any additional costs, which can be used for domestic and small-scale applications.
- In comparison with other densification techniques, such as charcoal production and pyrolysis, the energy yield is considerably higher. This is of particular importance in case of biomass import from areas, where an energy surplus cannot be readily applied.

Finally, torrefaction also has a potential as a unit operation in biorefinery concepts.

Economic evaluation of torrefaction for different specific applications has revealed a large economic potential of this new pre-treatment technique.

Pilot-scale testing is now foreseen as the next step in the RD&D trajectory.

11

ADDED VALUE BY REFINING OF BIOMASS IN SOUTHERN AFRICA

Definition of the problem
In the mechanical refining of grass / weed a number of individual fractions can be separated, such as proteins, sugars and fibre. This process was invented by AVEBE and is still promoted by Johan Sanders (WUR). Protein components can be used for animal feed. The sugar-rich fraction can probably be converted to ethanol via fermentation. The fibre fraction could be used as raw material for products or as a solid fuel. Optionally, this fraction can also be converted to a liquid biofuel, e.g. via the Iogen route. AVEBE has developed the refining route to the pilot plant state and discontinued further development. This route might be an interesting option for small-scale application in developing countries.

Questions
1. What is the economic viability of the process? (should probably be addressed in a pre-study)
2. What does the future value chain look like?
3. What is the added value for the recovery of proteins / sugars and fibres?
4. What should a follow up project look like?
5. What are the ideas to finance a pre-study?
6. Which parties could be interested to take part in a consortium of a larger study?

Daan Goense, Johan Sanders and Wolter Elbersen, November 2004. Report on BUS ticket no. A24, WUR-A&F

1. Background

The shortage of fossil resources raises interest for renewable ones. This leads to rethinking of the classical production and processing methods towards closed loop processes that have minimal losses to the environment. Utilization for different purposes like feed and energy, show potential as both resources are saved and environmental benefits are gained. Fractionation of feedstuffs give better possibilities for precise dosing of animal feed-ratio's needed for optimal growth.
In Southern Africa, the animal production method is grazing from natural range. The available area per cattle unit varies from 2.7 ha in Zimbabwe to around 11 ha in most other countries. This indicates an underemployment of biomass present as pasture. The whole of southern Africa is also characterized by a long dry period resulting in feed shortages for cattle. Non-ruminant animals are low in number when compared to cattle due to high local prices for feedstock. This is the effect of low local production, indicated by the relatively low area of arable land.
Since several decades, leaves have been investigated as the source for proteins. Recently a pilot plant has been in operation in the Netherlands that fractionates grass and Lucerne leaves in three fractions: protein, fiber and juice that can be concentrated.
The possibility to extract protein from biomass for feeding non-ruminant animals, leaving sufficient protein in the cake to feed cattle during the dry period, with a potential to use residues for energy production, is worthwhile to investigate. The potential to produce more beef from both ruminants and non-ruminants will increase local economic development by the associated processing activities.

Methodology
To investigate possibilities for more efficient utilization of biomass resources in southern Africa research will be done to:

1. Analyses of the different process cycles with quantification of mass flows for at least three different processes:
    a. Classical feeding of ruminant animals for beef and or milk production.
    b. Separating biomass in a watery, protein rich fraction and a press cake, containing still some protein. This will be our base case for further implementation.
    c. Full fractionalization of biomass through bio-refinery and splitting up in its main components.
2. Description of applicable technologies for above mentioned process cycles.
3. Inventory of biomass sources in different regions of Southern Africa, under natural and farming conditions.
4. Potential markets for products in Southern Africa.

Methods for biomass processing
Energy conservation is the main reasons to press grass for mechanical removal of moisture, in advance of a drying and palletizing process. This is done in grass drying factories in the Northern part of Europe (Andersen and Kiel 2000). In the Netherlands the Prograss consortium operated a pilot plant for bio-refining grass for protein, a sugar rich concentrate and fibers.
Grinding of grass, followed by pressing, produces leaf protein concentrate (LPC). From the juice, the protein is recovered by coagulation through heating the juice.
In Austria a process is developed in which a fermentation process is initiated, which is part of the ensiling process, called solid fermentation.

Availability of biomass
Table 1 shows that the area with permanent pasture and the low cattle density has a high potential to deliver biomass. This area is now extensively grown with grasses that do not meet the nutritional requirements of ruminants for maximum production. The main limitations are availability of green feed for at least half of the year in seasonally dry regions, and low nutritive value during most of the season of active growth. ('t Mannetje ,1981). So, both improved cattle production or biomass refining require nitrogen input either by means of fertilizers or leguminous crops

For a case for Western Province of Zambia it is possible to grow 18.5 ton DM per hectare during the rainy season from October to April, with adequate fertilization. (see Figure 1) The pasture is harvested in five cuttings with yields of 3.5 – 4.1 ton DM/ha/cutting. N-fertilizer efficiency is assumed to be 0.7. A protein content of 8% requires 340 kg N/ha/season, and a protein content of 15% requires 635 kg N/ha/season.
Use of a leguminous crop is studies for the case of Mucuna. This crop can produce 8 ton dry matter per hectare with a protein content of 22 percent, while binding its own nitrogen requirement. A growing period of 3.5 months allows to produce one grass cutting after the Mucuna is harvested. This grass can utilize the nitrogen left in the soil by the preceding Mucuna crop.
Mucuna contains a substance, L-Dopa, which is of toxic character and must be removed. Because heating plays an important role in L-Dopa removal, proposed processing might solve this issue.

Figure 1: Rainfall distribution in southern Africa after SADC.

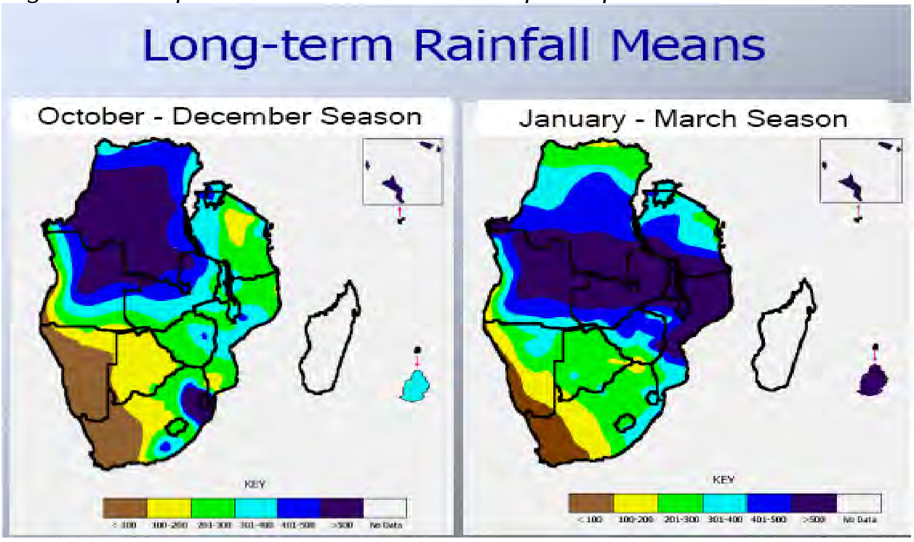


Table 1: Land utilization and the number of animals in southern African countries

	Angola	*Zambia*	*Mozambique*	*Namibië*	*Botswana*	*South Africa*	*Lesotho*	*Swaziland*	*Zimbabwe*
Total Land	*124,670*	*74,339*	*78,490*	*82,329*	*56,673*	*121,447*	*3,035*	*1,720*	*38,685*
Agricultural Area	*57,300*	*35,289*	*48,435*	*38,820*	*25,980*	*99,640*	*2,334*	*1,390*	*20,550*
Arable	*3,000*	*5,260*	*4,200*	*816*	*370*	*14,753*	*330*	*178*	*3,220*
Permanent crops	*300*	*29*	*235*	*4*	*3*	*959*	*4*	*12*	*130*
Permanent Pasture	*54,000*	*30,000*	*44,000*	*38,000*	*25,600*	*83,928*	*2,000*	*1,200*	*17,200*
Cattle (heads x 1000)	*4,150*	*2,600*	*1,320*	*2,509*	*1,700*	*13,600*	*540*	*580*	*5,753*
goats(x 1000)	*2,050*	*1,270*	*392*	*1,780*	*2,250*	*6,850*	*650*	*422*	*2,970*
sheep(x 1000)	*340*	*150*	*125*	*2,370*	*400*	*29,100*	*850*	*27*	*610*
Cattle unit(x 1000)[52]	*4,628*	*2.884*	*1.423*	*3.339*	*2.230*	*20.790*	*840*	*670*	*6.469*
Ha/cattle unit	*11.7*	*10.4*	*31*	*11.4*	*11.5*	*4.0*	*2.3*	*1.8*	*2.7*
Chickens (x 1000)	*6,800*	*30,000*	*28,000*	*2,600*	*4,000*	*120,000*	*1,800*	*3,200*	*22,000*
Pigs(x 1000)	*780*	*340*	*180*	*22*	*8*	*1,620*	*65*	*30*	*605*

Crop residues are, given the relative small acreages, not considered as a source for biomass.

Description of process cycles

1.1 Grazing

The simplest process is feeding cattle by grazing. By good pasture management it is possible to supply cattle with good quality feed. This involves fertilizing to obtain a

[52] 5 sheeps or goats in one cattle unit.

sufficient high protein content (minimal 8% DM basis) in combination with regular grazing or cutting to enforce young biomass. Grazing results in losses of about 30% due to trampling etc.

Measures must be taken to overcome the dry season. During the rainy season, part of the fields can be harvested and ensilaged for later use. A practical method is to use round balers with a foliage wrapper. The bales can be left in the field and opened when required during the dry season. As temperatures allow cattle to stay outdoors, this process does not involve transport and use of storage space.

Quantities
Our calculations are based on an average DM uptake of 7.5 kg/day/cattle unit with at least 8 % protein content (DM basis). The rainy season in Western Province of Zambia covers 155 days, which makes that with a harvesting efficiency of 70% by grazing, 90 hectare grass is required for grazing and 85 hectare for silage making to feed 1000 cattle units.

1.2 Biomass separation

Separation involves pressing fresh or ensiled biomass, which results in a protein rich effluent and a cake. Protein can be separated from the effluent after coagulation. The cake can be fed to cattle during the dry season, but should contain a protein level of at least 8% for adequate uptake.

Two sources of biomass are evaluated. i.e. grass and Mucuna with a protein content of respectively 15 and 22 percent on dry matter basis. The composition of both products, before and after pressing to a dry matter content of 50% is given in Tabel 1. It is assumed that 80% of the protein is soluble in water and that all soluble components are proportionally divided with the water over juice and cake.

Table 2: Composition of biomass sources grass and Mucuna and its product

.	Grass	Grass juice	Grass cake	Mucuna	Mucuna juice	Mucuna cake
Water	800	665	135	800	659	141
Protein	30	20	10	44	29	15
Sugar	30	25	5	10	8	2
Fat	20	17	3	10	8	2
Fiber	120	4	116	136	14	122
Total	**1000**	**680**	**320**	**1000**	**718**	**282**

The protein in the juice must be either chemically or thermal coagulated for successful separation. In respect of energy requirements, a chemical method is preferred. Separation is done by decanters, resulting in a paste of protein, some fiber, and fats with a total DM content of 45%. This paste can be fed to pigs as protein source in their feed, but direct conservation of this protein substrate is required, which can be done by lowering the pH to 4 or by drying. Energy wise, the former method is preferred.

When processing ensiled biomass during the dry season, a significant part of the produced cake can be directly fed to cattle. Overproduction of cake during the dry season and all production during the wet season should be ensiled for later use as feed.

Quantities
Based on the compositions given in table 2, a press capacity of 25 ton/hour wet biomass, plant operation of 3330 hours a year and the yields mentioned in paragraph 3, an area of around 410 hectares should be grown with grass and harvested 5 times from December till April. This results in 83,270 ton wet biomass (20% DM), ending up in 13,350 ton DM in

the cake which contains 900 ton protein and 1598 ton protein in the paste. A protein poor effluent of 46,600 ton, containing 2000 ton sugar remains. (Sugar concentration largely depends on grass varieties)
Based on an uptake of 0.4 kg protein uptake a day, 12,876 pigs can be fed from the protein, while 8476 cattle units can be fed from the cake during the dry season. (This amount of cattle requires an additional 760 hectare for feeding during the wet season)

When a mixture of grass and Mucuna is used, on an area of 1,853 ha, 3 cuttings of grass and one cutting of 1368 ha Mucuna are realized. (part of the grass is grown after Mucuna). This biomass source produces 2135 ton protein as paste and 1130 ton in the cake. It is possible to feed 17,205 pigs and 7,800 cattle units.

1.3 Full fractionalization

For full fractionalization of biomass it is required that the biomass is crushed. Seen the large variety of processing steps and resulting products, this line is not worked out in detail. Under the assumption that all protein will be separated and can be used as pig feed, it is possible to feed from the areas Mucuna and grass mentioned in paragraph 0 a number of 27,120 pigs.

1.4 Nutrient balance

To compensate the 384 ton nitrogen removed from the fields as 2400 ton protein in the case with 882(=4409/5) ha grass, an amount of 573 tons of nitrogen must be supplied to the fields, as 70 percent efficiency of supplied nitrogen is used.
The pigs and cattle excrete 53 percent of the consumed protein, which results in 211 ton nitrogen in manure. When this manure is applied on the fields, an amount of 362 tons must be supplied as fertilizer.
In the case of a grass – Mucuna mixture, there is no need for N input in the leguminous Mucuna crop, and also not on 670 ha of grass grown after Mucuna. For the remaining grass an amount of 102 tons of Nitrogen are required. The excreted amount of 276 tons Nitrogen in manure is more then sufficient to compensate nitrogen removal. A good balance between the amount of grass and Mucuna should be looked after to prevent potential pollution problems.

1.5 Energy

A strong point in biorefining is the utilization for different purposes. Apart from a protein source, remaining sugars can be used as energy source.
Energy input is required by:

- Eventual fertilizer input, (68.41 MJ/kg) = 24,764GJ for grass, 0 for Mucuna grass mixture
- Fuel to drive agricultural machinery (31.3 l/ha for grass ad 35,700 kJ) = 4,928GJ and (38,6 l/ha mucuna) = 3,510GJ for the mucuna grass mixture
- Energy to drive the processing plant. 112,700 l diesel = 4,023,GJ

1.6 Technology to implement the processes

Harvesting involves:

- Cutting of the grass, for which preferably a mower conditioner is used, as this process breaks the leaves and stems so that separation is facilitated.
- Windrowing of grass for efficient collection
- Collection by means of a round baler. This is preferred above other systems as matching of transport on collecting is not critical. For silage making, the bales will be

wrapped in a foil. An eventual alternative is the use of self loading wagons and silage in soil covered, horizontal silo's.

Tractors and agricultural machinery are required for harvesting and transport. Determination of optimal numbers requires optimization, taking seasonal constraints into account. In this study optimal efficiency for all types of machinery is assumed to estimate machinery cost for harvesting. This is set at $ 48.- /ha, from which $ 20.- ha is for fuel. (1 liter diesel = 1 $)

An open screw press does **pressing**. This requires relatively little power when compared to closed ones, but poorer extraction leaves the required amount protein in the cake.

The open screw press needs an investment of $ 60,000,- and results in hourly operating cost of $ 16,- from which half is fuel cost. (1$/liter)

Separation of the protein is by two decanters of 7.5 m3 each. This requires an investment of $ 200,000.- and $ 48,- /hr operating cost, from which also half is fuel cost. (1$/liter).

2. Financial aspects

In a grass-based system, the total expected cost is 354, 395 and 208 thousand dollars respectively for N fertilizer, machinery and processing. This results in a price of 383 $/ton protein.

In the grass Mucuna mixture these cost are 302 and 208 thousand dollar for machinery and equipment. There is no cost for N fertilizer. This results in a price of 150 $/ton protein. This global calculation does not yet include labor cost, cost of housing and some farm operations like manure hauling, P and K fertilizers and the use of chemicals and storage space. This would require an extensive optimization routine to determine realistic quantities, which are out of the scope of this study. However optimization will also lead to lower cost as calculated yet.

Compared to a price of 450 $/ton protein from soybean meal, there is sufficient room in the price of the Mucuna grass mixture.

Products and potential markets

An important market is protein to supply both ruminants and non-ruminants with adequate levels. This market is an indirect one, as the main pull comes from beef and pig meat and chicken meat consumption.

From Tabel 1 it can be concluded that for Zambia 20 processing units are required to cover feed requirement for the present number of pigs. This reflects the relative low pig meat production compared to beef. Cheaper protein sources have the potential to change this market, but it requires a market analyses in respect of acceptability.

3. Conclusions

There is a large land area in Southern Africa that can be used for biomass production. This can be realized by improving the present natural grass area to managed grasslands, but also by growing leguminous crops.

Leguminous crops play a key role in reducing cost and energy as the input of fertilizers are the largest cost factor and energy input in a sole grass biomass production system.

Heating and drying are an important energy consumer, so chemical coagulation and conservation means are preferred methodologies.

Based on cost of the main components in the system, there is a good basis for a system based on a Mucuna and grass mixture as biomass source. With a more complete cost calculation to be performed, there are good opportunities to keep leaf protein competitive with sources from soybean meal.

Energy production from the sugar rich effluent requires input of additional sugars for economic operation. This can be achieved by adding cassava starch as a source. This can be a valuable combination with cassava as energy source in pig feed, as the energy content in protein paste is low.
Market preference for pig meat and poultry are an important factor in the scale of operation that can be reached in the different African countries.

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12

BIO-FUELS IN DEVELOPING COUNTRIES

Definition of the problem
During the 2nd World conference for Biomass and Climate Change in Rome (May 2004) developing countries were considered large potential suppliers of biomass. Unemployment in these often rural areas is high. Developing processing capacity for bio-fuel production at local level in developing countries will contribute to local (non-rural) livelihoods and employment. Bio-fuels were suggested as a serious alternative for (often imported) mineral oil based products. Small-scale schemes converting biomass to bio-fuels might be of interest. The World Bank and the FAO support this approach.

Questions
Obtain insight into the criteria for bio-fuels to contribute to local livelihoods
Get insight in the crops suitable for first and second generation bio-fuels[53] (Which plant species are preferred? Small-scale, no competition with the food chain, sustainable, e.g. Jatropha, Cassave)
What would be preferred regions to grow these crops?
How to implement interesting schemes in a sustainable way (focus on people-component)

Gerdien Meijerink, Wolter Elbersen, Marieke Meeusen, November 2004. Report on BUS ticket no. A23, WUR-LEI and WUR-A&F

1. Energy crops

Besides using agricultural, livestock and forestry residues as sources of bio-fuel, there are also specific crops that can be cultivated as “energy crops”. Energy crops can be produced in two main ways: i) as dedicated energy crops on land specifically devoted to this purpose and ii) intercropping with non-energy crops. The way crops are produced has implications for the farming systems (see section on people dimension).

Here we will focus mainly on energy crops for transportation fuels. It is important to distinguish first and second generation bio(transportation)fuels.

The first generation bio-fuels are currently (technically) available. For gasoline motors ethanol is the main option as bio-fuel. Ethanol is currently produced by fermentation from sugars and starch. This means that any starch or sugar containing by-products and crops can be a source. Still, some crops are specifically grown for the purpose of ethanol production. Currently the main crop used for ethanol production is sugar cane, but other crops are also seriously considered. Often both sugar and ethanol are produced in sugar cane mills, because this is more efficient than producing sugar or ethanol separately. An increasing number of third world countries is producing or considering ethanol production specifically for fuel. The prime example is Brazil which has been producing ethanol from sugar cane as a fuel since 1975 (See for a description of the Brazil ethanol programme: http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/AD430E/AD430E00.HTM)

A number of countries produce or are considering production of ethanol for fuel purposes. Examples are China, Thailand, Argentina, Peru, Mexico, Colombia, South Africa (see annex 2). Motives for ethanol for fuel utilisation are environmental benefits such as prevention of air pollution (smog, lead, etc), less dependency on oil imports and support of

[53] First generation: ethanol from starch and sugar, and fatty acid methyl esters. Second generation: lignocellulose biomass

farmers. In table 1 an overview is given of the world ethanol production and outlook for 2010. Table 2 shows which third world countries are expected to make a contribution to ethanol production.

Table 1: World ethanol production in tonnes x 1000.

Region	**1990**	**1995**	**2000**	**2006**	**2010**	**Growth Rate** 1990/2000	**Growth Rate** 2000/2010
World Total	**18 391**	**19 418**	**19 284**	**25 192**	**26 768**	**0.4**	**3**
Brazil	12 028	12 700	10 900	14 268	14 017	-0.9	2.3
OECD Countries Total	3 487	3 789	5 129	7 214	8 790	3.6	5
United States	2 216	2 540	3 999	5 905	7 359	5.5	5.7
EU 15	1 144	1 121	1 002	1 174	1 293	-1.2	2.3
Mexico	126	128	128	135	137	0.1	0.7
India	1 175	1 434	1 985	2 290	2 434	4.9	1.9
China, Mainland	43	125	200	212	220	15.1	0.9
ACP Countries	14	18	21	24	26	3.8	1.8
Thailand	77	86	90	94	97	1.4	0.7
Former USSR	191	393	263	286	302	2.9	1.3
Rest of World	1 377	873	697	803	881	-6	2.2

Source: FAOSTAT (1990,1995,2000)

In annex 2 a discussion is given of recent developments in third world countries.

Table 2: The most important ethanol crops in the developing world

Crop	**Where?**	**Yields?**	**Remarks**
Sugar cane	All tropical and sub-tropical areas. Brazil is largest producer	Up to 4500 litre ethanol/ha/year	C4 grass, sugar crop. By far the most important crop
Cassava/ Tapioca	All tropical areas. Thailand is largest producer of ethanol from tapioca.	Up to 6700 litre ethanol/ha/year	Tuber starch crop. Adapted to low fertile soils.
Sweet sorghum	Also suited for milder climates (China, southen Europe?)	Up to 6500 litre ethanol /ha/year	C4 grass, sugar crop, will grow in temperate areas where sugar cane is not an option.
Grain crops (corn, wheat, etc)	China, Thailand		These are not specific energy crops.

See http://www.praj.net/article2.htm and other sources.

For diesel motors the main options are fatty acid methyl esters or pure plant oil (the first diesel motor ran on pure peanut oil). This means that in principle any oil can be used, though quality factors such as clouding point determine suitability. In annex 3 a list of oil crops is given. It appears that contrary to ethanol many different crops are considered. It is interesting to note that the highest yielding crops are all tree crops such as Palm oil, Jatropha and Castor bean. It seems that due to smaller scale and cheaper processing options oil crops for biodiesel may be easier to implement in poorer developing countries.

Second generation bio-fuels are mainly based on lignocellulose biomass from which a much wider range of fuels can be produced to replace diesel, gasoline or completely new systems like fuel cells
The most important second generation bio-fuels are lignocellulosic ethanol and Fisher Tropsch biodiesel. Still other fuels like methanol, buthanol, pyrolysis oil and biogas and in the future also hydrogen may be considered.

As feedstocks most agricultural by-products and residues can be used. Specific crops for second generation biofuels will generally be lignocellose crops. Dedicated crops suitable for second generation bio-fuel are therefore any crop that can produce large quantities of biomass at low cost that are easy to handle and process. They should have low input/output ratios. Overall cropping systems should have:

- High water use efficiency (kg water per kg DM)
- Low fertiliser use
- Low pesticide use
- Low labour use
- Low machinery use
- Low soil requirements
- High yields per ha

The demands mentioned above will generally exclude rotation crops as these require yearly planting or seeding and related inputs. As in Europe and North America, crops for second generation fuels will be perennial lignocellulosic crops such as C4 grasses and trees. Compared to C3 crops C4 grasses have a more efficient photosynthesis system allowing to utilise sun light more efficiently and use water more efficiently. Additional advantages are the lower ash content, because as ash content is related to water use and a lower (N) nutrient requirement.

Some crops that have been specifically mentioned for linocellulosic biomass production in developing countries are: Vetiver grass (C4), Miscanthus (C4), Arundo donax (C4), Switchgrass (C4), Bamboo (C4), Eucalyptus (Tree).

2. Technologies

During the last decade a wide range of technologies and expertise has been developed to convert biomass into heat, electricity and bio-fuels (Sims, 2002). Each type of conversion technology has its specific characteristics that impose certain restrictions on the biomass. The main requirements concern moisture content, degree of pollution/ash content, chemical composition, structure and shape and required pre-treatments. This means that there is a direct link between the technology used to convert biomass into bio-fuel and the production of biomass by farmers. This has implications for farming systems, as we will discuss in following sections.

For developing countries, large scale power plants are often not feasible due to the large investment costs, and required capacity in terms of supply of biomass, transport, infrastructure etc which is often not available in (poor) countries. Of the biomass conversion technologies, combustion is more suitable for large scale power plants than gasification (Annevelink et al., 2004).

Small scale power plants would suit many developing countries. However, gasification, which could be an option for small scale power plants, still needs a lot of technical effort to achieve a somewhat higher energy efficiency and the operation of a gasification installation requires certain skills (Annevelink et al., 2004).

Ethanol and second generation energy crops and conversion chains require sophisticated technology and investment making them generally unavailable for poorer developing world countries. As is already the case, more developed countries with large agricultural potential such as Brazil, Malaysia and Thailand are the countries implementing ethanol and second generation transportation fuels.

Oleiferous crops are relatively easy to grow, process and distribute and may therefore be suited to poorer developing countries.

3. A checklist for assessing the sustainability of biomass for energy

The role of biomass for energy purposes

The WEC (2005) states that it is difficult to predict at this stage what will be the future role of biomass specifically grown for energy purposes. This is, in many ways, a new concept for the farmer and we will discuss a few issues in the next sections. If large-scale energy crops are to form an integral part of farming practices, it will have several implications for farming systems.

In the past decade a large number of studies has aimed to estimate the global potential for energy from future energy forestry/crop plantations (WEC, 2005). These range from about 100 million ha to over a billion ha, e.g. Hall et al (1993) estimated that as much as 267 EJ/yr could be produced from biomass plantations alone, requiring about one billion hectares. However, it is highly unlikely that such forestry/crops would be used on such a large scale, owing to a combination of factors, such as land availability, possible fuel versus food conflict, potential climatic factors, higher investment cost of degraded land, land rights, etc. The most likely scenario would be at the lower end of the scale, e.g. 100-300 million ha.

The agricultural and technological possibilities for bio-fuel production in developing countries often do exist. However, the implementation of technological solutions in these countries are usually obstructed by different socio-economic factors, that reflect general conditions in many developing regions, for example, complex or disputed land ownership, lack of roads or other means to transport biomass to processing facilities and bio-fuels to markets (Larson & Williams, 1995). Despite these technical, socio-economic, political, and other difficulties, however, proof of the potential for growing energy crops on degraded lands can be found in the many successful energy plantations that already exist in developing countries.

A framework for a sustainable production of biomass for energy purposes

When a (new energy) crop is introduced into a farming system that can be used as a bio-fuel, there will be several implications that need to be taken into account to ensure that the energy crop will contribute to sustainable local livelihoods and not (unintentionally) leads to negative effects.

According to the FAO, a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and when it contributes net benefits to other livelihoods at the local and global levels in the short and long term (Hardaker, 1997). We put sustainable livelihoods in the context of sustainable agriculture.

Sustainable agriculture fulfills the following criteria (Hardaker, 1997):

- Meeting the basic nutritional requirements of present and future generations, qualitatively and quantitatively, while providing a number of other agricultural products.
- Providing durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production.
- Maintaining and, where possible, enhancing the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or causing contamination of the environment.

- Reducing the vulnerability of the agricultural sector to adverse natural and socio-economic factors and other risks, and strengthening self-reliance.

We will address these issues under the following headings:
- Issues concerning the use of inputs
- Issues concerning the processing, transport and marketing of outputs

These issues will be assessed in the next paragraphs.

4. Use of inputs

Resources in developing countries are in general scarce. Introduction of a new crop is often at the expense of other crops, because of stringent land, labour or cash constraints. The effects of substitution are all locally specific, because of the type of substituted crop, type of substituted land/area are locally specific.

However, if it concerns an existing crop which has a new application, it may result in creation and opening up of new markets for farmers – e.g. for sugarcane or maize farmers (from which ethanol can be produced).

Land

Land is one of the most important inputs in agriculture. It encompasses two dimensions: quantity (amount of land, or area) and quality (soil fertility). Land of good quality (high fertility) is often a scarce resource, and the most important crops (often the most profitable) are usually cultivated on good quality lands. Because the area around the homestead usually received most (organic) fertilizer such as manure[54], this area is also frequently the most fertile. Crops that are more extensive are usually cultivated on land that is further away.

To minimise competition between agriculture and energy production, a number of analysts have proposed that developing countries target degraded lands for energy production (Johansson et al., 1994). Grainger (1988) and Oldeman et al. (1991) have estimated that developing countries have over 2,000 million hectares of degraded lands, and Grainger estimates that some 621 million of these are suitable for reforestation. This is consistent with estimates that previously forested area suitable for reforestation amounts to 500 million hectares, with an additional 365 million hectares available from land in the fallow phase of shifting cultivation. However, large-scale harvesting of biomass will lead to nutrient depletion and if not replenished will lead to greater degradation of land.

Fertilisers

If substantial amounts of biomass are harvested, this will lead to nutrient depletion of the soils, which needs to be replenished by (in)organic fertilizers. This involves an additional investment if the farmer does not want to deplete the soil. In many poor countries, fertilizers are too expensive to be profitable. It therefore depends on the relationship between output prices (for bio-fuels) and input prices (fertilizer) whether use of fertilizer is feasible In many poor countries the infrastructure and institutions to deliver inputs (seeds, fertilizers etc) are not there.

If nutrients are not replaced, growing bio-fuel crops can lead to extensive nutrient depletion, which has been shown to result in (severe) erosion.

Water

Water may be another restrictive factor, if the bio-fuel crop is a water-intensive crop. In many poor countries investments in water pumps or other technical means to obtain water are not feasible due to lack of funds.

[54] This is due to transport constraints of manure to fields that are far away

Labour
Labour is another important input factor. Although in many rural areas, there is (hidden) unemployment, labour can be restrictive factor during peak, harvesting days. Poor rural households are not always able to hire labour due to financial reasons. The distinction between male and female labour is also important when assessing labour availability. Some work is done by men and other by women – they are not always substitutable.

Labour is used for growing the crop – from preparing land to harvesting. But labour is also used for post-harvest activities such as storage and processing. The amount of labour available for these activities is important, but also the necessary skills. Does the bio-fuel crop require special skills for cultivation, storage or processing?

Residues
It is often claimed that residues of crops can be used for bio-fuels. However, in many developing countries these residues are already used for a number of purposes, such as livestock fodder, green manure (i.e. organic fertiliser), food (such as cassava leaves). Resources are scarce in most developing countries and there are often no residues that are simply discarded. Most residues have a function in the farming system.

Other investments
The last issue to consider are other investments not covered above, such as necessary tools to harvest bio-fuel crops, or processing facilities. If additional investments are needed, this may pose additional constraints to (poor) farmers.

5. Processing, marketing and transporting outputs

The example of bio-fuel (sugarcane) in Brazil (see annex) teaches us that how and where the biomass is processed has important implications. Goldemberg and Johansson (1995) argue that most discussions of the energy sector have focused on supply-side issues only, but that the whole chain is important from collection and extraction of primary energy, which is converted into energy carriers suitable for the end-use. Thus, production of bio-fuels cannot be analysed in isolation of processing. However, processing of bio-fuels may signify agribusiness opportunities for the region, if necessary capacity (in terms of skills, investments, infrastructure etc) is available.

In Africa agro-industrial enterprises are relatively rare, while in Asia and Latin America there is a much longer tradition of processing agricultural products (Vellema, 2004). For Africa, the opportunities for producing large-scale bio-fuel will therefore be limited.

With respect to the type of output, it is important to consider which product of a crop is used for bio-fuel. Is the whole crop harvested or are only by-products harvested? In the latter case, are the remaining parts of the crop useful to the household, or can they be sold as well? In this case, additional income can increase the profitability of the bio-fuel.

With respect to marketing and transport of the output it is important to consider what is marketed in what form and to whom. The infrastructure and institutions for marketing are often incomplete in many (poor) developing countries. Is the necessary infrastructure (roads, vehicles) present to transport the bio-fuel products from the farm to processing plants or major markets (i.e. regional capitals or ports)? Are well-functioning institutions present (i.e. a marketing chain, information, contracts etc) to ensure that producers can sell their bio-fuel produce? In general, energy conversion (industrial) units must have a minimum size to achieve a reasonable efficiency, which means that there must be a minimum supply from producers. This means that growing bio-fuel crops is only feasible if a (large) group of farmers can organise themselves to grow a sufficient amount of biomass.

The experience in Brazil (see annex) also shows that transportation costs set an upper limit to how much biomass is efficiently available.

6. Conclusions

Suitable energycrops

- First generation ethanol and second generation energy crops and conversion chains require relatively large systems and often sophisticated technology and large investments, which are generally unavailable for poorer developing world countries. As is already the case more developed countries with large agricultural potentials such as Brazil, China and Thailand are or will be the countries implementing first generation ethanol and second generation transportation fuels.
- Oleiferous crops are relatively easy to grow, process and distribute and may therefore be suited to the conditions in poorer developing countries. An alternative for these countries is to export the raw (or half-processed) biomass if a (stable) and high price can be obtained.
- The number of crops considered for ethanol production seems limited to sugar cane, sweet sorgum, cassava, (sugarbeet), and existing grains crops. The options for oil producing crops appear to be much wider perhaps reflecting the smaller scale nature of the production system.
- For second generation bio-fuels (based on lignocellulose biomass) no specific crops have really been developed. One can expect that apart from by-products perennial low input highly productive C4 grasses and trees will be used.

Producing biomass in a sustainable way with respect to the people-component

- Growing energy crops instead of crops that are meant for the domestic (family) food supply is not recommended. It is important to see energy crops as a cash crop.
- Growing energy crops (i.e. biomass) for bio-fuels is only an interesting option to developing countries when these crops are more profitable than existing (cash) crops, because there is already competition between scarce resources such as land, fertilizer water and labour. Especially (soil) nutrients are an important consideration. Farmers will adopt energy crops when these are more profitable than other (cash) crops. For instance, cocoa and coffee crops that have been planted by many small-scale farmers (notably in Latin America, West Africa, parts of East Africa and some parts of Asia) have in many cases ceased to be profitable because of the low cocoa and coffee prices. These small-scale “plantations” may be replaced by more profitable energy crops.
- Growing energy crops instead of cash crops that are used as food for the developing countries is not recommended. One of the reasons that opposes growing energy crops that is often cited is that it will jeopardize food security in these countries. At a *macro*-level this may be an important consideration. When farmers switch from growing food crops to energy crops, food prices may rise. However, this will probably not affect farmers in developing countries, as they will always grow their own food crops on part of their land (often by the women). They will not likely replace these food crops as farm households will usually spread risk and will safeguard their food production. Higher food prices may, however, affect landless and urban poor.

Therefore, growing energy crops is only sustainable from a “people point of view” when it replaces (a) cash crops (b) with a lower profit and (c) which are not used as food for the developing countries.

Processing, marketing and transporting outputs

Developing processing capacity at local level in developing countries will contribute to local (non-rural) livelihoods and employment. The value added will remain in the country and will increase the benefits of bio-energy. However, in many poor countries (especially in Sub-Saharan Africa), the capacity (infrastructure, capital etc) for establishing processing industry is not available. Developing this capacity may need to be part of introducing bio-fuel crops.

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Annex 1
Converting Biomass to Liquid Fuels: Making Ethanol from Sugar Cane in Brazil
Isaias de Carvalho Macedo

In: J. Goldemberg and T.B. Johansson, (Editors). 1995. Energy As An Instrument for Socio-Economic Development. United Nations Development Programme, New York, NY,

One of the largest commercial efforts to convert biomass to energy anywhere in the world today is the substitution of sugar- cane-based ethanol for gasoline in passenger cars in Brazil.

Fuel for cars and light vehicles in Brazil is either neat-ethanol (94 per cent ethanol, 6 per cent water) or gasohol (78 per cent gasoline, 22 per cent ethanol). The programme to promote ethanol production was established in 1975 to reduce the country's dependence on imported oil, and to help stabilize sugar production in the context of cyclical international prices; it includes government-sponsored incentives to promote private production. By 1989, production reached 12 million cubic metres annually and continues at that level.

Important issues:
the programme is almost entirely based on locally manufactured equipment, helping to establish a strong agro-industrial system, with a significant number of indirect jobs.

The size of any biomass-based energy production system is determined by at least two factors:
1. the energy conversion (industrial) unit must have a minimum size to achieve a reasonable efficiency,
2. but transportation costs set an upper limit to how much biomass is efficiently available. This is very important for wood-to-electricity systems (leading to development of wood gasifiers and gas turbines), for higher efficiencies at low power levels); and it is also true for sugar cane to ethanol systems.

Thus, the so-called large-scale ethanol production system in Brazil is actually composed of a large number (approximately 400) of industrial units, with cane production areas in the range of 5,000 to 50,000 hectares. This much smaller-scale system is further decentralized by the fact that sugar cane is produced by more than 60,000 suppliers. External suppliers produced approximately 38 percent of the sugar processed in 1986, with mill owners themselves providing approximately 62 percent.

The seasonality of sugar cane production has a big impact on its ability to create high quality jobs. Climatic conditions and agronomic characteristics of the crop limit the harvesting season to six months out of the year in Brazil. The amount of manpower needed during the harvesting and the off season is largely determined by the level of agricultural technology employed. Because the work associated with sugar cane production is highly seasonal, jobs tend to be temporary; this, in turn, leads to high turnover, difficulty in training and, consequently, low wages.

Sugar and ethanol production have in common the costs of sugar cane production, delivery to the mill, cane preparation, milling, and utilities.

Annex 2
Latest information on ethanol production and usage in developing world countries from the World fuel ethanol: analysis and outlook.
By Dr. Christoph Berg
April 2004. http://www.distill.com/World-Fuel-Ethanol-A&O-2004.html

India

India's transport sector is growing rapidly and presently accounts for over half of the country's oil consumption whilst the country has to import a large part of its oil needs. Hastening interest in an ethanol program was the country's sugar glut (part of which the industry is now exporting to the world market) and burgeoning supplies of molasses. The sugar industry lobbied the government to embrace a bio-ethanol programme for several years. The industry emphasised that producing fuel ethanol would absorb the sugar surplus and help the country's distillery sector, which is presently burdened with huge overcapacity, and also allow value adding to by-products, particularly molasses.

India's Minister for Petroleum and Natural Gas gave his approval in December 2001 to a proposal to launch pilot projects to test the feasibility of blending ethanol with gasoline. Mid-March 2002 the government decided to allow the sale of E-5 across the country. On 13 September, 2002, India's government mandated that nine states and four federally ruled areas will have to sell E-5 by law from 1 January 2003. In response India's sugar producers reportedly planned to build 20 ethanol plants before the end of the year in addition to 10 plants already constructed. Most of the plants were being constructed in Uttar Pradesh, Maharashtra and Tamil Nadu, the key sugar producing states and will chiefly use cane sugar molasses as a feedstock.

Estimated annual ethanol needs for a E-5 blend is 0.37 bln litres. A 10% blend increases the need to 0.72 bln litres. This is against installed annual production capacity of 2.7 bln litres/year and annual consumption of 1.5 bln litres. These figures have to be treated with some caution. The chemical industry, fearing higher ethanol prices as a result of the fuel alcohol programme, usually estimates the surplus to be much lower or even non-existent. The sugar industry, on the other hand, estimates capacity at 3.2 bln litres inflating the surplus.

The success of ethanol in India will depend to a significant degree on pricing. The sugar industry originally claimed that it could provide ethanol at 19 Rupees per litre ($0.38/litre), which is at a lower cost than the product it would substitute, MTBE, which costs 24-26 rupees per litre ($0.49-0.53/litre). The oil industry however is seeking parity between ethanol and the price of gasoline on an ex-refinery or import basis. In April 2002 the government announced a Rs0.75 excise duty exemption. Implementation of the excise duty for ethanol which, however, was delayed however until February 2003, because the chemical industry opposed it, fearing higher prices and shortages of alcohol.

However, pricing appears to becoming a stumbling block and in June 2003 India's Petroleum Ministry announced that it would appoint a Tariff Commission to fix an appropriate price for ethanol sourced from sugar mills. Ethanol pricing in India is also complicated by differences in excise duty and sales tax across states and the central government is trying to rationalize ethanol sales tax across the country. More significantly perhaps, there are still substantial differences in the profitability of potable alcohol as against fuel alcohol and in several states. Consequently, insufficient fuel alcohol is being produced to meet demand. Other states have yet to set up sufficient production capacity. Analysts expect that there is a deficit of around 150 mln litres under the current geographic base to the fuel ethanol program; a deficit that will grow once the mandated blending requirement is extended to all states in India. Consequently, there may be a short-term market for imported Brazilian ethanol.

Thailand
Thailand's interest in establishing a large-scale bio-ethanol industry using feedstock such as cassava, sugar cane and rice, was manifested in September 2000, and reflects the nation's rising import bill for oil (the country is 90% reliant on imports) and high-energy prices which were adversely impacting the economy at that time. At the same time low prices for commodities such as sugar and cassava were a matter of concern for the government.

The Thai government moved swiftly in supporting the ethanol opportunity with the oil import bill as the swaying reason for pursuing the bio-ethanol programme. More recently, the role of ethanol in replacing MTBE has been offered as another justification for the ethanol program. The National Ethanol Development Committee has estimated that if 10% ethanol were blended with petrol or diesel, to replace MTBE, about 2 mln litres of ethanol would be required on a daily basis.

In order to encourage manufacturers to develop and market gasohol the Finance Ministry will waive the excise tax on gasohol as well as contributions to the State Oil Fund and Energy Conservation Fund. Furthermore to encourage investment in new capacity, promotion privileges are to be given by the Board of Investment. Tax privileges will be granted including duty exemptions on machinery imports and an eight-year corporate tax holiday. The Industry Ministry calculates the gasoline/ethanol blend would be 0.7-1.0 Baht/litre (US$0.01-0.02/litre) cheaper than conventional gasoline.

Late in 2001, eight private companies were granted licences by Thailand's Ministry of Industry to build ethanol production plants. The plants had a capacity to produce 1.5 mln litres of ethanol a day, or an annual capacity of around 0.495 bln litres. Four plants would use molasses as a feedstock and the others would use cavassa (tapioca). Five of the plants were expected to start production late in 2002 with a combined annual output of 114 mln litres. However, progress in constructing the plants has faltered. By mid 2003, only one distillery had advanced to construction stage and many had not submitted feasibility plans.

China
China is now home to the world's largest fuel ethanol plant. The Jilin Tianhe Ethanol Distillery has an initial capacity of 600,000 tonnes a year or 2.5 mln litres per day. Potential final capacity can be raised to 800,000 tonnes per year. Ground breaking took place in September 2001 and by late 2003 the first trials had started.

In November 2002 construction on a plant designed to produce 300,000 tonnes of fuel ethanol annually started in Nanyang, Henan province. The project, built by the Tianguan Ethanol Chemical Group Co., Ltd. (TICG), is expected to cost $155 mln and take two years to complete. Combined with the company's existing facility, TICG's total fuel ethanol capacity would reach 500,000 tonnes a year.

Fuel ethanol has already been in trial use in China for some time. From 2001, Zhengzhou, Luoyang and Nanyang in Henan as well as Harbin and Zhaodong in Heilongjiang province have been experimenting with using ethanol as a vehicle fuel. China is promoting ethanol-based fuel on a pilot basis in five cities in its central and north-eastern regions, a move designed to create a new market for its surplus grain and to reduce oil consumption. The promotion of ethanol as a fuel has been approved by the State Planning and Trade Commission and the State Development and Planning Commission.

Peru and other Latin America
In summer 2002, the Peruvian government announced that the country plans to become a leading ethanol exporter. Under the so-called Mega-project the country plans to construct a pipeline from the central jungle in the north of Peru to the port of Bajovar. Under the

project up to 20 distilleries will be built which all plan to use sugar cane juice as a raw material. The overall investment costs are estimated at around $200 mln.

Peru is planning that by December 2004 it will begin exporting the first lots of ethanol to California. Under the first stage of the project, some 100 mln litres will be exported by 2005, rising to 1.2 bln by 2010. In order to sustain the project, the country plans to introduce up to 240,000 ha of sugar cane in jungle areas, now home to the production of much of Peru's coca leaf. This is used to make cocaine of which Peru is the world's second biggest producer. The government hopes that coca farmers will see that sugar cane growing is a much more profitable enterprise.

In September 2001, the Colombian government approved a law which will make mandatory from 2006 the use of 10% ethanol in fuel in cities with populations larger than 500,000 inhabitants. According to the Ministry of Agriculture, this program will require the cultivation of an additional 150,000 ha of sugar cane. This compares with the present area under cane for sugar production of around 200,000 ha. Another 230,000 ha under cane are used for the production of non-centrifugal sugar, in Colombia's case panela. In order to supply the domestic market nine new ethanol plants have to be built from scratch in order to achieve the required production capacity of around 1 bln litres a year. In order to attract sufficient investment, the country will completely exempt ethanol from the tax on gasoline which would result in a significant price advantage of the green fuel. At present it may not be gauged whether or not the investment drive in Colombia will result in any surplus capacity.

The Association of Central American Countries is also looking at the possibility to increasingly produce fuel alcohol. Total output by 2010 is expected to reach around 500 mln litres, which would allow for a 10% ethanol blend in gasoline. However, the association is also looking at diversifying its export markets. At the moment, Costa Rica, Jamaica and El Salvador are exporting fuel ethanol to the United States under the Caribbean Basin Economic Recovery Act. Under this scheme the countries mentioned may import raw alcohol and re-export it duty-free to the United States.

Latin America is likely to continue to lead the world in fuel ethanol production. This may be explained with the high yields in sugar cane production and the fact that many of these economies are agriculturally based. Several projects in Latin America such as Peru, Colombia or the Central American states were already mentioned. We may see large trade flows from South America to North America in general and California in particular. Another trade flow may be directed at the Asian/Pacific region and here Japan and possibly South Korea could take a top position. Moreover, there is the possibility of a developing export flow from South America to the European Union. As has been mentioned earlier, the European Union could develop into a net importing country if the Commission's directives are implemented. Several countries in Latin America enjoy duty-fee access to the European market and they would be in a prime position to act as suppliers. A third trade flow in the Americas will consist of raw alcohol from Brazil to the Caribbean and onwards to the United States. This sort of trade is likely to continue as long as Brazil does not enjoy duty free access to the US under the Free Trade Area of the Americas.

Southern Africa

Southern Africa is another potential supplier to the world market also because of relatively high sugar cane yields and some under-utilized areas. Several South African countries also enjoy duty-free access to the European Union and therefore, some quantities may go there. Another potential export market for distillers in sub-Saharan Africa could be the Far East. In Asia, India, Thailand and Australia may emerge as smaller to medium sized exporters with South Korea and Japan on the importing side.

Annex 3
List of oil crops and oil yields (these yields are for a good crop)

Crop	kg oil/ha	litres oil/ha	Crop type
corn (maize)	145	172	Annual crop
cashew nut	148	176	
oats	183	217	Annual crop
lupine	195	232	Annual crop
kenaf	230	273	Annual crop
calendula	256	305	
cotton	273	325	Annual crop
hemp	305	363	Annual crop
soybean	375	446	Annual crop
coffee	386	459	
linseed (flax)	402	478	Annual crop
hazelnuts	405	482	Tree
euphorbia	440	524	
pumpkin seed	449	534	
coriander	450	536	Annual crop
mustard seed	481	572	Annual crop
camelina	490	583	
sesame	585	696	Annual crop
safflower	655	779	Annual crop
rice	696	828	Annual crop
tung oil tree	790	940	Tree
sunflowers	800	952	Annual crop
cocoa (cacao)	863	1026	Tree
peanuts	890	1059	Annual crop
opium poppy	978	1163	Annual crop
rapeseed	1000	1190	Annual crop
olives	1019	1212	Tree
castor beans	1188	1413	Tree
pecan nuts	1505	1791	Tree
jojoba	1528	1818	shrub
jatropha	1590	1892	Tree
macadamia nuts	1887	2246	Tree
brazil nuts	2010	2392	Tree
avocado	2217	2638	Tree
coconut	2260	2689	Tree
oil palm	5000	5950	Tree

13

PALM OIL PRODUCTION FOR OIL AND BIOMASS: THE SOLUTION FOR SUSTAINABLE OIL PRODUCTION AND CERTIFIABLY SUSTAINABLE BIOMASS PRODUCTION?

Definition of the problem
In the bio-based economy the availability of biomass as feedstock for energy and products will partly depend on the residues from the agro-food chain. In this paper the concept of increasing the sustainability of the palm oil value chain will be elaborated with the aim to produce a certifiable sustainable biomass. It is shown that a combined utilisation of both the appreciated edible oil and biomass residues will result in a more sustainable value chain. This means that it should be environmentally sound, economically viable and socially acceptable.

Jan van Dam and Wolter Elbersen, November 2004. Report on bus ticket no. A36, WUR-A&F

Rationale and question
In the palm oil production chain large quantities of biomass by-products (up to almost 5x the oil production) are produced which are hardly used for adding value to the production chain. The current palm oil production system is generally seen as unsustainable because of detrimental effects on biodiversity such as loss of virgin forests and greenhouse gas emissions associated with current waste disposal methods. The use of by-products for energy and green chemicals offers perspectives for designing a "certified" sustainable food oil production chain that fits well in the development of a bio-based economy.

The major topics for discussion of sustainable palm oil production so far, have concentrated on the issues of rain forest loss, soil fertility and reproduction, biodiversity, pest and water management and the emission of greenhouse gasses. Utilising the available energy that can be derived from the biomass by-products has been recognized and in many cases residues from oil production are used to provide the energy required to run the plant operation.

Improvements taking into account the entire value chain have however not been addressed until recently. This paper will look at opportunities to exploit the abundantly available biomass wastes (shells, fibre, press cake, empty fruit bunches, palm fronts, etc.) as renewable resources for new products and energy that enhance the sustainability of the palm oil production chain.
How much of the different biomass residues are available for alternative use?

Approach
Firstly the potential utilisation of palm oil by-products as a sustainable biomass source was assessed by analysing the gross availability of by-products. Subsequently, factors were determined that have to be considered to determine the possible net biomass availability. The following steps were taken:

First the overall production of end-products and by-products was quantified giving a gross biomass production picture. Then the current practical and proposed uses of the (by-)products were listed, together with a short discussion on the utilisation rate and efficiency of the use (Chapter 4).
Potential constraints reported in the literature to making by-products available for energy and other uses were listed (Chapter 5).

A short discussion was given on the possibility of increasing the sustainability of the palm oil production by optimal by-product utilisation for energy and other purposes..

Products and by-products in the palm oil production chain

In Table 1 a list is given of the main by-products generated each year on palm oil plantations (field by-products) and at the mill. Figures show that the potential amount of biomass is very large with an estimated 30 to 50 million tons at the mill and 70 to 80 million tons in the field. These figures are conservative dry weight estimates. Most of this material is found in Malaysia, which accounts for almost 50% of world palm oil production and in Indonesia which accounts for almost 1/3 of world palm oil production.

Table 1: List of products, by-products and nutrient contents in the oil palm production chain at field and mill level in 2002

Product Acronym	**Where, when available?**	**DM, per ton of CPO**	**H_2O**	**N**	**P**	**K**	**Mg**	**Ca**	**Worldwide production x1000 tons DM/ yr #**
			-- % --	-------------------		% DM		-----------------	
Crude Palm Oil (CPO)	Mill	1	-	-	-	-	-	-	25.000
Kernel oil (KO)	Mill	0.10-0.15	-	-	-	-	-	-	2.500
Oil Palm Fronds (OPF)	Field	1.65-2.0		0.73	0.06	1.29	0.17	0.35	41.500
Roots	Field, every 20/30 years	0.87		0.32	0.03	0.80	0.08	0.05	22.000
Trunks	Field, every 20/30 years	0.4-0.67	50	0.56	0.05	1.62	0.15	0.31	10-17.000
Empty Fruit Bunch (EFB)	Mill	0.32-0.42	58	0.80	0.06	0.24	0.18	-	8-10.000
Fibre	Mill	0.32-0.5	17	2.30	0.01	0.20	0.04	-	8-12.000
Shells	Mill	0.13-0.4	20	-	-	-	-	-	3-10.000
Palm Oil Mill Effluent (POME)	Mill	0.35-1.0	>70	0.11*	0.005*	0.02*	0.02*	-	9-25.000
Palm Kernel Cake (PKC)	Mill	0.06	33	2	0.70	2	0.30	0.25	1.500
Products	Mill	1,1							28.000
Field by-products	Field	2.9-3.5							70-80.000
Mill by-products	Mill	1,2-2.3							30-50.000

- = not found; * on % of water basis.
dry matter (DM) calculated based on total palm oil production of 25 million ton crude palm oil (CPO) (Oil world annual, 2002).

Practical and proposed uses of palm oil by-products

In Table 2 a list is given of current and potential uses of palm oil by-products. The list shows that currently most by-products are used (disposed off) within the system for mulching / fertiliser and for energy production at the mill. Currently only part of the total by-products is used a fuel feedstock in plant operations. Especially the EFB is barely used and creates problems for its disposal since open field/pile burning is often no longer allowed. Palm oil mill effluent is also hardly used and creates an accumulating problem at the oil production mills.

Literature clearly shows that biomass utilisation is not optimised and that there is a demand for other uses. This is illustrated by the list is of relevant articles from one journal dealing with potential alternative uses for palm oil by-products (annex 2).

Table 2: List of practical and some proposed uses of palm oil (by)-products

Product Acronym	**World-wide production x1000 tons DM/ yr #**	**Prod/ ha/yr**	**Composition**	**Current or *possible* uses**	**Remarks**
OPF	41,638	5,70	crude fibre 45%; protein 5.8%	Mulch, pulp, fibre, feed	Distributed over plantation
Roots	21,954	3,01	-	Mulch	too much available at once, uprooting disturbs soil
Trunks	16,907	2,32	-	Mulch, fibre board	too much available at once, often at remote sites of plantation
EFB	8,075	1,11	45-50% cellulose; 25-35% hemicellulose and 25-35% lignin (Deraman 1993).	Mulch, fuel, bunch ash, *fibre board, pulp, paper*	EFB less well suited as fuel than fibre or shell and does accumulate often
Fibre	8,075	1,11	65% cellulose; 19% lignin (Sreekala et al., 1997)	Fuel for mill, *fibre board*	
Shells	3,281	0,45	-	Fuel for mill, activated carbon, briquette, *particle board*	Silicate forms scale when burned
POME	8,832	1,21	95-96% (w/v) water; 0.6-0.7% (v/v) oil; 4-5% (w/v) total solids including 2-4% suspended solids	Methane production, fertilizer, feed, *soap*	Methane emission, river pollution are a problem when not managed properly.
PKC	1,514	0,21	8.3% oil, 17.5% crude fibre, 14.5-19.6 % protein	Feed, fertilizer	Feed potential not fully used

Total palm oil production was 25,235 million ton on 7,3 million ha giving an average palm oil yield of 3,457 ton per ha in 2002 (Oil world annual, 2002) and www.gpfeeds.co.uk/analysis/palmkern.htm

It is hard to get quantified data on the current use of by-products and especially on the efficiency of such use. In the following paragraphs we will discuss the issue of current utilisation rate and efficiency of such uses.

Utilisation rate

In Table 3 a list is given of by-products and their utilisation rate in Malaysia (Gurmit, 1999). The table shows quite a high utilisation for field by-products (80 to 95%) as mulch and for shells and fibre as fuel for the mills (90%). For POME and EFB the utilisation rates are much lower (35 to 65 %). Apparently the material is not easily used for energy production and benefits of returning the material to the field as mulch / fertiliser are considered too low to offset the cost. Accordingly literature indicates that these products often form environmental problems producing methane and polluting waterways. A large number of initiatives are underway to find ways of mitigating this problem. In Yeoh (2004) it is estimated that in Malaysia methane emission from open of POME ponds amount to 225.000 tons (1999), which is equivalent to 5,17 million tons of CO_2, or 3.6% of the estimated total emissions in Malaysia. Empty fruit bunches are less attractive as a boiler fuel and are therefore generally not used for energy.

Table 3: Level of utilisation of oil palm biomass residues in Malaysia (1998)

Biomass	Quantity produced (Million tons)	Quantity utilised (Million tons)	utilised (%)	Method of utilisation
Pruned fronds	27.20	25.83	95	Mulch
Trunks and fronds at replanting	1.38	1.10	80	Mulch
Fibre	3.56	3.20	90	Fuel
Shell	2.41	2.17	90	Fuel
POME	1.43	0.50	35	Nutrient source & organic fertiliser
EFB	3.38	2.20	65	Mulch & bunch ash
Total	39.36	35.00		

Level of utilisation = 89%. Source: Gurmit (1999)

For other countries utilisation rates should be lower than in Malaysia, which has the most advanced palm oil production system.

Efficiency of utilisation

Table 4.1 and 4.2 do not give an indication of the efficiency of the use for energy or as fertiliser / mulch. Again, it is hard to find quantified data here. Husain et al (2003) found that the palm oil industry is one of those rare industries where very little attempt is made to save energy. The energy balance in a typical palm oil mill is far from optimum and there is considerable scope for improvement. Currently most mills operate low pressure boilers generating steam for operating. In Malaysia increasingly mills are implementing high pressure boiler systems generating electricity and steam for operation of the mill and delivery to the grid.

Still, some data can be found for energy production potential in Malaysia. Hashim (2005) estimates that for 1999 the annual palm oil mill residues amount to 18 million tons of biomass sufficient for generating 3197 GWh and 31.5 million tons of POME with a generation potential of for 1587 GWh. This estimate is low compared to Yeoh (2004) who estimated that 2250 GWh electricity can be generated from POME through biogas production (55C) followed by electricity generation (for 1999 data).

Based on the data from Hashim (2005) the total electricity generating capacity from mill residues is at least 5000 GWh. Field residues amount to 2x the amount of biomass at mill level (roots excluded). This means that in Malaysia the electric production potential is 15000 GWh. As Malaysia account sfor only 50% of the world palm oil production world wide some 30000 GWh can be produced from Palm oil residues.

Menon (http://www.ptm.org.my/biogen) compared the gains from utilising EFB as mulch in fields (nutrient value minus logistics costs) and the gains when used for electricity generation. The returns for electricity generation are 3.5 times higher. Indeed, a number of initiatives exist mainly in Malaysia to produce electricity from palm oil by-products for delivery to the grid. It must be remarked that electricity production through combustion generates ash which contains most of the P and K and some other nutrients that can still be recycled to the plantation.

The examples above are based on electricity delivery to the grid. Still, many mills are too isolated to be able to provide electricity to the grid and other by-product outlets should also be considered such as charcoal, pyrolysis oil, HTU oil, paper pulp, fibre board, etc. Other mills, especially in poorer developing countries will be too small to warrant investments in conversions systems. How many there are and which options do and do not apply is not known.

For the efficiency of recycling of field and mill residues little data could be found. Obviously recycling of POME and EFB is very limited. The effectiveness of recycling field residues was not specifically looked at.

Constraints to making palm oil by-products available for energy and other uses
Constraints on the use of by-products are derived from the contribution that the utilisation has on increasing the sustainability of the palm oil production chain and the world in general. This means that it should be environmentally sound, economically viable and socially acceptable.

The "Round table on sustainable palm oil" (www.sustainable-palmoil.org) is probably the best source of information on discussions surrounding the sustainability of Palm Oil production. In the Table 4 members and other relevant groups involved the sustainability discussion are listed.

Indeed the issue of sustainability is a serious topic which has been recognised by producers in Malaysia (as illustrated by the citation below):

"Malaysian palm oil producers will have to be ready to adapt to other changes given EU moves to adopt policies on labelling, genetic modification and environmental issues linked to product acceptance"

Malaysian Palm Oil Promotion Council News Bulletin Volume 13, issue 1/6, 2003. (http://www.mpopc.org.my/pol/pol1603.pdf)

Table 4: Organisations involved in discussions on the sustainability of oil palm production at national and international level Roundtable on Sustainable Palm Oil

INTERNATIONAL	EUROPE
World Wildlife Fund for Nature	Friends of the Earth UK
Friends of the Earth	Friends of the Earth Finland
Greenpeace	Friends of the Earth (Milieudefensie) Netherlands
World Rainforest Movement	Greenpeace Netherlands
Global Forest Coalition	MALAYSIA
Rainforestweb.org	WWF Malaysia
ECA-Watch: campaign on export credit agencies	INDONESIA
Focus on Finance	WWF Indonesia
Forest Trends	Friends of the Earth Indonesia
	Down to Earth

http://www.sustainable-palmoil.org/players/ngos.htm

When reviewing the issues discussed at the Roundtable, by-product utilisation is mostly discussed in the context of waste disposal, energy use and the reduction of emissions of pollutants and greenhouse gasses (methane). This is best illustrated in the most recent discussion paper "RSPO Draft Criteria for Sustainable Palm Oil, November 2004" where the topics are discussed in Principle 4 "Environmental responsibility and conservation of natural resources and biodiversity" (See Table 5).

Table 5: Sustainability issues related to by-products and wastes from palm oil production.

Criterion	**Proposed guidance**
Criterion 4.3 Waste from the plantation and the mill is reduced, recycled and re-used and any waste produced is disposed of in an environmentally and socially responsible manner.	A policy of minimal wastes and emissions should be promoted through improving the efficiency of resource utilisation (e.g., achieving high extraction efficiency to reduce oil in EFB (empty fruit bunches) and effluent) and recycling wastes as nutrients (e.g., EFB) or converted into value-added products (e.g., through animal feeding programmes). Issues raised for further discussion: The Criteria Working Group should provide guidance and/or refer to existing best practice guidelines on recycling and re-use of nutrients, managing effluent ponds, increasing mill extraction efficiency and appropriate disposal of wastes that cannot be recycled. Guidance should also be provided on appropriate ways for nutrients in EFB and effluent to be returned to smallholders from the mill that processes their fruit. Suggested guidance includes Unilever guidelines, MPOA best practices and ample literature. The term 'socially responsible manner' needs clear definition.
Criterion 4.4 Efficiency of energy use should be maximised whilst minimising fossil fuel use	Develop and implement a strategy to become as close to self-sufficient as possible in terms of fuels, including: maximising fuel burning efficiency; using renewable energy sources wherever possible (e.g., fibre and shell). Large plantations should assess the energy balance of their operations and energy efficiency of their operations. Issues raised for further discussion: The CWG should provide more detailed guidance, e.g., from MPOA guidelines on disposal of waste water and emissions.
Criterion 4.5 Use of fire for waste disposal and for preparing land for replanting is avoided except in exceptional circumstances and should always be consistent with the ASEAN Policy on Zero Burning	Fire should be used only when permitted "Guidelines for the Implementation of the ASEAN policy on zero burning'" and where an assessment has demonstrated that it is the most effective and least environmentally damaging option for minimising the risk of severe pest and disease outbreaks. Issues raised for further discussion: The extent that smallholders can comply with this, especially in Africa, is unclear, at least without extension/training programmes. The term 'exceptional' needs clear definition.
Criterion 4.6 Plans to reduce pollution and emissions, including greenhouse gases, should be developed, implemented and monitored	An assessment of all polluting activities should be conducted, including gaseous emissions, particulate/soot emissions and effluent. A plan should be developed and implemented to reduce the company's pollution and the progress of this plan is regularly monitored. Issues raised for further discussion: The CWG should consider providing a simple checklist of activities that should be addressed.

(See http://www.sustainable-palmoil.org)

We have used the discussions within the "Roundtable on Sustainable Palm Oil" as one of the sources to make an inventory of possible constraints. A short analysis of the possible effects of by-product utilisation is given per subject. The discussion is organised from 3 viewpoints: People, Profit and Planet.

In Table 6 a listing is given of factors to consider in the evaluation of sustainable use of palm oil by-products.

Table 6: Factors that should be considered when utilising palm oil by-products/wastes

Pro	Contra
People	
Local people may benefit from local electricity and bio-gas production	It is possible used locally are now exported increasing demand for (fossil) fuels
Local employment would be positively affected when new biomass based industries could be set up	The available labour is often restricted in Palm oil growing areas
Local economy may profit from lower fossil fuel imports	Will biomass that is based on a controversial palm oil system be considered sustainable?
Environmental pollution problems affecting local people can be mitigated by efficient utilisation of waste biomass	Export of biomass may increase the need for local people to buy other more expensive fuels
Profit	
Additional income per ha due to energy production and other uses of palm oil by-products	Nutrients exported in the biomass have to be replaced at a cost.
The cost of recycling nutrients and can be reduced because digestate from POME biogas production is more concentrated and cheaper to transport to the field	If field by-products are used, returning ash and digestate are essential to prevent depletion of soil and thus productivity of the plantation.
Planet	
Increased revenues per ha will make more money available for good management and make investments to maintain soil fertility more attractive, thus increasing sustainability of the system.	Soil carbon has to be replaced on poor forest soils. Generally rain forests recycle nutrients
Manufacturing of novel wood substitute products from plantation and agro-industrial residues will have a slowing impact on the rate of deforestation	Utilisation of waste for energy instead of recycling can lead to loss of soil fertility and reduce sustainability of the plantation. This can lead a lower yields requiring more production area which increases pressure on virgin forest
Methane emissions from POME and EFB can be greatly reduced	
When by-products are used for energy production nutrients may easier be recycled to the plantation increasing soil fertility and sustainability and productivity of the system	
The need for fire to burn residues at the mill and field will be reduced as the biomass finds profitable uses	

Discussion and conclusions

In the Palm Oil value chain there is an overall surplus of by-products and the utilisation rate of these by-products is low, as is especially the case for effluent and empty fruit bunches. For other mill by-products the efficiency of the application can clearly be increased. For field residues the main utilisation now is disposal as mulch and fertiliser. The efficiency and effectiveness of this application could not be determined here. Still this will depend on local conditions and it should be possible to give indications of what recycling or valorisation system will be optimal here.

By-products are considered at best as a nuisance which may lead to environmental problems. As the biobased economy develops and markets for carbon neutral products grow those by-products should be seen as resource. The first effects are becoming clear with delivery of sustainable palm oil waste electricity to the grid in Malaysia.

The primary benefits of external demand for by-products is the solving of problems concerning polluting by-products and increasing the profitability of the production by:

- balanced recycling nutrients and carbon at the field,
- increasing the efficiency of boiler fuel utilisation at the mill
- supplies of surplus energy to local electricity net
- novel economic activity and generation of local employment by conversion of biomass residues in value added products

The increased nutrient recycling will increase soil fertility and increase sustainability of palm oil production. Systems that minimise the removal of nutrients and carbon from the system should be preferred. Still not all carbon and nutrients have to be re-cycled. What the optimum is between biomass utilisation and recycling varies according to soil and climate. This is a most relevant research question.

In the case that external demand for by-products of palm oil production materialises, larger amounts of by-products will become available. The palm oil industry will have to weigh the own demand for fuel and the need for recycling of nutrients and soil carbon against the cost of fertiliser and the profits of biomass conversion. It is important to know what are the optimum conditions here in order to design sustainable systems that also produce large quantities of biomass for energy and products.

A very rough guess is that 25 to 50 % of the by-products may be available for energy export (corresponding roughly to 30-60 million tons dry weight biomass). It would be a good development if the by-products from Palm oil production were considered as a potential resource for CO_2 neutral energy and products instead of a waste.

A much more detailed study into the net mass balance and potential biomass production from the palm oil chain and the possibilities of finding added value for these products in a biobased economy is essential for developing economically, socially and environmentally sustainable palm oil systems.

The recognition that utilising by-products for added value is beneficial to the sustainability of palm oil production is essential for certifying the sustainability of the palm oil biomass energy and products.

Multi-stakeholder involvement is required for addressing the sustainability of the food oil supply chain. This would also include outsider (non-food) industries involved in energy and fibre products marketing.

Issues that should be addresses
More information is needed to determine how much biomass is needed at the mill for plant operations and how efficient this use is.
How much nutrients can be removed from the system without affecting sustainability (nutrient and carbon recycling).
Evaluations are needed of systems that generate energy and products and make it possible to recycle nutrients.
Evaluation of the competitive potential of supplies to the market of energy, products and carbon fixation.
More quantified information is needed on countries outside Malaysia that have similar palm oil waste disposal problems and potentials to utilise these products as a resource.

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Quick-scans 2005

14

BIOMASS ENERGY: EXPLORING POTENTIALS AND COMPETING RESOURCE CLAIMS

Definition of the problem
There seems to be a discrepancy between the results of the GRAIN study by the University of Utrecht, which suggest that world-wide there is enough land available both for the production of food and of biomass for energy and other researchers who doubt it. This quick-scan should give an idea about the area actually available

Questions
1.Which reaches are involved in these kind of studies?
2.On which points do they fundamentally disagree with the results of the GRAIN study
3. What is needed to make a more reliable estimation of the area potentially available for biomass production?
4. Is an ecological cost-benefit analysis the right tool for such an assessment?
5. Which are the main assumptions and uncertainties?

Frank van Tongeren and Marieke Meeusen, February 2005. Report on BUS ticket A21, WUR-LEI

Introduction
Renewable energy from biomass production is one option to create a more sustainable global energy economy in the long term. Production and consumption of biomass is driven by technical as well as economic considerations. Technical feasibility does not imply that new developments are actually taken into production, and long-term projections based purely on technological potential have time and again proven to be off-mark. The utilization of biomass potential for (bio-) energy depends on a number of factors, including:

1. Agronomic features, including land availability and growing conditions
2. (supply) response of farmers, i.e. the decision to grow bio-energy relevant crops
3. Technical substitutability of biomass energy for conventional energy sources
4. Economic substitutability of biomass energy for conventional energy sources
5. National and global policies
6. Social considerations
7. Environmental considerations

Economists and economic models have something to say about items 2, 4 and 5 on the above (non-exhaustive) list. Agronomic, biophysical and technical aspects are typically included in these models in a cursory fashion. Agricultural economist, however, have a tradition in including agronomic production features into their models, and recent developments in the EU attempt integrated modelling of economic, agronomic, environmental, climatic and social issues. (e.g. SEAMLESS and SENSOR, which are both so-called integrated projects sponsored by the FP6 of the European Union).

Key to fruitful long-term projections of biomass issues is a proper modelling of the supply side of biomass and a proper representation of the demand side for bio-energy. In both demand and supply, technical and economic considerations play a role, and therefore a multidisciplinary approach is warranted.

GTAP model
The GTAP modelling framework is a potentially a useful starting point, but it would need to be adapted for the specific issues at hand. The GTAP model is a global economy-wide model that covers worldwide production, consumption and trade. It is a general equilibrium

model, based on the micro-economic foundations of production- and consumption behaviour. It captures backward and forward linkages within each of the regional economies through an input-output structure. In the general equilibrium structure both prices and quantities are endogenously determined as outcomes of the model after a perturbation of exogenous variables, such as policies, technological changes, taste changes etc..

Since its inception in 1992, the explicit aim of the GTAP project has been the lowering of entry barriers to global trade analysis. The project is now supported by a consortium of 18 national and international agencies and provides financial support as well as guidance to the Center of Global Trade Analysis at Purdue University (USA). The consortium includes some of the major players in global trade analysis (World Bank, WTO, UNCTAD). The GTAP website provides more information on the consortium, conferences, courses and other activities and is a repository of resources: http://www.gtap.org/

Much of the focus of GTAP is directed towards the analysis of agricultural policy and trade, but there are also applications in non-agricultural trade-related issues as well as environmental policy analysis. More recently, database development and modelling have also expanded in the direction of energy usage and climate change. The current version of the database (version 6) has coverage of 87 regions, 57 commodity groupings and 5 primary factors (Land, Skilled and Unskilled Labour, Capital and Natural Resources), and is benchmarked to 2001 US dollar values. See Annex 1 for a country and commodity listing. The main components of the database consist of bilateral trade, transport and protection matrices that link the country/ regional input-output (IO) databases. Although the commodity coverage has a deliberate agricultural bias with 12 primary agricultural sectors (8 food processing sectors, 1 forestry sector and 1 fishing sector), within the remaining commodity groupings, there is significant disaggregation of manufacturing, services and fossil fuel sectors. The database contains energy use data for 5 energy commodities (coal, oil, gas, petroleum commodities, electricity), and a special model version (GTAP-E) is geared towards modelling energy and climate issues (this model has been used extensively in the IPCC context).

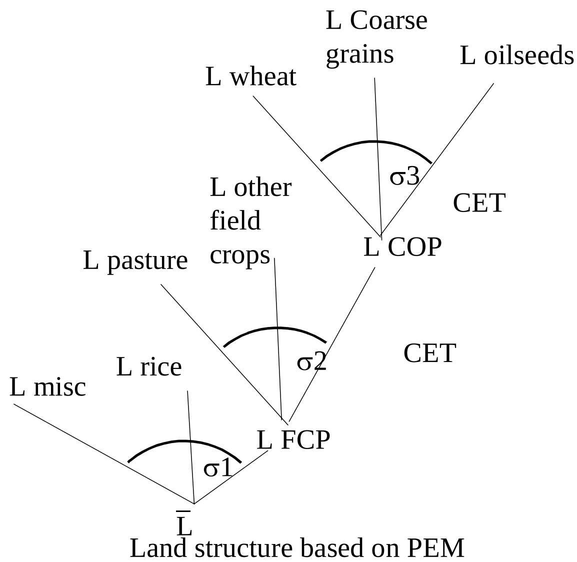
Given its current low share in global energy use, the database does not include separate information for biomass energy.

Modelling the supply side of biomass

A crucial aspect of modelling the supply of biomass crops is the allocation of land. In conjunction with the OECD secretariat, LEI has undertaken to model the agricultural supply side in GTAP in a specific way that allows us to capture the limited substitutability of land across alternative crops (and livestock for feeding purposes). In a nutshell, the land allocation is driven by relative returns that can be earned, while taking into account the fact that not all crops can easily be grown on alternative soils. The following figure illustrates the concept:

Total available land L is allocated over 3 broad ‘nests’. Within each nest, the allocation is guided by constant elasticities of transformation σ_1, σ_2, σ_3. For example in the upper nest, land can easily be transformed between wheat, coarse grains and oilseeds (the COP complex), but it will require big shifts in relative returns to move land out of COPs and into pasture. In a way, alternative crops can be seen to compete about the available land resources. The relative returns of alternative uses depend on market returns and the policy setting.

Issues around trade offs between biomass and food security can easily be analyzed in this framework. The demand for food crops is derived from estimated demand functions that include relative prices and income and allow for varying expenditure shares as income grows.



Land structure based on PEM

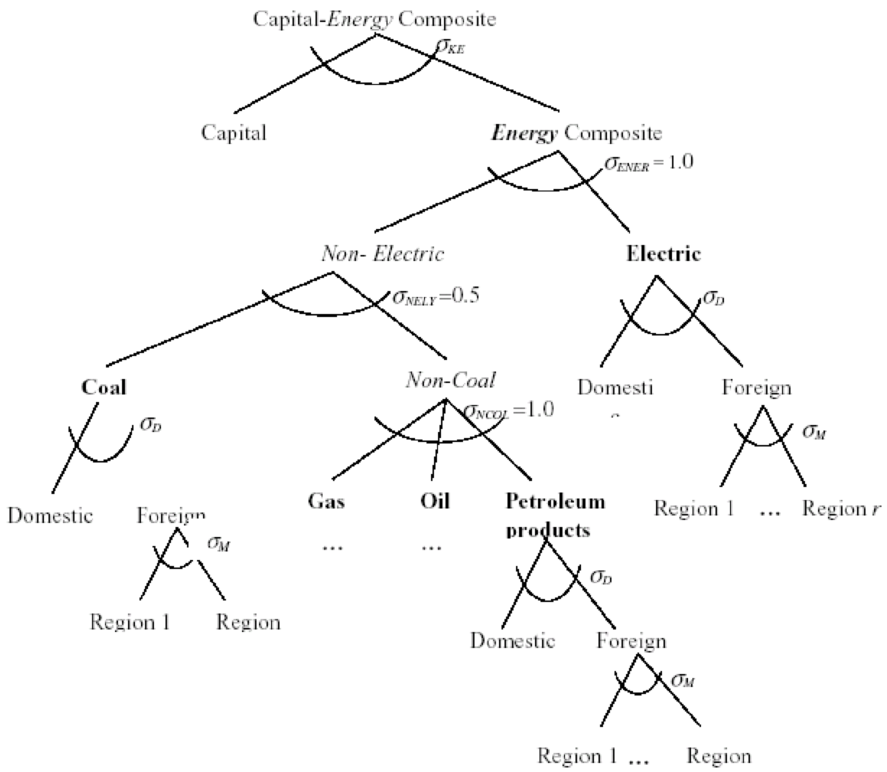
Modelling the demand side for bio-energy
Energy modelling in GTAP already has a tradition, and as said above, we have a consolidated (i.e. consistent) database of conventional energy use. For energy modelling the substitution possibilities in demand amongst alternative energy sources is very important. This can be done in a variety of ways. The GTAP-E model proposes the approach pictured in the figure below, where the various σ now indicate elasticities of substitution. The users of energy decide their mix of sources on the basis of relative prices, including the domestic/foreign price ratio. If, for example, foreign electricity becomes cheaper, relative to domestic electricity, more will be imported. If this cheaper electricity import leads in addition to falling composite electricity sources, more electricity will be demanded relative to non-electric sources.
For bio-energy modelling, the biomass component would have to be folded into this structure.

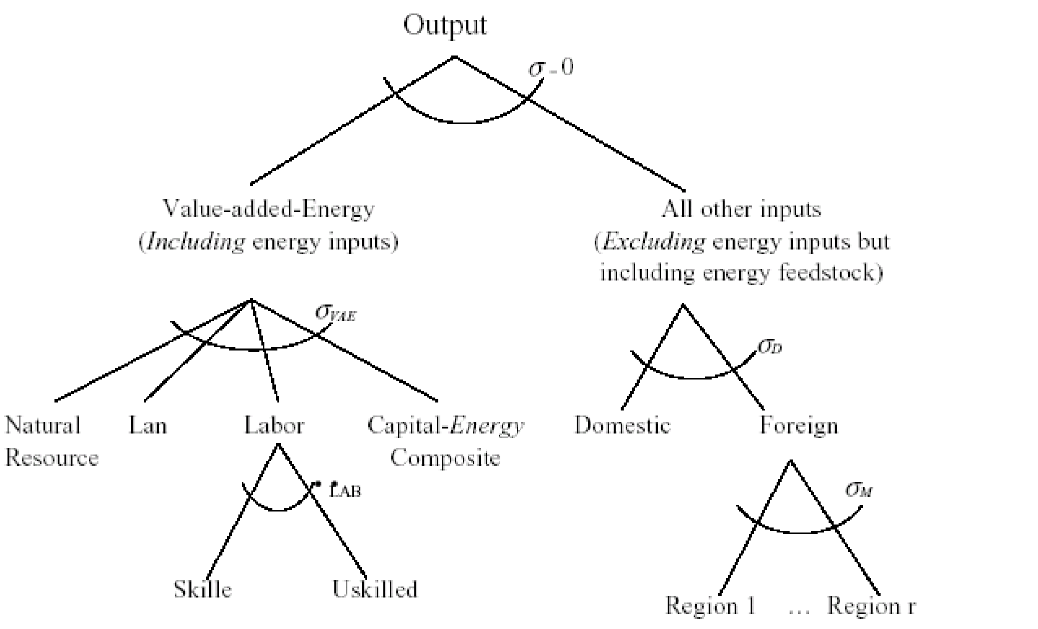
Where to go from here?
A very fruitful way of exploring future biomass potential is scenario analysis. We believe that an amended GTAP framework could be a very useful input in such a scenario analysis, and could indeed have a central role as a consistency framework.
Scenarios would evaluate contrasting visions of the future global economy, including amongst others the following driving forces:

- Global economic development (GDP growth)
- Population growth
- Policy developments, such as trade policy, agricultural policy, climate policies
- Consumer preferences wit regard to sustainable energy
- Technological assumptions on bio-energy

Development of scenarios should be a team effort, encompassing various disciplines, and in close cooperation with Shell.

Figure 1: Production structure GTAP-E





15

INFLUENCE OF AGRICULTURAL PRACTICE ON BIOMASS AVAILABILITY

Definition of the problem
Different studies show that the availability of land for the growth of dedicated energy crops will depend on the food requirements (population growth and diet). The future land requirement for food production might influence also the total available area for forestry and the amount of forestry residues that could be used for biofuels. Furthermore the kind of agricultural farming and techniques used influence the sustainable removal of agricultural residues. Food / feed production will therefore determine on large scale which and much lignocellulosic biomass becomes available for the use in the energy sector.

Questions
1. How would a sustainable food production look like and how does it influence future biomass availability?
2. What are the consequences of future food production needs for the availability of biomass for energy (residues and dedicated crops)?
3. Is there a win-win situation for the production of food and biomass?

Gerdien Meijerink, April 2004. Report on BUS ticket no B18, WUR-LEI

What is sustainable food production?
We consider sustainability as being founded on triple-P: people, planet and profit, which means that sustainability has three important principles: social equity, environmental quality and economic development.

Social equity refers to the well-being of individuals and the stability of society. Social equity therefore includes eliminating poverty so that everyone has their basic needs met. Although "basic needs" can be defined in various ways, here they are construed to include such needs as clean water, adequate food, sanitation, shelter, the opportunity to earn a living, and access to health care.

Environmental quality refers to the long-term health and stability of natural systems. Natural systems provide natural resources and a range of ecosystem services that support human life (Daily 1997). Conserving natural resources, and protecting ecosystem services such as biodiversity, stabilizing atmospheric composition and global climate is necessary to protect the stability and productivity of earth systems.

Economic development includes economic growth. However, development is broader and includes other aspects such as reducing illiteracy and poverty. Economic development need not be in conflict with social needs or environmental protection, in fact, social equity and a healthy environment are supported by economic development and support it in turn. Sustainable food production means that when food is produced, all three principles are taken into account.

Sustainable food production in relation to biomass
The FAO has produced comprehensive studies on the state of the World Agriculture. Its latest study (Bruinsma, 2003) makes a forward assessment of possible future developments in world food, nutrition and agriculture, including the crops, livestock forestry and fisheries sectors. taking a long term perspective (2015/2030). We will review the most important conclusions, with respect to future projections, and what they imply for the production of biomass.

Population, income and poverty

The UN (2001) has estimated the world population of 5.9 billion (1997/99) will grow to 7.2 billion in 2015, 8.3 billion in 2030 and 9.3 billion in 2050. The growth rates are projected to fall from 1.35 percent in the mid 1990s to 1.1 percent by 2015, to 0.8 percent by 2030 and 0.5 percent by 2050. This deceleration in demographic growth and the gradual saturation in per capita food consumption for parts of the world population are important factors that will slow the growth of food demand and, at the world level, also of production.

Practically all of the increases in world population will be in the developing countries. Within the developing countries themselves there will be increasing differentiation. East Asia will be reaching a growth of under 0.5 percent per year towards 2050. At the other extreme, sub-Saharan Africa's population will still be growing at 2.1 percent per year in 2025-30. The growth of incomes is the other major determinant of the growth of food demand and of changes in food security and nutrition. The outlook for income growth is mixed. The latest World Bank assessment for the period 2000-15 (cited in Bruinsma, 2003) anticipates higher growth rates in per capita GDP than in the 1990s for all regions and country groups. However, there is great contrast as regards the prospects of two regions with high relative concentrations of poverty and food insecurity, South Asia and sub-Saharan Africa. In the former region, a continuation of the relatively high GDP growth holds promise of positive impact on poverty alleviation and increases in per capita food consumption. But progress in sub-Saharan Africa may be very limited and far from sufficient to have a significant impact on poverty and food insecurity. The Bank assessment concludes that the proportion (not absolute numbers) of the population living in poverty in the developing countries as a whole may fall from 32 percent (1990) to 13.2 percent (2015). However, the absolute numbers in poverty in the developing countries will remain high and will have effect on the number of undernourished people.

Prospects for food and nutrition

The 2001 FAO assessment of food insecurity in the world estimates the incidence of under nourishment in the developing countries (1997/1999) at 777 million people or 17 percent of their population (FAO, 2001). This is a decrease from 20 percent of the population in 1990/1992. The projections of food demand for the different commodities suggest that the per capita food consumption (kcal/person/ day) will grow significantly. The world average will be approaching 3 000 kcal in 2015 and exceeding 3 000 kcal by 2030. These changes in the world averages will reflect above all the rising consumption in developing countries, whose average will have risen from the 2680 kcal in 1997/99 to 2850 kcal in 2015 and close to 3000 kcal in 2030.

The implication of the projected higher levels of average national food consumption per person is that the proportion of undernourished people in the developing countries as a whole could decline from 17 percent in 1997/99 to 11 percent in 2015 and to 6 percent in 2030. All regions would experience declines in these percentages and, by 2030, all of them, except sub-Saharan Africa, should be in the range of 4 to 6 percent of the population. Sub-Saharan Africa could still have 15 percent of its population undernourished in 2030.

Food production and trade

At the world level, production equals consumption. For the individual countries and country groups, however, the two growth rates differ depending on movements in their net agricultural trade positions. In general, the growth rates of production in the developing regions have been below those of demand, and as a result their imports have been growing faster than their agricultural exports. These trends led to a gradual erosion of their traditional surplus in agricultural trade. In fact, the developing countries have turned in recent years from net agricultural exporters to net importers. This trend continues in the projections. In table 1, the projections for the demand and production of the main categories of food are given.

Table 1: projections for the demand and production of the main categories of food are given

	Demand		Production	Net Trade	Growth rate	
	Food	All uses			Demand	Production
Cereals – World (million tons)						
1997/1999	1003	1864	1889		1.4	1.4
2015	1227	2380	2387		1.2	1.2
2030	1406	2830	2838		1.3	1.3
Cereals – Developing countries (million tons)						
1997/1999	790	1129	1026		1.9	1.6
2015	1007	1544	1354		1.5	1.3
2030	1185	1917	1652		1.7	1.5
Meat – World (000 tons)						
1997/1999	215795		217898		2.7	2.7
2015					1.9	1.9
2030					1.5	1.5
Meat –developing countries (000 tons)						
1997/1999	117141		115938	-1238	6.1	5.9
2015				-3900	2.7	2.7
2030				-5900	2.1	2.1
Oilcrops – world (million tons)						
1997/1999		98.3	103.7		3.7	4.3
2015					2.7	2.5
2030					2.2	2.2
Oilcrops – developing countries (million tons)						
1997/1999		61.8	67.7	4	4.6	4.7
2015				3.4	3.2	2.8
2030				3.4	2.5	2.4

Source: Bruinsma, 2003

Cereals
Cerals will continue to be by far the most important source (in terms of calories) of total food consumption. World consumption and production of cereals are projected to increase (see table 1). Of this increase, some 50 percent will be for feed, and about 42 percent for food, with the rest (8 percent) being used for other purposes (seed, industrial non-food use and waste). This supply is expected to come from the traditional cereal exporters in the industrial world (United States, Canada, the EU and Australia). The FAO expects that in the future, the production system in these countries will have the capability of responding flexibly to meet increases in demand within reasonable limits, as it has done in the past.

Livestock
This is becoming a more important commodity as the world food economy is being increasingly driven by the shift of diets towards livestock products, although most of the increase in meat production (especially poultry) stems from China (and to a lesser extent Brazil). For milk and dairy products, China is of less influence but also for these products, demand is expected to grow. The driving forces of rapid growth of the meat sector in the past are expected to weaken considerably, because of lower population growth, and attainment of high consumption levels in a few major countries. Consumption of milk and dairy products is expected to continue growing. The trend for the developing countries to become growing net importers of meat is set to continue.

Oilcrops and products.

This category of food products with a high calorie content has played an important role in the increases of food consumption in developing countries and it is expected that non-staples such as vegetable oils still have significant scope for further consumption increases. The growth of aggregate world demand and production would continue to be well above that of total agriculture, although it would be much lower than in the past. On the production side, the trend has been for four oilcrops (oil palm, soybeans, sunflower seed and rapeseed) and a small number of countries to provide much of the increase in world output (see below). The sector accounted for a good part of cultivated land expansion in the past and in the industrial countries it made up for part of the declines of the area under cereals. There are five major net exporters among the developing countries (Malaysia, Indonesia, the Philippines, Brazil and Argentina) that increased their net exports from 4 to 21 million tonnes. However, the rapid growth of demand of the developing countries was accompanied by the emergence of several of them as major importers of oils and oilseeds, from 1 million tonnes in 1974/76 to 17 million in 1997/99. In the future, these trends are likely to continue and the net trade balance of the developing countries would not change much, despite the foreseen further rapid growth of exports from the main exporter developing countries.

Roots, tubers and plantains[55].

These products (mainly cassava, sweet potatoes, potatoes, yams, taro and plantains) represent the mainstay of diets in several countries, many of which are characterized by low overall food consumption levels and food insecurity. The great majority of these countries are in sub-Saharan Africa. Significant quantities of roots are used as feed, including potatoes (mainly in the transition countries and China), sweet potatoes (mainly China) and cassava (mainly Brazil and the EU). In Thailand, the main supplier of cassava to the EU, cassava production and exports followed closely the developments in the EU. The rapid expansion of cassava production for export in Thailand is thought to have been a prime cause of land expansion and deforestation, followed by land degradation in certain areas of the country. This link provides a good example of how the effects of policies (or policy distortions such as the high support prices in the EU) in one part of the world can exert significant impacts on production, land use and the environment in distant countries. The food products in this category will continue to play an important role in sustaining food consumption levels in the many countries that have a high dependence on them and low food consumption levels overall.

Crop production and available land

By 2030, crop production in the developing countries is projected to be 67 percent higher than in the base year (1997/99). In spite of this noticeable increase in the volume of crop production, in terms of annual growth rates this would imply a considerable slowdown in the growth of crop production as compared with the past, because of the anticipated deceleration in the growth of aggregate demand. Most of this increase (about 80 percent) would continue as a result of a further intensification of crop production in the form of higher yields and of higher cropping intensities (multiple cropping and reduced fallow periods), with the remainder (about 20 percent) as a result of further arable land expansion. The developing countries have some 2.8 billion ha of land with a potential for rainfed agriculture at yields above a "minimum acceptable level". Of this total, some 960 million ha are already under cultivation. Most of the remaining 1.8 billion ha, however, cannot be considered as land "reserve" since the bulk of the land not used is very unevenly distributed with most of it concentrated in a few countries in South America and sub-Saharan Africa. In contrast, many countries in South Asia and the Near East/North Africa region have virtually no spare land left, and much of the land not in use suffers from one or more constraints making it less suitable for agriculture. In addition, a good part of the land with

[55] Not in table 1 because precise figures are lacking

agricultural potential is under forest or in protected areas, in use for human settlements, or suffers from lack of infrastructure and the incidence of disease. Therefore, it should not be considered as being a reserve, readily available for agricultural expansion. Taking into account availability of and need for land, arable land in the developing countries is projected to increase by 13 percent (120 million ha) over the period to 2030, most of it in the "land-abundant" regions of South America and sub-Saharan Africa, with an unknown but probably considerable part of it coming from deforestation.
In terms of *harvested* land, the land area would increase by 20 percent (178 million ha) on account of increasing cropping intensity. The latter will reflect the growing role of irrigation in total land use and crop production. Irrigation is expected to play an increasingly important role in the agriculture of the developing countries. Expansion of irrigation would lead to a 14 percent increase in water withdrawals for agriculture, although this depends crucially on the projected increase in irrigation water use efficiency (from 38 to 42 percent on average). Without such efficiency improvements it would be difficult to sustain the necessary expansion of irrigated agriculture.

Conclusions

The projections show that future production of food will most likely be able to meet demand, although distribution will not be even. Many developing countries will become net importers of food, and the number of people who are undernourished will still be high.
The increased production will stem mostly from an increase in productivity, by using improved technologies. This might have implication for the sustainability of food production. There is an ongoing discussion[56] on whether future food production could be sustained by biological agriculture and whether this would be more a environmentally friendly option than intensive agriculture. We will not repeat the discussion here, but highlight the question of whether, and if so how intensive agriculture could be made (more) sustainable. Intensification implies using inputs such as fertilisers, pesticides or (genetically modified) seeds, which are known to have had negative impacts on the environment and human health. Although much progress has been made in this area by banning toxic pesticides, better targeting fertiliser use (e.g. through precision farming), not all problems have been solved, especially in developing countries. Biological agricultural technologies make less (or no) use of these external inputs, relying on the use and recycling of resources available on the farm. This may mean, however, that there is less scope for using residues for biomass, because these will have a function in the biological agriculture system (for instance as feed for livestock, or green manure). However, promising solutions for sustainable agriculture might be found in combining technologies that are used in the biological agriculture with those of intensive agriculture.

Additionally, more needs to done in improving the efficiency of natural resources use, especially that of water. In developing countries, irrigation will be crucial to facilitate the required agricultural productivity increase. However, this will need additional water, which may be problematic for arid regions, or other regions where water is already scarce. In general, many irrigation systems in developing countries are still extremely inefficient with high water losses. An important point to take into account when increasing the production of biomass crops is how many additional inputs these crops need in terms of soil nutrients, pest protection and water. Although in principle intensification of agriculture seems to be possible with minimising environmental damage, in practice this is often difficult to attain in developing countries.
With respect to available land for biomass production, the FAO study has calculated that there appears to be land available, especially in Latin America and Sub-Saharan Africa (Bruinsma, 2003). However, most of this land is not suited, either for agronomic reasons, or

[56] See for instance NRC Handelsblad: Louise Fresco, Joost van Kasteren en Rudy Rabbinge "Verbeter vooral de gangbare landbouw" (19-04-2005) and Kees van Veluw en Boudewijn van Elzakker "Biologische landbouw is succes in Afrika" (26-04-2005)

it is reserved as nature (e.g. The Amazon)[57]. It is therefore expected that any future increases in agricultural land will be through deforestation. We can conclude that there is no additional land available that could potentially be used for biomass production. Making available additional land will be at the expense of natural habitats (deforestation), which is incompatible with our definition of sustainable development or sustainable food production.

Therefore, solutions must be found in combining existing agricultural production (including food) with the production of biomass. Possible win-win situations can be found in using residues of (food)crops for biomass production. However, not all residues may be freely available for biomass production. In developing countries, many residues already have a use, for example for livestock feed, green manure, other food purposes. Residues may not always be "free" and there will be opportunity costs involved, and this needs to be well analysed beforehand. And generally speaking, in case of substitution, residues should be used for most economic use taking into account the triple P principle.

Another possible win-win option is substitution of existing crops for biomass crops. If biomass crops are more profitable, or have other advantages over existing crops, this may induce farmers to switch to biomass crops. This is a good possibility for cash crops that are no longer profitable due to price decreases. Many commodities such as coffee, cocoa, and cotton have experienced fluctuating but steadily decreasing price levels. Providing better alternatives to poor farmers in developing countries will certainly address the "people" dimension in the triple P. However, to analyse these possibilities, economic analysis is needed that takes into account opportunity costs, substitution effects and trade policies of major players such as the EU and US. Again, the triple P principles should be taken into account – what negative impacts does biomass production have on the agricultural sector (higher use of inputs), natural areas (increased deforestation), incomes (does biomass production offer better alternatives to poor people) etc.

We have directed this outline to include generally all biomass crops, but the type of biomass crop will have implications for the extent to which it can be combined with sustainable food production. Cassava, a food crop, will have different implications than sugarcane, an annual cash crop. The BUS card 18 mentions specifically using forestry residues as biomass. Forestry residues need a different analysis than agricultural crops, because this topic will lie in the area of sustainable forestry rather than sustainable agriculture. A win-win situation for using forestry residues can be in combining reforestation or afforestation projects with biomass projects. Care should be taken that forestry biomass production will not lead to further deforestation.

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[57] A recent study by CIFOR has calculated that most of the growth of area devoted to commodities (such as soybeans, oil palm, cocoa, and coffee) in developing countries came at the expense of forests, including the Amazon (Niesten et al., 2005).

16

TYPHA FOR BIOENERGY

Definition of the problem
Typha is a type of reed that covers large parts of the Senegal river. Two dams have been constructed limiting the natural fluctuations of the river and providing an opportunity for Typha to establish itself permanently along the shores. Because of the extensive Typha growth irrigation canals are blocked, the local population has difficulty accessing the river, fishing has become impossible, and health problems arise from still water. In the last few years possibilities have been evaluated to remove the Typha in order to utilise it for charcoal production. Mechanical removal of Typha is costly and is not a sustainable option unless the cost of removal can partly be recovered by selling (energy) products.

Questions
1. What is required in order to establish a sustainable and continuous production of solid biofuels?
2. Describe the harvesting system and calculate at what cost Typha can be harvested and delivered to the shore.
3. Describe the composition of Typha as is relevant for the conversion into biofuels
4. Compare local use of the biofuel to export of the biofuel
4. Evaluate Typha as a feedstock in two scenario's: Capex paid from aid funds. Capex has to be repaid from bio-fuel delivery.

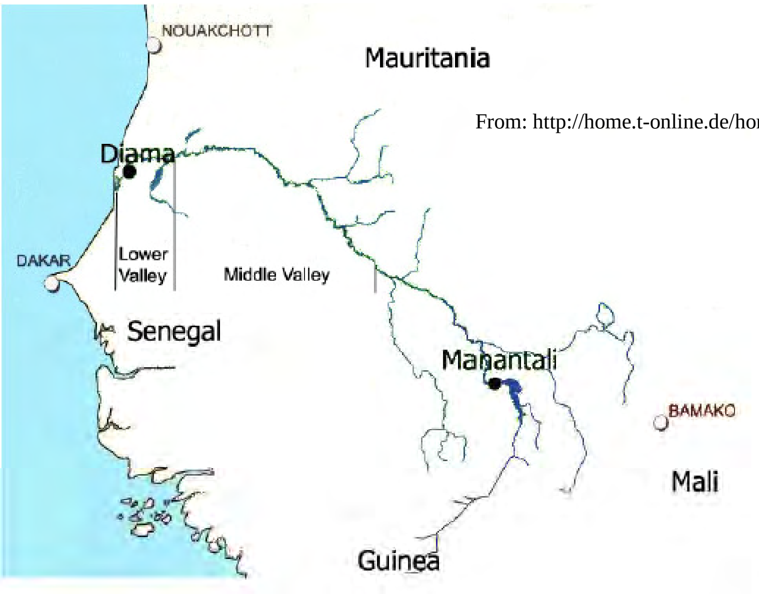
Wolter Elbersen, April 2005. Report on bus ticket no. B1, WUR-A&F

1. Approach
First a description is made of the situation in the Senegal River basin and the role that Typha plays as a pest. Then the important aspects of a Typha to biomass energy production chain are discussed, from harvest to utilisation as a biofuel. A discussion of the most important issues is followed by conclusions and recommendations. Along the way the specific questions as described above are answered.

2. Description of Typha situation in the river basin

The Senegal river basin and Typha
The Basin of the River Senegal lies in four countries, Guinea, Mali, Mauritania and Senegal, as shown in figure 1. In this river two dams have been constructed to provide electricity, irrigation, drinking water and to prevent seawater incursion (see Kolff and Pieterse for more information). The system provides irrigation water for some 250.000 ha of farm land. The dams provide 800 GW of electricity and drinking water to the capitals of Mauretania and Senegal. The dams have also made the river navigable allowing transport throughout the year.

After the construction of the Diama dam in 1985 in the River Senegal (see figure 1) a shallow lake has been formed in the former delta. Lack of stream velocity combined with the effects of eutrophication of the river water due to agriculture located upstream, provides favourable abiotic conditions for several aquatic water plants that can become a nuisance. In the shallower parts along the shore emergent water plants such as reed (*Phragmitis australis*) and the native species *Typha australis* can occur, but also floating water plants such as Salvinia, Pistia and possibly in the future Water hyacinth (lat name) can become a pest under these nutrient rich conditions in still water. Pistia seems to be under (biological) control and currently Typha is the most problematic weed. The lake between the dams is shallow (maximum depth 3 m) making most of the area potential habitat for Typha, which requires less than 1.5 m of depth. The salt content has become less than 1.6%, ideal for Typha, which requires less than 2% salt.



From: http://home.t-online.de/home/320033440512-0004/typha/kloff.pdf

Figure 1 : Senegal River Basin with the location of both dams

Problems associated with Typha

The proliferation of Typha leads to many problems including:

- Clogging of irrigation canals
- Bird pests ("Roodbekwevervogel") invading rice areas: birds find refuge in the Typha
- Reduced access to water for villagers
- Impediments to fishing
- Reduced water quality
- Water borne diseases such as Bilharzia and Malaria
- Air pollution because villagers burn above water parts of Typha
- Weed problems in rice growing areas because of Typha seeds blowing into rice fields

Area and biomass potential of Typha

Typha now covers some 140.000 ha of shallow water and wetland areas that were formed due to dam construction. In figure 2 a map is shown of the area with an indication of the Typha proliferation and density. The dry matter density of Typha varies with soil type, water depth and availability of nutrients. Yield estimates for Typha range from 6 to more than 20 tonnes of dry matter per ha. Overall a productivity of 6 to 8 tonnes of dry matter should be expected (van Kooten, pers comm.). The current area of 140.000 ha is expected to be reduced to some 30.000 to 40.000 ha due to several measures that will be part of a large World Bank project partially financed by the Dutch government (van Kooten, pers comm.). The proposed measures include (van Kooten, pers comm.; Scharloo and Drost, pers comm.):

- Construction of small levies (dams) to reduce wet and inundated areas, this essentially reduces the area of the lake and thus the area where Typha can grow.
- Dredging inlets to irrigation canals to a depth of 2 to 3 m, thus preventing growth because Typha needs water shallower than 1.5 m to grow.
- Similarly the access of villages to the water can be dredged deeper to prevent establishment of Typha, thus giving the villages better access to the water.
- Making small levies allowing selected areas to dry out from which Typha can subsequently be removed or eradicated after which the water is returned again
- Mechnical removal of Typha

The remaining 30.000 ha of Typha would then be available for continuous sustainable exploitation making it possible to establish commercial production of Typha products. One idea is to rent out this area for commercial exploitation for charcoal production (pers comm.. van Kooten). At a yield of 6 to 8 tonnes of dry matter this would potentially yield 180.000 to 240.000 tonnes of dry matter per year.

The most important factor to determine the feasibility of such a scheme will be the cost of harvesting, drying and transporting Typha to a processing facility and the sustainability and continuity of the Typha growth.

Harvesting and drying of Typha

In order to utilise Typha an effective harvesting and transportation system has to be devised, which can be difficult:
“La difficulté majeure réside dans la coupe, le ramassage et le transport d’une biomasse importante dans un environnement aquatique qui complique singulièrement les choses” (Dieng, 2002). (The main problem is the harvest, the handling and the transport of biomass in an aquatic environment which much complicates things).

Harvesting Typha for eradication or for sustainable use requires very different approaches. For sustainable use special equipment has to be used and specific measures have to be taken (Hellsten et al., 1999; Henning, 2002):

- The emergent Typha plants should be cut 20 cm above water level (to maintain air exchange with the lower parts of the plant). If plants are cut too short Typha may die down creating anoxious conditions (because of decaying plant material) and associated pollution problems together with a reduced ability for re-growth.
- Plants should be cut at senescence to maintain sufficient reserves for re-growth in rhizomes but before seeds are spread.
- One harvest per year.

The cost of harvesting

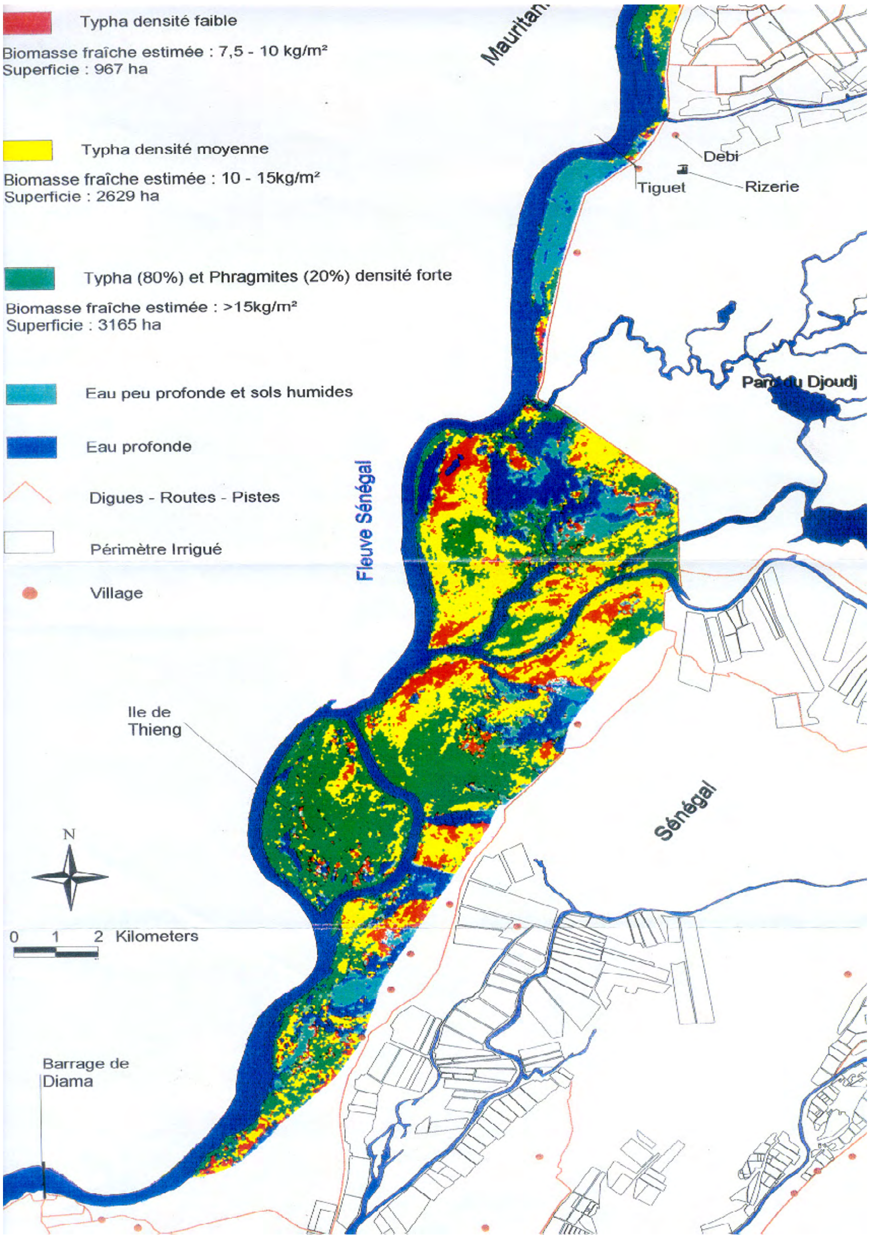
On the cost of harvesting Typha little information can be found. A wide range of equipment is available but costs are never given. From a study on aquatic weed management coordinated by the Royal Dutch Tropical Institute, it was concluded that a mowing boat costing 75 000 US$ could only cut 1 hectare in 35 hours (Hellsten, 1999). Henning gives more optimistic estimates, indicating some 15 mowing boats or 15 amphibious mowing vehicles would be needed to harvest 100.000 tonnes of dry biomass. If we assume the investment cost of such a vehicle is 75.000 US$, mowing equipment would cost more than 2,25 million US$ for 30 machines harvesting 200.000 tonnes of biomass (dry basis) from 30.000 to 40.000 ha per year. Operational cost is not given. If we assume other costs to be 2 x the machine costs and a 10 year operational live the cost would be: 2,25 x 3 = 6,75 million US$ for harvesting 10 x 200.000 tonne of biomass = 2 million tonnes of biomass. This means 3,40 US$ per tonne dry matter harvesting costs.

One of the main objectives of the Word Bank project (mentioned above) is to identify mowing options for Typha (pers comm. Van Kooten; perscomm Scharloo and Drost).

A problem seems to be that most aquatic plant harvesting machinery and harvesting systems are geared towards eradication and not yet towards sustainable production. An alternative may be to use areas, within levies, that can be dried out periodically for harvesting Typha after which the area is flooded again (van Kooten). This will certainly make harvesting less costly as it can be done with conventional equipment such as sugarcane or rice harvesting equipment.

Drying
Drying of biomass can be problematic in tropical areas. Fortunately the Senegal river area mostly has a desert climate with low rainfall (approximately 600mm per year) and a very low humidity most of the year (20 to 30 % humidity, pers comm. Van Kooten). Therefore biomass can be air dried to 80% dry weight in less than 10 hours (Henning, 2002). It is necessary to create a large area for drying within the boundaries of levies.

Figure 1: Typha cover and density in the Senegal river (Figure OMVS, SOGED, AGRER)



Composition and utilisation options for Typha

Composition of Typha
Typha is an aquatic plant that is rooted in the soil. The composition of plant material will depend on factors such as plant type and soil type, but there are many more. A quick search of composition data of Typha did not yield much relevant information. The only data found on Typha composition (on internet) refer to Duke, 1983 and only apply to North America:

Whole plant	Dry matter basis
volatile matter	71,6 %
ash	7,9 %
fixed C	20,5 %
C	43,0 %
H	5,3 %
O	42,5 %
N, S, Cl	0,8 %
Undefined rest	8,4 %
Energy content:	16,3 - 17,8 MJ / kg
Leaves	
dry matter	16 - 24 %
carbohydrates	38 - 48 %
raw protein	7 - 12 %
Lipids	1,5 - 3,5 %
raw fiber	30 - 39 %
Minerals	6 - 18 %

It is possible to speculate on the composition of Typha based on soil type. The delta soils will often contain heavy clay, leading to a higher ash content than on sandy soils. Furthermore it is known that the water of the lake has elevated salt concentrations and there are salt containing soil layers (van Kooten pers comm.) this means that higher Cl and K and Na loads (Na and K reduce melting point of the ash, complicating thermal conversion). It is not difficult to leach out these components but this increases processing costs.
It can be concluded that it is likely that Typha from Senegal will have lower quality for thermal conversion due to elevated Na and Cl levels. For other options like charcoal for household use or lignocellulose ethanol production this may be less of a problem.

Utilisation options for Typha
Currently several options for using Typha plant material are being considered including:
Compost for local horticulture farms. Many other uses can be found from paper making to construction material, food and even medicine (http://www.typha.net)
Energy use of which charcoal production has been most extensively investigated.
Charcoal production appears to be the most logical and pragmatic route, taking into consideration the large volume of material that has to be dealt with.

The following facts can be found for the production of charcoal from Typha:
It is necessary to have Typha biomass at air humidity of less than 20%
For production of one tonne of charcoal some 3 dry tonnes of Typha is needed (Henning , 2002) which compares favourably to wood.
The only price quoted (Henning, 2002) varies between 55 and 70 FCFA per kg (1 Euro is 655 FCFA. Thus one tonne of charcoal would cost approximately 100 Euro's. It is not known if the cost of harvest and transport are included in this estimate.
Carbonisation of Typha produces a coal powder that needs to be pressed with a binder (molasses, starch) into briquettes.

The overall (sustainable) yearly production potential of charcoal from Typha based on 200.000 tonnes of dry matter (see above) = 200.000 x 1/3 (conversion to charcoal) = 65.000 tonnes of charcoal.
Thus Typha can provide up to 15% of the charcoal demand of Senegal (more than 400.000 tonnes according to GTZ data. (pers comm. van Kooten)). The demand for charcoal in Senegal (and in many other African countries) is a threat to forests and forest destruction causes erosion, especially in southern Senegal which has sufficient precipitation (2000mm) for forest. Much effort is given to finding alternative sources charcoal. World Bank and GTZ projects aimed at finding more efficient charcoal production methods are evaluating Typha as a source. Carbon credits for such a project can be obtained as it contributes to less forest destruction in Southern Senegal (pers. comm..van Kooten).
Therefore it has to be concluded that utilization of Typha for charcoal production and local use seems to be the most attractive option compared to exporting the biomass.

Discussion and conclusions
The picture that emerges is that the establishment of dams in the Senegal river has led to important benefits such as an end to floods and droughts, a new source of drinking and irrigation water, and a large electric potential. But, these benefits have been less than anticipated and a number of environmental problems have been created. One of the these is the infestation of the large and shallow lake(s) with aquatic weeds. A problem that has to be dealt with. Utilisation of the major aquatic weed Typha that currently covers 140.000 ha in the Senegal river delta for biofuel can only be part of a solution. Other measures such as dredging out the access to villages and irrigation channel entrances will also have to be implemented. It also appears that the importance of fulfilling the main purposes of the watersystem (irrigation water, drinking water, etc) can not be compromised for biofuel production as is illustrated by the quote:
"*Typha* continues to have diverse negative impacts on drinking water, fishing, water-borne diseases and pests, which far outweigh any potential of the plant to combat erosion or be used in manufacturing" (http://pest.cabweb.org/Journals/BNI/Bni23-1/Gennews.htm).

"All profits from Typha will never outweigh the negative impacts. Typha is first of all a pest and not a new resource" (Boubouth et al.,1999).
If Typha is to be exploited on a large scale it will require investments in an infrastructure for harvesting, drying, transport and conversion to a fuel. This investment will have to be repaid requiring a guaranteed continuous supply of Typha. As explained above, harvesting Typha for sustained production requires a different approach than for eradication. Also the quality of the biomass in terms of soil contamination, etc may be less favourable. Therefore we can conclude that a large quantity of Typha can become available from eradication activities, but this quantity is variable over the years and may not be sustainable. For a guaranteed Typha supply as needed to recover investments, some kind of production system will have to be incorporated in the management of the river basin. It may be possible to link the Typha harvesting system to reduce eutrophication (beneficial to the water quality and therefore to the rest of the aquatic ecosystem and water use purposes), which is one of the main causes of the weed problem in the first place. Thoughts exist to eventually rent out some 30.000 to 40.000 ha for Typha production and use as biofuel or for other uses.

Investments in a biofuel production system based on Typha can only be justified if some kind of guarantee can be given of continuous supply if Typha. This seems at odds with goals of eradicating the weed unless Typha production and removal becomes part of the management of the lake such as the reduction of eutrophication.

Harvesting techniques of Typha needed for eradication or sustained production are very different. But it seems well possible that the equipment used to eradicate Typha from

certain areas can also be used to harvest, dry and transport Typha in the production system of Typha.
Currently some 140.000 ha of Typha exists in the Senegal river basin. This area should not be seen as all available for exploitation since the main goal is to eradicate Typha in most of this area. Eventually some 30.000 to 40.000 ha of Typha could be used for continuous sustainable production.
It seems quite possible that continuous exploitation of Typha fits in with other management goals such as reduced eutrophication leading to less weed problems in other areas like irrigation channels and benefits other water use purposes (drinking water) and the aquatic ecosystem.
From an investor point of view the cost of continuous production and harvest of Typha for biofuels should probably be compared with growing biomass in the same region in an agricultural setting.
The risk of the investment in conversion and logistics may be reduced by also utilising other biomass residues such as rice straw in the region.
It is interesting to note that a large amount of natural biomass that is essentially available for free is still very difficult to exploit because of logistical problems and uncertainties with respect to the continuity of the supply. It appears that the only way of exploiting the potential sustainably will be by making the biomass removal an integral part of the whole management system.

Further research

Large problem that exists in Africa because of deforestation and erosion due to the increasing demand for charcoal. The process of charcoal production is generally not very efficient. It would be interesting to see if small scale Torrefaction of biomass would produce an acceptable fuel that can substitute charcoal for cooking purposes.
It would be interesting to explore how a Typha biomass production system could be fitted into the management system of the Senegal river and to quantify the potential benefits to the environment (and irrigation, drinking water quality, etc) and the costs at which biomass could then be produced.

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17

POSSIBILITIES OF SOCIAL FORESTRY AND AGRO-FORESTRY FOR THE PRODUCTION OF BIOMASS IN THE TROPICS

Definition of the problem
Large scale energy plantations are relatively labour extensive, because of this social problems can arise in densely populated areas in developing countries. Plantations can also be established at the expense of agricultural lands. For this reason social- and agro-forestry have been promoted as a social friendly alternative. In these systems each individual farmer can grow a limited number of trees and supply these together to a timber processing industry. So far there are no examples known for the production of biomass, but there are examples in the pulp- and paper sector. Is it possible to predict whether this could also work for producing biomass and if so: in which way?

Questions
1. What are the experiences with such a sound social production method?
2. Could similar systems work for the production of biomass?
3. If so, under which conditions?

Mark van Benthem, May 2005. Report on BUS ticket no. B8, Probos

Summary
Plantations can effectively meet the ever-increasing demand for many different wood products, including biomass. Although this has been recognized for over a century, progress in getting large areas into production has been much slower than projected. There are many reasons for the shortfall in tree plantation production (see e.g. Report on BUS ticket no. 23), including a general lack of effort in actively engaging communities in plantation schemes in a way that benefits both the small-scale producers and the wood products industry.

An important means of expanding plantation establishment, thereby benefiting small-scale producers, is through corporate-smallholder partnerships which include agreements with industries to purchase wood produced by (but not limited to) smallholders. While there are some examples of successful corporate-smallholder partnerships in the tropics, many attempts have been only partially successful or have failed entirely in producing significant quantities of wood in ways that benefit both producers and users.[58]

If partnerships between growers and forest companies adhere to and learn from the principles mentioned in the various studies on this subject (see Annex 1), it should be possible to establish a similar system for the sustainable production of biomass for bioenergy. It is interesting to see that various production scales are possible through corporate-smallholder partnerships: from producing biomass on a very small-scale for a local combustion plant or biodiesel engine, to PICOP size of over 20.000 ha and perhaps even larger.

[58] http://www.fao.org/documents/show_cdr.asp?url_file=//DOCREP/005/Y4803E/y4803e01.htm

1. Case study: The agro-forestry development plan and practices of the Paper Industries Corporation of the Philippines (PICOP)[59]

A short version of the PICOP-case presented here was also included in the study by Shell and WWF published in 1993: Shell/WWF Tree Plantation Review[60]. Study nr. 7 describes 'The social and cultural issues of tree plantations in local economies, and their implications for management'.

In Annex 1 an overview is given of other relevant projects on forest company-community partnerships e.g in KwaZulu-Natal (South-Africa), Tasmania,Western Australia, Brazil, India,Thailand and Indonesia.

Origin of the PICOP-project

The Paper Industries Corporation of the Philippines (PICOP) is an integrated wood-based industry, which obtains most of its supplies of raw material from its own concessions. To obtain further sources of supply for growth and expansion it has embarked on an agro-forestry programme involving landowners whose land is outside PICOP's own concessions. Planned agro-forestry began in the Philippines in 1967 through the initiative of forester Nicholas Lansigan, then PICOP Assistant Vice-President for Forestry, in setting up the PICOP programmer. This is essentially a self-help programme for the improvement of the socio-economic welfare of the people living near PICOP's concessions, and is especially designed to develop supplementary sources of pulpwood for the pulp and paper mill at the town of Bislig.

Planting began in a very modest way in 1968 with a few sceptical landowners who were reluctant to undertake tree farming. Progress accelerated considerably in 1972, when the farmers obtained their first earnings from early thinnings, and realized the great potential of agro-forestry for improving their living standards.

In 1972 also, the Development Bank of the Philippines (DBP) became interested in the project, after a study had been submitted to it by PICOP and bank officials had visited the twenty-two demonstration tree farms in the Bislig area. In view of the praiseworthy objectives of the project they agreed to provide funding for the participating farmers. Later the World Bank, recognizing that the project was a viable and profitable one, took part in the financing through the DBP. It was considered that the PICOP plan would be a good model suitable for duplication not only in the Philippines but in other developing countries as well. A condition of the loan to farmers was the inclusion of a pulpwood marketing agreement between the farmers and PICOP.

Progress

By December 1980, 3,800 farmers were participating in the PICOP project, as compared with 22 in 1969. By that date 11.3 million trees of *Albizia falcataria* had been planted at a normal spacing of 4 metres by 4 metres on 22,600 hectares. Of the participating farmers, 44 per cent had availed themselves of the finance provided by DBP and the World Bank, and 56 per cent used their own resources.

With an average yield on an eight-year rotation of 250 cubic metres of pulpwood per hectare, the potential pulpwood supply was about 760.000 cubic metres per annum. At 72.75 pesos per cubic metre, this will provide the farmers with a total of about 51.4 million pesos year (in 1980, 1 U.S.$ = 14 pesos).

Actually, between 1975 and 1979, before the plantations were fully mature, PICOP had already bought 660,579 cubic metres of pulpwood from farmers, valued at 37,963,500 pesos. (2.7 million US$). During the first half of 1980, 119,932 cubic metres were sold to PICOP for 13,248,600 pesos (almost 1 million US $).

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[59] http://www.unu.edu/unupress/unupbooks/80502e/80502E0d.htm

[60] Shell/WWF, 1993, Guidelines: Shell/WWF Tree Plantation Review, Shell International Petroleum Company Limited and World Wide Fund for Nature, London

PICOP Incentives for Agro-forestry Farming
1. Assistance in locating and acquiring vacant public agricultural lands.
2. Technical advice in determining which portions of the land are good for food cropping and livestock farming and which for tree growing.
3. Technical advice on the preparation of land for planting, methods of planting, maintenance and management of tree farms and marketing of pulpwood trees.
4. Technical advice on the methods of planting, cultivating, processing and marketing of food crops, as well as on the raising and marketing of livestock.
5. Assistance in obtaining loans from government financing institution for tree farming and for food production.
6. Providing *Albizia falcataria* seedlings the cost of which is payable after the pulpwood is harvested, without interest.

Details of the Agro-forestry Development Plan

Under the "Agro-forestry Development Plan for Farmers" PICOP staff not only guide the farmers in growing fastgrowing trees for pulpwood, but also give advice on growing food-crops and on raising pigs, poultry, cattle and fish. The general objective of the plan is to assist in the socio-economic uplift of the people, particularly the small landowner-farmers, as well as the members of their families. through a self-help agro-forestry project. The specific objectives are (a) to assist the farmers to increase their production of cereals, vegetables, fruits, meat and fish, and (b) to assist the farmers to grow fast-growing pulpwood on their privately owned land for sale to the PICOP pulp and paper mill.

The concept of the project is to develop the land intensively, by devoting 20 per cent of the most suitable land to production of farm crops and livestock, and using the remaining 80 per cent of poorer land for tree farming. Intercropping of annual food crops, such as rice. maize, root crops, vine crops, and vegetables, between the young trees, possibly until they reach the age of three years, was advised. It provides the farmer and his family with additional food and cash income, and helps in weeding and maintenance of the tree plantations.

Under the loan assistance programme of the DBP and the World Bank, landowner-farmers who own from five to fifty hectares of land, outside the PICOP concession, but within 100 km distance by road from the PICOP mill, can obtain loans for the development of their land, both for food and pulpwood production.

Three methods of agro-forestry farm management are recognized. The first is used where there is existing good second-growth forest. Here on ten hectares, two hectares will be used for food-crops and livestock, while the remaining eight hectares will be managed for pulpwood by harvesting the trees which reach pulpwood size each year, and allowing the smaller ones to continue to grow.

In the second case, second-growth forest is converted into cropland and tree plantation. As before, on a ten-hectare plot, two hectares are used for foodcrop and livestock production, and of the remaining eight hectares, one hectare is cleared of secondary forest and artificially planted with fast-growing trees each year. In the third case when the land is bare of trees, two hectares are planted with foodcrops, etc., and one hectare is planted with fast growing species each year.

Economics of Agro-forestry PICOP Tree Farming Project

I. Gross income from the average harvest of 250 m^3 of *Albizia falcataria* per hectare in the ninth year, and selling at the rate of 72.75 pesos/ m^3, totals 18,187 pesos (1300 US$)

II. Costs[61] Establishment costs

1. Land clearing and preparation 300 pesos
2. Purchase and handling of seedlings, lining, staking, holing, planting and replanting 755 pes.
3. Weeding, cultivation and fertilization 645 pesos
4. Sub-total 1,700 pesos (i.e 121 US$)

Harvesting and transport

1. Harvesting and transporting to roadside, debarking and cutting to convenient length of 2.5 metres at the rate of 32.50 pesos per m³ based on 250 m³ harvest per hectare totals 8,125 pesos. Hauling from roadside to mill site (subsidized by PICOP as far as 100 km road distance from mill site)
   Sub-total 8,125 pesos (i.e 580 US$)

Interest and taxes

1. Interest on investment of 1,700 pesos upon harvest on the ninth year at the rate of 12 per
   cent (simple) per annum costs 1,632 pesos
2. Land tax and special educational fund for eight years at the rate of 2 per cent yearly of the assessed value of the land, is 560 pesos per hectare
3. Contingencies including other government levies 2,000 pesos
   Sub-total 4,201 pesos (i.e 300 US$)

Total cost per hectare 14,000 pesos (i.e 1000 US$)
Net income per hectare at the ninth year 4,160 pesos (i.e. 297 US$)

Conclusions

- The PICOP agro-forestry programme has shown that the private sector can be an effective partner of the government in making the hills and mountains "greener" by planting economic trees. Agro-forestry not only contributes to raising the socio-economic standards of the people, but is also an effective means of forest conservation, forest protection, maximum utilization of land, avoiding erosion, improving public relations, community development, and creation of employment.
- Employment is created in preparation of land for food and wood-pulp production; in planting, maintaining, harvesting and marketing trees; and in producing, harvesting and marketing farm crops and livestock. The results are: increased family income, better education, improved health, and more active family participation in the affairs of the community and the government.
- At present, in addition to the 3,800 participant farmers, 11,400 labourers, 65 truck drivers and 65 truck helpers are employed as a result of the project, under the management of the farmers themselves, and on their payroll. Thus a relatively small-scale project has benefited 15,330 people plus their dependents. This is a great step forward in the fight against poverty.
- Agro-forestry as practiced in PICOP is simple, practical, economical, profitable and duplicable. It is hoped that such schemes will, in fact, be duplicated on a wide scale.

2. When do such social forestry and agro-forestry schemes work?

Small scale social- and agro-forestry systems are appropriate for timber processing companies, when:

- wood is supplied at a lower cost than alternatives would provide, and when continuous supply can be secured

[61] Costs in (1980) pesos. Not included is the labour-income of the working Agro-forestry farmer and/or the members of his family, in such activities as land clearing and preparation, lining, staking, holing, planting and replanting, weeding, cultivation, fertilization, harvesting, hauling to roadside, debarking, and cutting of pulpwood to convenient length of 2,5 m.

Small scale social- and agro-forestry systems are appropriate for growers, when:

- the land used is not required for food production
- they have security of land tenure (land title may not be essential)
- the earning from trees compares favourably to alternative land uses
- they are involved in the negotiations for defining terms and conditions and designing the scheme, including the right to determine when the trees are harvested
- they receive advance payments from the company to assist them in meeting initial costs
- tree growing provides a stable and fair source of income in terms of the price of products, an assured market, and access to technical advice and inputs exists
- regional competitive markets are developed
- reliable information about the industry is made available
- they experience labour shortage (e.g. for labour intensive agriculture)

Small scale social- and agro-forestry systems are **not** appropriate for growers:

- who have very little or no land; and may not reach the very poor unless different arrangements are reached, providing them with land for tree growing without restricting food production
- when risk sharing between partners is not appropriate in the local context

Problems between growers and companies may arise from:

- the terms of agreements in relation to the freedom to sell to other buyers, the price for the product and the availability of credit, extension and support. Flexible contractual arrangements are needed
- a lack of financial assistance with the cost of inputs (fertilizer in particular)
- discouragement from the company of diversification of farm production
- lack of incentive for farmer initiatives to manage trees appropriately
- the role of the government, which needs to be clarified and developed

3. Recommendations

1. Empower and train growers associations to negotiate on behalf of the growers and to provide many of the services required, so that they are not entirely dependent on the goodwill of the forest company.
2. Inform growers about the economic viability of small scale social forestry and agro-forestry schemes, long-term market prospects and reliable market information, their capacity to negotiate with the industry, fair returns from joint ventures, market structures, the benefits of small scale forestry for land and water degradation, and tax arrangements.
3. Learn from the agricultural industry, which has a long history of working within these producers/buyers relationships. Future agro-forestry projects may benefit from this extensive working experience.

4. Follow up?

1. Prepare a specific case for which this social forestry scenario can be worked out for the dedicated production of biomass. Search for local partners, sites, species, etc.
2. Put the benefits and costs in a realistic perspective from a ‘bioenergy’ point of view.
3. Convert the results of this quick-scan into a project proposal, for external funding and with co-funding from the BUS, focussing on poverty reduction and generating bioenergy for the local market.

Annex 1
Overview of relevant literature on forest company - community partnerships

Results of a workshop held in May 2002 in Bogor, Indonesia, put together with country reports, case studies etc, and published under the title: 'Towards equitable partnerships between corporate and smallholder partners, relating partnerships to social, economic and environmental indicators' (FAO and CIFOR, 2002[62]) is a very interesting document on this matter. It compiled, for instance, an overview of relevant literature[63], which is presented here.

- **Arnold, M. 1997. Trees as outgrower crops for forest industries; experiences from the Philippines and South Africa. Rural Development Forestry Network Paper 22a. London, UK, Overseas Development Institute.**

Drawing on a number of studies, Arnold presents two long running outgrower schemes in the Philippines and South Africa, operating since 1968, and the mid-1980s, respectively. In the Agroforestry Tree Farming program of the Paper Industries Corporation of the Philippines (PICOP), and three outgrower programmes in KwaZulu-Natal where landholders are growing wood for forestry processing companies, with the companies providing an assured market, and a variety of support services to growers. He outlines how the schemes originated and have developed, and analyses the schemes' impacts on outgrowers and their livelihoods.

He finds outgrower schemes to be appropriate for forest processing companies when wood is supplied at a lower cost than alternatives would provide, and with a measure of security. The appropriateness of the schemes for growers may be when growers obtain reliable income from other sources, when the land used is not required for food production, when tree growing provides a stable source of income in terms of the price of products, an assured market, and access to technical advice and inputs exists. Land security is important also, although land title may not be essential for this. Finally, outgrower schemes may not be appropriate for people with very little or no land, and hence may not reach the very poor unless different arrangements are made, e.g. by providing them with land for tree growing without detriment to food production.

Problems arise from the terms of agreements between growers and companies in relation to the freedom to sell to other buyers, price for product, the availability of credit, and extension and support. Arnold perceives these problems to arise from a broader institutional issue, that is needed to achieve balanced and equitable relationships between growers and companies. He believes growers associations, empowered and trained to negotiate for growers and to provide many of the services required but which are currently only available from the company, need to be formed. He suggests the forestry outgrower schemes may learn much from the agricultural industry, which has a long history of working within these relationships.

- **Curtis, A. & Race, D. 1998. Links between farm forestry growers and the wood processing industry: lessons from the Green Triangle, Tasmania and Western Australia. RIRDC Publication No. 98/41.**

This report outlines the nature of the links between small-scale tree growers and the forest industry in these three important farm forestry regions in Australia, namely joint ventures, cooperatives and on-farm processing. The study found that from the growers' viewpoint, current linking arrangements can be improved. Of primary concern to farmers was the uncertainty about the economic viability of farm forestry, long-term market prospects and reliable market information, their capacity to negotiate with the industry, fair returns from joint ventures, market structures, the benefits of farm forestry for land and water degradation, and concern about tax arrangements. The findings pointed to a need to develop competitive regional markets, to make available reliable information about the industry, for

[62] http://www.fao.org/documents/show_cdr.asp?url_file=//DOCREP/005/Y4803E/y4803e09.htm
[63] http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/005/Y4803E/y4803e12.htm

industry to demonstrate its willingness to offer fair prices and hence a reasonable share in profits for growers.
In addition, the industry also needed to demonstrate a long-term commitment to farm forestry in regions, either through the development of processing infrastructure or funding of field staff. Finally growers needed to develop the capacity to negotiate appropriately, or choose from a range of grower industry arrangements.

- **Higman, S., Bass, S., Judd, N., Mayers, J. & Nussbaum, R. 1999. The sustainable forestry handbook. London, UK, Earthscan.**

In this book issues concerning the sustainable forestry development are raised. Outgrower schemes are perceived to have potential to contribute to sustainable forest development. Based on the review of outgrower schemes in Brazil, India and the Philippines a range of benefits to growers and companies are identified. Outgrower schemes are seen to make good business sense, and increase the potential social benefit from forest management, and hence enhance support for forest managers, including companies, and the support from others, including communities. A case study of the Swiss Lumber Company scheme is presented.

- **Makarabhirom, P. & Mochida, H. 1999. A study on contract tree farming in Thailand. Reprinted from Bulletin of Tsukuba University Forests No. 15.**

This document outlines the historical development of contract tree farming. It provides a general description of contract elements. The incentive for processing companies to enter contract arrangements with tree growers is the assurance of a continuous supply of wood from small-scale tree planting. Case studies of contract tree farming are described in relation to the contractual arrangements, the company objectives, farmers' perspectives, and problems and prospects.
The study found that farmers would enter contract tree farming agreements where they experienced poor production or labour shortages. Issues raised by growers were the lack of financial assistance with cost of inputs (fertilizer particularly), poor extension, the discouragement from the company of the diversification of farm production, and the high production risk carried. The author perceived the lack of incentive for farmer initiatives in managing trees appropriately to be of particular concern.

- **Mayers, J. 2000. Company-community forestry partnerships: a growing phenomenon. Unasylva, 200: 33-41. Rome, FAO.**

A range of formal and informal partnerships between private sector companies and communities are emerging as the importance of forest farms for the production of forest goods and services increases. In this discussion, communities may encompass farmers and individuals as well as community groups and cooperatives. To gain an understanding of the arrangements needed to establish equitable partnerships, James Mayers examines a range of existing company - community relationships, including outgrower schemes, and discusses the advantages and disadvantages of these for growing trees outside forests. He outlines some considerations for the development of good partnerships for the secure delivery of forest goods and services. Outgrower schemes, one of the main formal partnership arrangements, vary. While, in some schemes, growers control production with the company paying the market price on delivery, in other schemes companies may have considerable control over production, or may incorporate fixed prices for products.
Sappi, an international pulp and paper company in South Africa, has run outgrower schemes with farmers since the 1980s. The company obtains trees from over 8,000 farmers covering about 88,000 ha in KwaZulu-Natal. Under this scheme, the company provides farmers with marketing and production services, including free expertise, silvicultural training and seedlings. The purchasing agreement is also laid out in the contract. The farmers grow trees on their own, receiving advance payments from the company to assist them in meeting costs which are then deducted from market price paid at harvest. The earning from trees compares favourably to alternative land uses.
A review of the literature available on company-community partnership arrangements in Brazil, India, Philippines, South Africa, and Australia (Arnold, 1997; Clarke, Magagula & von Maltitz, 1997; Curtis & Race, 1998; Roberts & Dubois, 1996) enabled the following

lessons for good partnerships to be learned: risk sharing between partners needs to be appropriate to the local context; arrangements need to cover potential fluctuations in market and hence price; growers need to improve their bargaining power to create strong, equitable partnerships; partnerships may have a negative impact on some community members; secure partnerships may require broader cooperation; extension and technical support is crucial; dealing with communities present greater challenges for companies; and the roles of government needs to be clarified and developed.

- **Race, D. 1999. Forest company - community partnerships: ingredients for success. Discussion Paper based on a meeting held at the International Institute for Environment and Development (IIED), London, UK on 9 April 1999.**

In this paper the context in which forest company-community partnerships have developed is outlined after a review of the literature. The paper focuses on outgrower schemes and joint venture, while acknowledging self-processing, market intermediaries and grower cooperatives as additional strategies that have developed in the forest industry if contractual partnerships are not preferred. The benefits of partnerships as well as some disadvantages for growers and the industry have also been highlighted. It identifies the following key issues for the formation of effective partnerships; the need for competitive markets, for flexible contractual arrangements, for reliable assessment of long term market stability, and clarity of roles of third parties involved in, or supporting, such partnerships. In summary, four key elements were identified for effective partnerships.

- **Roberts, S. & Dubois, O. 1996. The role of social/farm forestry schemes in supplying fibre to the pulp and paper industry. Towards a sustainable paper cycle. Substudy Series 6. London, UK, International Institute for Environment and Development.**

In this report social forestry schemes supplying wood fibre to the pulp and paper industry are reviewed in Brazil, India and the Philippines to identify why the schemes were initiated, how they are implemented and the perceived success of the schemes for different stakeholders.

The terms and conditions of the social forestry schemes vary considerably. The findings indicate that social forestry schemes do have a role in providing wood fibre to the industry. However, industry and growers have not always found the schemes to be successful. In addition to the need for stakeholders to be involved in the negotiations for defining terms and conditions and designing the scheme, the success of such schemes is also dependent the following features for growers to become involved: security of land tenure, access to credit prior to harvest, higher returns than alternative land uses, and secure markets for wood. The main issues of concern for growers identified were the choice they have of the species they plant, their rights to determine when the trees are harvested and to whom they are sold, and the price paid for the wood.

- **Shingi, P. 1997. Production and marketing of poplars in India: a case study. Ahmedabad, India, Centre for Management in Agriculture, Indian Institute of Management.**

The case study of WIMCO (Western India Match Company), a processing company manufacturing matches in India, was undertaken to understand the factors leading to the development of farmer-industry linkages for the commercial production of wood. To access additional wood resources for production, his company promoted poplar plantations on farmland. The study covers the poplar production from agro-forestry systems in three northern Indian states.

The study finds that after motivating a large number of farmers to plant poplar a joint scheme involving WIMCO farmers and the National Bank for Agriculture and Rural development was initiated in 1983. Farmers were offered loans, and also saplings, technical support and guaranteed market by the company. Difficulties with the schemes varied between the regions. However, growers were not bound to sell trees to the company. Insecurity of supply became a major issue for the company as growers sold to other buyers, defaulting on loans. Consequently, the company altered their strategy, focussing instead on the production of saplings for sale to growers.

- **Vuokko R. & Otsamo, A. 1998. Social and technical considerations in establishing large-scale *Acacia* plantations on grassland and bushland in West Kalimantan, Indonesia. In Turnbull *et al*. Recent developments in *acacia* planting. ACIAR Proceedings No. 82. Canberra, Australia.**

In this technical paper plantation establishment of *Acacia mangium*, *A. crassicarpa* and *Eucalyptus pellita* in West Kalimantan, Indonesia under a joint venture between a Finnish and two Indonesian companies is presented. The venture is working closely with communities to secure their participation in the venture as holders of traditional user rights. The arrangements under the joint venture are described, and include employment, a range of community and agricultural development benefits, in addition to ownership of a percentage of the plantation area, with the company guaranteeing to purchase wood at current stumpage rates. The effectiveness of the joint venture is demonstrated through the take up by villages, which is proceeding without difficulty. At this time the joint venture was operating in 50 villages and plantations covered 15,000 ha.

18

THE SUPPLY OF BIOMASS IN CHINA

Definition of the problem
Studies by Koopmans and Koppejan (1998)[64] and Jingjing et al. (1998)[65] have estimated a large, unused biomass potential in China, mainly consisting of forestry and agricultural residues and municipal solid waste. However, it is unclear what the impact is of current agricultural practice, traditional uses of residues and the future demand for food, on the availability of these residues.

Questions
1. How large is the biomass potential in China, especially in the forestry and agro-sector for the main types of residues?
2. What is the current use of agricultural residues and how much of it can be sustainably used for bioenergy purposes? What problems are to be expected?
3. What are the characteristics of the current agricultural practice, how is it expected to change and what would be the influence on the future biomass supply?

Leen Kuiper, May 2005. BUS-report on BUS-ticket B5, Probos

1. Introduction

Biomass in China may be derived from (1) forestry and wood processing, (2) agricultural production and processing of agricultural products and (3) from municipal solid waste. A forth main source of biomass, manure from animal husbandry, is not taken into consideration in this quick-scan, because it requires a completely different conversion route (anaerobic fermentation producing biogas). Neither have we looked for information on dedicated energy crops, such as e.g bamboo. In a more thorough future assessment all these resources may be dealt with in greater detail. Furthermore, the current approach by means of a quick-scan, gives a rough overall picture, which does not do justice to the great regional variation which exists in China.

1.1 Forest resource assessment[66]

- Total land area 960 million ha (280x The Netherlands). Chinese total forest area is 164 million ha (i.e a 16.5% forest cover), of which 70% is designated for timber production (i.e.110 million ha). China's State Forestry Authority has set a target to increase forest coverage to 19% by 2010, which would imply an increase of 18 million ha of forests in the next 5 years. The current (2004) afforestation rate is 2.7 million ha/a. Forest cover is expected to reach 24% by 2030.
- Distribution of forests in China is extremely uneven due to large geographical differences: in the northwest provinces e.g there are very few forests. Consequently, there are large differences in regional timber supply, China's traditional timber base being the north-east of China.
- By the 1990's China's forests have been vastly overexploitated, resulting in disastrous floods, which killed thousands. In response, the government has banned logging in some natural forest areas and implemented a huge tree planting programme.

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64 Koopmans, A. and Koppejan, J. 1998. Agricultural and forest residues – generation, utilization and availability. In: FAO 1998. regional Consultation on modern applications of biomasss energy, January 6-10, 1997, Kuala Lumpur, Malaysia

65 Jingjing, L.I, Jinming, B.A.I and Overend, R. 1998. Assessment of biomass resource availability. Chinese Ministry of Agriculture and US Department of Energy, China Environmental Science Press, Beijing

66 Anonymus 2001. China: timber trade and protection of forest resources. Chinese Academy of International Trade and Economic Cooperation

- As a response to the major floodings of the Yangtze River, a natural forest resources protection program was implemented in 1998, which focuses on protection of the upper reaches of the Yangtze river, the Yellow River and parts of northern China and inner Mongolia. Due to this protection program the domestic timber supply has dropped dramatically.
- While the government is giving priority to protection of the natural environment, China is trying to compensate the shortfall in domestic timber production by vigorously speeding up to plant fast-growing, high yielding man-made plantation forests, especially in southern and southeastern regions of China, where water and climate conditions are more favourable and where trees are planted mostly for commercial purposes. In the north, northwest and northeast of China trees are planted mainly to form anti-desert shelterbelts67.
- By 2003 the total tree plantation area was 46 million ha, with an annual increase of 2 million ha. Farms for fast growing trees covering 13 million ha will be set up over a period of 15 years (from 2000 to 2015) across the country, which are supposed to meet up to 40% of the countries future demand for timber68.
- The expansion of commercial tree plantations is to be achieved largely through foreign investments and by joint ventures with companies such as Weyerhauser69. Government incentives to encourage foreign investments in tree plantations include low interest loans, fifty years leases on land, tax fee income from thinnings and allowing private forestry on public land. This policy has already resulted in half a million ha's of forest being planted70. There is a Fast-growing Timber Plantation Program and a Conversion of Forest to Cropland Program, with millions of ha's of cultivated land being converted back to forests each year to curb soil erosion and desertification. However, recently there have been conflicting demands on land by policies to increase agricultural crop production (especially the production of grain)71.
- China's government even intents to rent overseas land such as in Malaysia for the planting of fast growing trees for wood fibre production

Timber procurement

- In 1999 China's total wood production was 280 million m3, of which the production of saw timber was 52 million m3. The national saw timber consumption was 92 million m3, far exceeding domestic supply. Annual saw timber supply is expected to decrease from 52 to 40 million m3/a by 2010, due to further logging restrictions in natural forests.
- Fast economic growth has boosted the demand for timber, especially for building and interior decorating, but also for furniture, charcoal an paper making. By 2010 China's timber supply will fall short of demand by 70 million m3.
- Imports of timber can help mitigate the shortage of domestic timber supply. China has already become the world's second largest importer of forest products after Japan and it is the top importing country worldwide of industrial roundwood.
- China is the largest buyer of stolen timber in the world: about 44% of all timber imports are from illegal sources72.

[67] William F. Hyde, Brian Belcher, Jintao Xu (eds.) 2003. China's Forests. Global Lessons from Market Reforms, 214 pp
[68] Xinhua News Agency, May 9, 2001
[69] Higgs, G. 2004. China's booming demand and it's impact on Canada. Taiga news 48, 2004
[70] According to the Tropical Forest Products Information and Consultation Center of China in 2001
[71] Zang Lei, 2004. Peoples Republic of China Solid wood products Annual 2004. USDA Foreign Agricultural Service, Global Agricultural Information network report CH4024.
[72] IEA 2004. The last Frontier. Illegal logging in Papua and China's massive timber theft. Report Environmental Investigation Agency

Fuel wood supply
China is one of the world's largest wood producing countries, although two-thirds of its production is burned as fuel[73]. China's total annual fuel wood production was estimated 190 million m3 in 2002[74]. This amount includes all roundwood used for cooking, heating and power production. It includes wood harvested from main stems, branches and other parts of trees and wood intended for charcoal production. However, it does not include biomass from indirect sources such as industrial residues derived from wood processing industries and recovered wood (wood waste from demolition, packaging, etc).

According to the resource study by Koopmans and Koppejan (1998), which presents somewhat outdated information, wood processing residues derived from saw milling and manufacturing plywood and particle board, may amount to 20 million m3/a (table 1 and 2). At present, the bulk of these residues remains unused. The amount of recovered wood in China is not known.

Current uses of wood processing residues in China are for instance:

- Internal heat supply (steam)
- Source of energy for manufacturing of bricks
- Small industrial applications
- Feedstock for blockboard and particle board
- Saw dusk may be briquetted and carbonised (high-grade charcoal)
- Used to cover charcoal mound kilns; used for insect repellents

As liquid propane gas and electricity are going to be distributed more widely throughout the country, some of the current fuel wood resource (190 million m3/a) may be used by the emerging bioenergy market or redirected towards wood panel and paper production, who rely on the same raw material. Given that two-third of China's wood resources are used for fuel, even a small percentage reduction in the traditional fuelwood demand could release a significant amount of wood for other uses. At present, wood chips for paper making are being imported mainly form Indonesia and Australia, wood pulp from Canada Indonesia and Chile and softwood logs mainly from the Russian Federation. If part of this very vast fuel wood resource is going to be used in more energy efficient ways, this will create substantial savings.

Table 1: Common recovery rates in forestry and wood processing (percentage of inputs, usually logs)

Operations	**Rec. Rate**	**residues**
Logging	60%	40%
Saw milling	45-50%	50%
Plywood production	50-55%	50%
Particle board prod.	90%*	10%

* in which all types of wood are used and residues are partly being recycled.
Recovery rate

Table 2: Estimated amounts of forestry and wood processing residues in China in 1997

Residues from forestry and wood processing	**Million tons/a**	**%**
Logging residues*	46	66
Saw milling	15	22
Plywood production	5	7
Particle board production	<1	5
Total	**69**	**100**

* excluding yields from conventional thinnings and clear cuts

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[73] Wood and paper product markets in China. Abare current issues 02.4, March 2002.
[74] Earth trends 2003: http://earthtrends.wri.org country profile China

Conclusions on forest biomass

1. China's forest resources are still under-utilised: the total annual increment is 485 million m3, of which only 280 million m3 is being harvested at present. This is a 58% utilisation rate. Most of the forest (73%) is natural forest, of which 90% is located in mountainous areas. Government policies discourage logging in natural forests. Therefore, the possibilities to significantly increase present-day harvest levels are limited. Yet even a small increase would mean a huge additional supply.
2. The government is actively stimulating the establishment of fast-growing tree plantations, but it will take some time before they reach maturity. In the mean time China will need substantial imports of wood products. However, imports of stolen wood from illegal logging and associated trade is a big problem, acknowledged by the Chinese government.
3. The traditional use of fuel wood is substantial. The introduction of modern, highly efficient conversion technologies will create large savings. Due to the increasing popularity of propane gas as the main household fuel, in some areas a substantial amount of fuel wood may become available for renewable energy. On the other hand e.g. the charcoal and paper industries are competing for the same raw material resources.
4. In a few decades the newly established tree plantations will yield a considerable amount of timber but also will produce large amounts of biomass for bioenergy. Because these tree plantations are still relatively young, at least half the volume of their annual increment (i.e. 10 m3/ha/a) could become available for bioenergy purposes. Assuming a tree plantation area of 60 million ha by 2010, half of which will then be 20 years old, the total annual yield will be about 150 million m3 of biomass (30 million ha x 5 m3/ha/a)
5. In the mean time, before these tree plantations are mature enough to be thinned commercially, and as the local fuel wood resources are becoming more and more depleted, imports of large amounts of fuel wood is conceivable, given the aggressive way in which China is importing other raw materials.
6. This could impact the international biomass trade, in which sustainability issues are considered crucial. However, at the moment it seems unlikely that sustainability aspects of biomass imports will rank high on the China's priority list.

1.2 Agricultural production

To a very large degree China's agriculture is characterised by relatively high-input cropping systems. The total area of cultivated cropland is about 130 million ha. Table 3 gives an overview of the main cops. In central, southeast and southwest China there is about as much irrigated land as dry land agriculture. In northern China the farming is mainly on dry land. In southern China rice, sugar cane and oil bearing crops are cultivated; in northern regions the main crops are corn, soybeans and tubers. Rice and wheat is grown in all regions of China.

Although China is rapidly changing into an urban and industrial society, 63 percent of China's population still live in rural areas. Currently, one third of the total energy consumption in rural areas comes from biomass. This corresponds with 200 million tons of coal equivalent.[75] 70 million people experience shortages of cooking fuel. In some areas, inappropriate utilisation of natural resources has caused environmental degradation and soil erosion.

[75] Jingjijng et al 1998

Bioenergy

The Chinese Ministry of Agriculture has made bioenergy a priority area. However, much R&D still needs to be done on the commercialisation of biomass resources, on conversion technologies and on market development. In 2006 a Chinese Renewable Energy Law will become effectuated[76], which, however, does not apply to the direct burning of straw and firewood in low-efficient stoves. The Renewable Energy Law encourages the conduction of resource surveys, the formulation of mid and long term targets en the preparation of a renewable energy development and utilisation plan. It will fund R&D and the establishment of demonstration projects. The Chinese government will encourage the development of dedicated energy crops, the production and utilisation of liquid biofuels and renewable energy in rural areas. There will be tax incentives and a renewable energy development fund to support research, pilot projects in rural areas, surveys and assessments of resources and the development of information systems. An example of a project funded by the Asian Development Bank to enhance the development of sustainable bioenergy systems in rural areas in China with special attention for the environment and poor farmers participation is the "Efficient utilisation of agricultural waste project", which was initiated in 2002 in the provinces of Henan, Hunei, Jianxi and Shanxi.[77]

According to a recent assessment by the Chinese Biomass Development Center in Beijing by 1999, about 1.6 MTOE of energy consumption in China has come from biomass energy through energy-efficient technology and biomass energy conversion technology[78].

Table 3: Overview of the main agricultural crops in China in 2001

Crops	**Area (M ha)**	**%**	**Production (M tons)**
Rice	29	22	177
Wheat	25	19	94
Corn (maize)	24	18	114
Veg. oil crops	15	11	29
Soybeans	13	10	20
Tubers	10	8	35
Cotton	5	3	5
Sugar cane	1	1	75
Total	**130**	**100**	

(Source: National Bureau of Statistics of China)

Straw and stalks from agricultural crops are available in almost all regions of China. Koopmans and Koppejan (1998) estimated the total amount of residues from crops in the field 900 million tons/a (table 4). Note that these estimates were based on an assumed product/residue-ratio, which can vary considerable. A more thorough study by Jingjing et al (1998) estimates the total available amount of crop residues at 600 million tons/a, most of which (58%) is being used for cooking and heating in rural households. Other traditional uses include forage (24%), organic fertiliser (15%) and as raw material for paper production (3%).

[76] www.renewableenergyaccess.com/assets/download/China
[77] http://www.adb.org/Documents/RRPs/PRC/rrp_33443.pdf
[78] Z. Yuan, C.Z. Wu, H. Huang, G.F. Lin 2002. Research and development on biomass energy in China. International Journal of Energy Technology and Policy 2002 - Vol. 1, No.1/2 pp. 108-144

Table 4: Estimated amounts of crop residues in the field in China (1997)

Crop residues (in the field)	**Million tons/a***	**%**
Rice straw	356	39
Wheat straw	216	24
Maize stalks	209	23
Soybean straw & pods	51	6
Cotton stalks	38	4
Sugar cane tops	24	3
Others	12	1
Total	**900**	**100**

* 15% moisture content on average
(Source: Koopmans and Koppejan 1998)

An important observation is that the present use of agricultural residues is at very low efficiency, which means that there is considerable scope for improvement. In many areas the traditional straw consumption is rapidly decreasing due to a combination of increasing incomes and the availability of fossil fuel resources such as coal, gas, oil and electricity (table 5 and 6). Jingjing (1998) estimate that the traditional use of straw as fuel has already reduced from 350 million tons to about 150 million tons/a in 1998.[79]. This would imply that about 200 million tons are available in a sustainable way for more efficient bioenergy purposes and 150 million tons for traditional biofuel purposes (350 million tons in total).

Table 5: Energy consumption in China (2001)

	%
Coal	67
Crude oil	24
Hydro	7
Natural gas	3
total	100*

(Source: National Bureau of Statistics of China)
* 100% corresponds with 1320 million tons of standard coal equivalents

Table 6: Consumption of electricity in 2000 (million GWh)

	Million GWh
Total	1.35
Residential households	0.18

Projections by 2010 indicate a total production of straw and stalks of 725 million tons/a. Excluding the straw used for forage, paper making, fertiliser and collection losses, the amount available for bioenergy use will be 375 million tons, which corresponds with approximately 170 million tons of coal equivalents or with 450 TWh of green electricity (assuming reasonable conversion efficiencies)[80]

[79] Report of Sustainable Development Study in Rural Areas, Energy Consulting Program of the Chinese Science Academy of Engineering, in: Jingjing et al 1998.
[80] Jingjing et al (1998)

In addition to residues derived from primary crop production, the processing of agricultural products too produces significant amounts of residues, which according to Koopmans and Koppejan (1998) may total about 150 million tons/a (table 7). Furthermore, woody residues from pruning plantation species (coconut, oil palm and rubber trees) in China amount to 2 million tons/a in total (mainly derived from rubber plantations).

Table 7: Estimated amounts of residues from processing agricultural products in China (1997)

Residues from processing	**Million tons/a***	**%**
Rice	54	34
Maize	48	31
Sugar cane	24	15
Groundnuts	22	14
Others	7	6
Total	**155**	**100**

(from: Koopmans and Koppejan 1998)

Current uses of agricultural residues

Residues usually are used for various purposes in the local community: the 6 F's: fuel, fodder, fertiliser, fibre, feedstock and further uses. Some residues have multiple uses: e.g rice straw used as medium for mushroom growing and for animal bedding and subsequently used in composting; rice husks are used as an insulator and as biofuel for power generation in large rice mills, with ashes used by the steel industry; crop residues are used as a source of energy for the brick industry, and they are widely used as a domestic fuel in areas where fuel wood is scarce. In other areas stalks and straw are simply left in the field or burned in the field (ash serves as fertiliser). Landless people are often allowed to collect residues on other people's lands. Trying to use these residues for renewable energy without offering compensation is asking for trouble. Thus a large proportion of agro-residues is used as fuel, fodder, animal bedding, paper making and building material.

1.3 Organic fraction of municipal solid waste

With the growth of cities and continued urbanization by 1995 China had 640 large cities, ten of which with populations over 2 million. In 2001 the number of large cities had already increased to 662, twenty-five of which with populations over 2 million (table 8). In 1995 these cities produced 107 million tons of residential solid waste and 30 million tons of excrements. More recent 2001data by the national Bureau of Statistics of China indicates a production of 135 million tons of municipal solid waste.

Table 8: Large cities in 2001

Population	**Number of cities**
< 200,000	37
200,000 – 500,000	180
500,000 – 1 million	279
1 – 2 million	141
2 – 4 million	17
> 4 million	8
Total	662

Waste resource utilisation is still very low. In many small cities the economy is still comparatively backward. In cities where the rate of gas use for cooking is high, the amount of inorganic waste is low and consequently the organic content high. The applied measures of solid waste disposal are land filling, composting and incineration. At present, sanitary landfill is the main method used in China accounting for 96% of all waste disposal. Waste incineration is less than 1% [81]. Forecasts predict that somewhere between 2010 and 2020 the urban population will outnumber the rural population (in 1995 70% of the population still lived in rural areas; in 2001 the rural population was 62%) and total population numbers will have increased to almost 1.5 billion (by 2001 total population was 1.27 billion).

As income increases and as consumption and lifestyle changes, the amount and composition of municipal solid waste also will change, i.e the higher the income the more refuse. By 2010 a total of 290 million tons of refuse is forecasted, which is more than a doubling compared with the 135 million tons in 2001. By 2020 the amount may even be 400 million tons. This demonstrates a rapid increase in the amount of municipal solid waste in China. In the near future China will face a huge task of determining how to dispose of increasing amounts of municipal solid waste and making use of these waste resources.

Conclusion on MSW

There will be a rapid increase in the amount of municipal solid waste in China, part of which may be used as a resource. The recoverable fraction, however, is unknown.

2. Discussion

For a country with 1.3 billion consumers and limited natural resources, China is surprisingly self sufficient in food supply. It is even a net exporter of many food products, primarily to neighbouring Asian countries. China's agriculture has to feed 22% of the world's population on 7% of the world's arable land, 67% of which lies in remote mountainous areas. China has ten persons per hectare to feed from arable land, whereas the world's average is 4.4 people per ha.

China maintains its high level of food production by double cropping (planting winter wheat and summer corn), and by applying large quantities of fertilisers and pesticides to its limited land base[82]. In 2001 the use of chemical fertilisers totalled 42 million tons[83]. Furthermore, China has a relatively high share of its land irrigated (41%, i.e. 54 million ha). Due to the intense use of land, about 30% of China's arable land suffers from wind and water erosion, by which 5 billion tons of topsoil are washed away each year. About 27% of its total land area suffers from desertification, which affects over 400 million people.

China's annual grain production was about 466 million tons in 1995; peaked in 1998 with 512 million tons and dropped to 452 million tons in 2001, according to the National Bureau of Statistics of China[84]. Over the past 5 years (from 1999 to 2004 data) China's annual grain harvest has dropped 70 million tons, which is an amount that exceeds the entire grain harvest of Canada! (2004 grain harvest was 438 million tons). China's harvest shortfalls of recent years have been covered by drawing down its stocks of grain, which were filled up to the brim by record harvests in 1998 and 1999 (with 512 and 508 million tons respectively). However, these will soon be depleted, forcing the government to cover the shortfall with imports. The rice deficit is even more serious. Trying to cover a rice shortfall of 20 million tons in a world where annual rice exports total only 26 million tons will have

[81] Kefa, C., Mingjiang, N., Jianhua, Y., Yong, C., and Xiaodong, L. The progress for the thermal treatment of municipal solid waste in China. Conference proceedings from the 4th International Symposium on Waste Treatment Technologies, 29 June - 2 July, 2003, Sheffield, UK. 5 pp.

[82] http://www.ers.usda.gov/publications/aib775/aib775e.pdf

[83] National Bureau of Statistics of China

[84] http://www.stats.gov.cn/english/statisticaldata/yearlydata/YB2002e/ml/indexE.htm

an enormous impact on the world rice economy. And with a corn shortfall of 15 million tons China may soon have to import corn as well.

The fall in China's grain harvest is due largely to reduction of the area of arable land used for cereal production from 90 million hectares in 1998, via 82 million ha in 2001 to 76 million hectares in 2003.[85] Reduction of the grain area was caused by several factors: the loss of irrigation water, desert expansion, the conversion of cropland to non-farm uses, the shift to higher-value crops and a decline in double-cropping, which was partially due to the loss of farm labour in the more prosperous coastal provinces, as farmers have sought higher paying jobs elsewhere. Water shortages in important grain-producing regions in China may significantly affect its agricultural production potential. In the competition for scarce water, China 's cities and industry invariably get first claim, leaving farmers with a shrinking supply.

The high level of fertilizer and pesticides use on most arable land (fertiliser use is about the US average with 367 kg/ha) means that greater agricultural input use may not be sustainable. Water supplies are dwindling and pollution is worsening. More than half of China's rivers and lakes are already seriously contaminated. About 80% of discharged water is not effectively treated before release. The available area of arable land is further reduced because of China's policy to return ecologically fragile land to forest and grass cover. Because farms are increasingly remote from cities, inadequate storage and transportation networks are now responsible for 10% of China's grain losses and 33% of its fresh vegetable losses.

The agricultural sector will face the need to make more efficient use of its resources, e.g. by changing the mix of crops planted, adopting higher yielding varieties, improving land management and by achieving an economy of scale. China's farms are small and cultivated by family households. The average size is less than 1 ha. The inequality between rural and urban areas will create a significant income gap, which will be an important consideration in future rural development policies. Already the per capita income and living standards in cities are twice as high compared with rural areas. With three workers for every hectare of farm land, farming in China is very labour intensive and consequently income per worker is low. China is expected to see an exodus of labour from rural areas to urban areas.

All these examples illustrate that China's food supply comes from a decreasing land base, both in quantity and quality. The strong income growth and rapid urbanization are diversifying China's diet and creating demands for high value and speciality food products. When people move to cities they tend to eat more meat, processed food and restaurant meals and less grain. Urban residents consumed 70% more meat and eggs than rural residents, revealing a pattern in consumption growth in China in the coming years. Already in 1996 China has surpassed the USA in red meat consumption, eating five times more meat than 18 years earlier[86].

Country in transition

Since 1978 China has been in transition from a rural to an urban society and from a command economy to a market based one. Due to these transitions China has experienced one of the fastest agricultural growth rates, i.e. 6 percent per year for two full decades. Agriculture has played an important role in poverty reduction, lifting over 200 million people out of poverty[87]. Recently China has joined the World Trade Organisation, which will certainly affect the trade in agricultural products.

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[85] http://www.theglobalist.com/DBWeb/StoryId.aspx?StoryId=3827

[86] Jennifer Lin, 1996. Battle to satisfy awesome appetite: China's vast needs could disrupt the security of world food supplies, *South China Morning Post*, 22 November 1996, p.21.

[87] http://www.index-china.com/index-english/agr-s.html

It is unlikely that WTO accession will threaten China's more or less self-sufficiency in grain production in the near term. In the longer term, however, market forces may bring about structural adjustments within the agricultural sector, such as more labour intensive crops that need less land. The prevailing small scale of farms makes producing high value crops (e.g fruits and vegetables) more profitable. The lifestock sector is expected to play a key role in reshaping China's agriculture in the coming years. The shift from backyard to modern feeding operations will expand the demand for feed ingredients, including grains and protein meals.
As the Chinese agricultural sector modernizes itself to face global competition, China's rural economy must reconsider the deployment of agricultural inputs. Rural policies continue to impede the free flow of land, labour and capital. Lack of land ownership and poor access to credit discourage investments that have long-term productivity payoffs, such as soil conservation measures.[88]

It is highly uncertain how these transitions towards a more efficient agricultural sector will affect the future availability of biomass. It will probably decrease. At the moment, the Chinese government is actively stimulating the afforestation of arable land. In due time these forest will yield considerable amounts of wood products. The fuel wood fraction will probably be as much as 150 million m3 of fuel wood per year. Traditionally, residues from primary agricultural production have been used in many ways. However, the growing urbanisation in the coastal provinces already has lead to shortages in labour in rural areas. Some of the traditional uses of residues will certainly decrease or even disappear and become available for alternative uses.

Factors affecting the use of residues

- Seasonality in supply
- Ownership and access
- Fraction economically recovered
- Environmental considerations
- Current and competing uses, which influence the availability and price
- Availability of appropriate equipment

Because of the increasing popularity of using liquefied propane gas by private households (table 9), it is very likely that fuel wood and crop stalks are going to present a huge unused biomass resource. Projections by 2010 indicate that perhaps as much as 376 million tons of residues per year could become available as biomass for energy purposes and as a raw material for bio-based products. How much of it will actually be deployed by the emerging bioenergy market will very much depend on the state of commercialization of biomass resources, available conversion technologies and the demands made by other industrial users.

Table 9: Population numbers with access to gas (2001)

Type of gas	Population in million
LPG	140
Coal gas	43
Natural gas	32
Total	215

(Source: National Bureau of Statistics of China)

[88] http://www.ers.usda.gov/publications/wrs012/wrs012a.pdf

3. Conclusions on agricultural residues

This quick-scan should be considered a first attempt to get an impression of the residue situation in China. Because of the very limited time-frame, the results can only be provisional. To get a more complete picture a more thorough assessment of the available sources of information will be needed, especially to do justice to the great regional variation in China. In many areas current economic developments are extremely fast. Consequently, the information will be quickly outdated. That is why it may be useful in a possible follow-up study to verify these findings with the views of a number of experts in the field of forestry, agronomy and waste management.

1. It seems that at present a considerable amount of agricultural residues are unused in China.
2. Even if they are used, the current residue-use is very inefficient, leaving much scope for savings and improvements
3. The large and complex local and regional differences which exist in China are not taken into account in this resource assessments yet, which results in an over-simplification of the actual situation. Region specific data are needed.
4. Unreliability of data is a big problem. Because most information is scattered, incomplete and often outdated and because of the limited time available for this quick-scan, data on actual use of residues were difficult to find, which e.g. could imply that much less residues are actually available than this study suggests.
5. Social impacts of a re-allocation of biomass sources are largely unknown, but will be very important for the actual implementation of bioenergy schemes.
6. It is of critical importance that he on-farm effects on soil conservation and soil fertility (affecting future crop growth), on income generation, on the local environment and on the livelihood of local communities (e.g differences in access to residues) are adequately addressed since they determine the social and environmental sustainability of the agro-residue resources.
7. The agricultural sector will feel the need to make more efficient use of its resources, as it modernizes itself to face global competition. In the longer term, market forces may bring about structural adjustments within the agricultural sector in which case the deployment of agricultural inputs and their environmental impacts will have to be reconsidered. This trend towards a more efficient agriculture will probably reduce the availability of residues in the long run.

4. Overall conclusions

1. Projections by 2010 indicate that 376 million tons of agricultural crop-residues per year could become available. Residues from forestry and wood processing may increase from 180 to 249 million m3 , the fast growing tree plantation will start to yield 150 million tons of fuel wood and the recoverable amount of municipal solid waste will more than double (table 10).

2. To utilize this vast biomass resource, totalling over 1 billion tons/a, the development and implementation of highly efficient conversion technologies will be urgently needed.

3. Thus it seems likely that at the short term China will not much impact the international trade in biomass. Much can be gained by energy savings and the application of energy-efficient technology.

4. It seems that in the biomass-scene the sleeping dragon has not awakened yet (but probably soon will…).

Table 10: Current supply of residues and projections by 2010 (million tons)

Main sources of biomass	Current supply	2010 projections
Forestry + wood processing	180	249
Fuel wood from tree plantations	-	150
Agricultural residues	350	376
Municipal solid waste*	135	290
Total	**665**	**1065**

* of which the recoverable organic fraction, unfortunately, is unknown

5. Follow-up?

To get a more complete picture a more thorough assessment of the available sources of information will be needed, especially to do justice to the great regional variation in China. In a possible follow-up study it may be useful to verify these findings with the views of a number of experts in the field of forestry, agronomy and waste management.

19

DEVELOPMENTS IN GENETICALLY MODIFIED OILSEED RAPE

Definition of the problem
Oilseed rape (*Brassica napus*) is cultivated on a large scale as an oil plant from which oil can be pressed for numerous food and non-food applications including biodiesel. Biofuels are irrefutably the way forward. However, oilseed rape is also one of the four crops subject to the most genetic modification worldwide. Globally, oilseed rape is one of the most important crops for which genetic modification (GM) is applied in practice on a large scale. However, GM is not always acceptable as far as sustainability is concerned. There is therefore a real risk that a certain proportion of liquid biofuels consists of genetically modified oil. This paper deals with the issue of GM oilseed rape.

Questions
First question is the amount of GM oilseed rape and the possibility to distinguish it. Second issue is the opinions of non-governmental organisations about GM oilseed rape.

Marieke Meeusen, Linda Puister and Leen Kuiper, August 2005. Report on BUS-ticket C2, WUR-LEI and Probos

1. Genetically modified oilseed rape: how much and where?

GM-crops worldwide
Worldwide, GM crops are already being cultivated on 48 million hectares of land, according to estimates by the FAO (2000). The growth in the number of hectares of GM crops is enormous: 15% in 2003 and 20% in 2004 (ISAAA, 2004) and ISAAA (2004) mentions 81 million hectares of GM crops in 2004. Other information sources estimate the area used for GM crops as being 58 million hectares in 2002, 3 million hectares of which were used for GM oilseed rape.[89] Greenpeace (also) assumes an area of approximately 80 million hectares of GM crops in 2004.
Of the 48 million hectares of GM-crops in 1999 99% are in the USA (29 million hectares), Argentina (13.5 million hectares), Canada (3.5 million hectares) and China (2.1 million hectares).
Approximately 16% of the global acreage of soya, maize, cotton and oilseed rape already consists of GM crops. These four crops are the most relevant concerning GM-variants. Three-quarters of the genetic modifications of agricultural crops relate to herbicide resistance (glyphosphate) and almost 20% relate to the addition of the *Bacillus thuringiensis* bacteria, whereby the plant produces its own insecticide. Approximately 5% is a combination of both types of modification.

Oilseed rape and GM-oilseed rape
In 2003, a total of 23 million hectares of oilseed rape were cultivated worldwide (source: FAO), of which 3.6 million hectares (16%) were GM oilseed rape (Clive, 2003).
In 2004, 4.3 million hectares were being used for GM oilseed rape (ISAAA,[90] 2004). Opponents of GM refer to a different figure for 2004, namely 3.7 million hectares. For 2003, they also state the number of hectares as being 3.6 million (Network of concerned farmers, 2004).
GM oilseed rape is cultivated mainly in Canada and the USA where it is usually referred to by the brand name Canola.[91] In 2003, 3.19 million hectares of GM Canola were cultivated

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[89] http://www.australianoilseeds.com/__data/page/237/Fast_Facts_2_-_Trade_Implications_GM_Canola.pdf
[90] ISAAA (The International Service for the Acquisition of Agri-biotech Applications) is a not-for-profit organisation that delivers the benefits of new agricultural biotechnologies to the poor in developing countries.

in Canada and 0.41 million hectares in the USA (Brookes, 2004; Network of concerned farmers, 2004). A projection of this ratio for 2004 gives us 3.75 million hectares in Canada and 0.55 million hectares in the USA. Half of the acreage of oilseed rape in Canada now consists of genetically modified oilseed rape (canola), corresponding with 2.4 million hectares out of a total of 5 million hectares (1998 figures).[92] More recent figures indicate that two-thirds of the Canadian oilseed rape acreage already consisted of GM canola in 2002.[93]
Rapeseed oil from GM Canola contains no GM material and is therefore identical to rapeseed oil produced from non-GM Canola (Canola Council of Canada). Another source speaks of "no major difference" between GM Canola oil and non-GM Canola oil. However, this source does not state what that minor difference is (Donaldson, B. 2004).

GM-oilseed crops in EU
The EU will be investing heavily in increasing the market share of liquid biofuels over the coming years. Part of this will come from oleaginous crops, the most important of which is oilseed rape. The annual production of oilseed rape worldwide is 40 million tonnes, from which approximately 10 million tonnes of oil can be made. Production mainly takes place in the EU, Canada, India and China. Within the EU, oilseed rape is most common in France, Germany and the UK.[94]
The development in the market introduction of GM crops makes oilseed rape a questionable raw material for biodiesel (and, or course, for many other food and non-food applications). The cultivation of GM crops is currently still prohibited within the EU, but the Commission is becoming increasingly lenient in allowing GM products onto the European market. Field tests are actually already permitted. The EU has permitted imports of genetically modified oilseed rape since 1997[95], with all the risks of unintentional dissemination, as demonstrated by a recent Greenpeace report on Japan.[96] It is therefore certainly not unthinkable that there could soon be large quantities of genetically modified rapeseed oil on the European market (see box 1). Genetically modified products are generally not routinely kept separate from conventional product and can therefore form a considerable proportion of the imports.[97]

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[91] Canola (**Can**adian **o**il **l**ow **a**cid) is a variety of oilseed rape with less than 2% erucic acid and less than 30 micromol/g of glucosinolate (Canola Council of Canada).
The old varieties up until about 1978 contained both erucic acid and glucosinolate. There was a switch from the normal varieties to single zero varieties (1979) and double zero varieties (1990). Varieties with low levels of erucic acid in the seed were called single zero varieties. Varieties that were both low in erucic acid and glucosinolate were called double zero varieties. (Bernelot Moens H.L. and Wolfert J.E., 2003).
[92] http://stockholm.usembassy.gov/biotech/oilseedrape.html#transgenic
[93] http://www.australianoilseeds.com/__data/page/237/Fast_Facts_2_-_Trade_Implications_GM_Canola.pdf
[94] http://www.eufic.org/gb/tech/tech02b.htm
[95] On Friday 24 June 2005, the European Commission pronounced its approval of the import of Monsanto's transgenic oilseed rape variety GT73. GT73 is the third genetically modified product to be approved since the EU put an end to the non-acceptance of this type of crop last year. Monsanto has requested approval for the use of this oilseed rape in animal feed and in industrial applications (AgriHolland 28/06/05).
[96] http://www.greenpeace.org/raw/content/international/press/reports/canola-report.pdf
[97] http://www.australianoilseeds.com/__data/page/237/Fast_Facts_2_-_Trade_Implications_GM_Canola.pdf

Box 1: An example of the European decision-making process[98]
On 11 February 2004, the European Food Safety Authority (EFSA) Scientific Panel on Genetically Modified Organisms concluded that "… GT73 oilseed rape is as safe as conventional oilseed rape and therefore the placing on the market of GT73 oilseed rape for processing and feed use is unlikely to have an adverse effect on human or animal health or, in the context of its proposed use, on the environment.' Once a GMO application has received a positive safety assessment from the EFSA, a 'Draft Decision' is sent for approval to the appropriate Regulatory Committee (in this case under the Committee covered by Directive 2001/18/EC). The Committee comprises representatives of the member state concerned. A qualified majority of votes (88 out of 124) in favour of the application is needed to approve an application. Member states' votes are weighted on the basis of their population and corrected in favour of less-populated countries. Following a vote in the Regulatory Committee on 16 June 2004 on the release of genetically modified organisms into the environment, the decision to authorise the imports and processing of the genetically modified oilseed rape known as GT73 will pass on to the Council of Ministers. The Committee, which was set up under Directive 2001/18 and represents the member states, did not reach the qualified majority necessary to support the Commission proposal to authorise the oilseed rape. Over the coming weeks, the European Commission will now formally adopt the proposal to be sent to the Council of Ministers. The Council can either adopt or reject the proposal with a qualified majority. If no decision is taken after three months, the file returns to the Commission, which can then adopt it. If authorised, the oilseed rape, which has been modified for increased tolerance to the herbicide glyphosphate, would be clearly labelled as containing GM oilseed rape, in accordance with the new legislation in force since 18 April 2004.

2. Risks of NGOs about GM-oilseed rape, according to non-governmental organisations

One of the main objections to genetically modified crops is the risk of the spread of extraneous genes to the surrounding area. Transgenic contamination has already been detected for oilseed rape and maize.[99,100]

"Over 60 incidences of illegal or unlabelled GE contamination have been documented in 27 countries on five continents. Genetic contamination may occur as a result of a GE plant cross-breeding with conventional varieties of the same species, or with other related species. It may occur as a result of human handling, storage or transport errors, or of wind, pollination, water or movement by animals," according to the Worldwide GE Contamination Register compiled by Greenpeace and Genewatch UK, June 2005[101]

Most conservation and environmental organisations consider genetic modification undesirable as well as unacceptable from the perspective of sustainability and the certification of sustainability. However, it is not only NGOs that are hesitant with regard to GM crops. For example, the majority of Australian farmers (who planted 2 million hectares of oilseed rape in 2002) are against the introduction of GM oilseed rape.[102] "
An Australian study found that gene-carrying pollen from GM canola can travel up to three kilometres on the wind or insects, whereas the present isolation distance between GM and

[98] http://www.foodstandards.gov.au/mediareleasespublications/factsheets/factsheets2004/gmcanolasafetyassess2498.cfm
[99] http://www.foe.co.uk/resource/media_briefing/government_to_publish_the.pdf
[100] http://www.cbc.ca/stories/2002/06/27/gncanola020627
[101] http://www.greenpeace.org.au/truefood/news2.html?mode=intl&newsid=239
[102] http://www.control.com.au/bi2003/articles246/feat_246.shtml

non-GM canola is usually only 100m wide."[103] In Canada there are major objections to GM oilseed rape within the National Farmers Union. They are even supporting a lawsuit against it: "Mass contamination following the introduction of GM canola means that organic farmers now find it virtually impossible to grow organic, GM-free canola."[104]

A few non-governmental organisations have been asked for their opinions about GM-oilseed rape: HIVOS, Greenpeace, IUCN and the World Wildlife Fund. It seems that those organisations are aware of the risks of GM-oilseed crops. Within this paper their opinions are given.

The opinion of HIVOS (development organisation)[105]

In the case of oilseed rape, HIVOS is very concerned that the GE (genetically engineered) versions will rapidly cross-breed and mix with non-GE varieties. This is almost inevitable, according to HIVOS. No safe distances can be determined at which the risk of the crop cross-breeding is zero. The Terlouw committee concluded that the Netherlands is too small to prevent the cross-breeding of GE oilseed rape.

HIVOS: "GE-free oilseed rape will therefore soon be a thing of the past. Oilseed rape also has related wild plants, which are also likely to become "contaminated" rapidly. The environmental damage will be irreparable. The consequences for human consumption are unclear. Great prudence is therefore called for. This means that the large-scale introduction of GE oilseed rape in Europe and, in particular, its cultivation must be prevented as far as possible."

According to HIVOS the large-scale cultivation of the herbicide-resistant variety would bring with it the risk of an ecological disaster due to the rapid increase in the amount of herbicide used. There are now also doubts about the potential health hazards posed by "Roundup Ready" (to which the herbicide-resistant GE oilseed rape is resistant), as it could be an "endocrine disruptor." (A French research institute published the first suspicions in February 2005.) In short: according to HIVOS, it is undesirable and a major hazard for humans and the environment. In any event, "we should work to prevent the increase in the cultivation of GE oilseed rape and its spread across the world".

Greenpeace[106] (campaigner against genetic manipulation)

Greenpeace is an opponent of the use of genetically manipulated crops in the open natural environment. The technology is still in its infancy and the environmental consequences of the cultivation of this crop are therefore unpredictable. Such consequences are also uncontrollable and irreversible since genetic manipulation relates to living organisms that reproduce. Furthermore, one cannot see from a plant's appearance whether it has been genetically manipulated or not. It is therefore impossible to return to the original situation. For every solution to a problem, one needs to make sure that the solution is not ultimately worse than the problem. In the case of genetic manipulation, this is a very real risk. The environmental consequences could be so serious that we are ultimately confronted with a bigger problem than the one we were trying to resolve. Mother nature has already shown us that huge problems can be caused by introducing extraneous plants or animals in a new environment. Examples include the rabbits in Australia, African killer bees in South America, which are now advancing towards North America, and the Nile perch in Lake Victoria.

For a genuinely sustainable solution to problems, one must therefore look at all aspects of the three Ps from a long-term perspective. A serious consideration of the P of Planet and the P of People is therefore required. Genetic manipulation is not viewed very positively

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[103] http://www.percyschmeiser.com/Gene%20Flow.htm
[104] http://www.nfu.ca/canola.htm
[105] Harrie Oppenoorth
[106] Sandra Schalk

where the P of People is concerned (as small-scale farmers are pushed out, and also with regard to the whole problem surrounding patents).

The same therefore applies to the production of biomass: the solution must not be worse than the problem. In our opinion, if the solution is sought in genetically manipulated crops grown in the open natural environment, then that solution is automatically no longer a sustainable one. Some of the consequences are uncertain, but a number of consequences for Planet and People can be seen straight away: increased use of herbicides, large-scale land use at the expense of natural areas (e.g. the rainforests of South America) and small-scale farmers, restrictive contracts for farmers, etc.
In short, Greenpeace sees no solution for the biomass problem in the form of genetically manipulated oilseed rape.

IUCN[107]
The viewpoint of IUCN is clear: no GM technology, on the basis of the precautionary principle, with a small possibility if adequate precautions are taken. The IUCN website (http://www.iucn.org/congress/members/WCC_Res_Recs_ENGLISH.pdf) presents the resolution (resolution 3.007 and 3.008) that was accepted in Bangkok following lengthy discussions, as some were of the opinion that this is an outdated viewpoint, in view of the rapid developments in this field, and that it is better to make concrete recommendations. However, no such recommendations have yet been made.
A manual for policymakers on genetically modified organisms was compiled by the IUCN on 13 August 2004 regarding the possible ecological impact of GMOs on the environment and specifically on biodiversity, socio-economic matters and food security (http://www.nciucn.nl/nederlands/actueel/nieuws/archief/2004/augustus/13_.htm). The Netherlands has ratified the Cartagena Protocol, which entered into effect in September 2003. This biodiversity treaty looks explicitly at the dangers and consequences of introducing genetically modified organisms into the natural environment and farmland. In May 2003, the IUCN published a book on "biosafety." This publication, entitled "Explanatory Guide to the Cartagena Protocol on Biosafety” looks at how we should deal with genetically modified organisms and safety issues (http://www.iucn.org/themes/law/pdfdocuments/Biosafety-guide.pdf).

World Wildlife Fund
The WWF objects to the introduction of GMOs into the natural environment, because they can trigger changes in the adaptability and interactions of organisms. This may alter the natural balance and affects established ecosystem processes, which are essential for maintaining environmental integrity. The release or escape of GMOs into the environment further threatens the declining biodiversity and natural resources. The WWF calls for a total ban (moratorium) on the use of GM crops and urges the agro-industry to avoid food and feed resources containing GM substances. (WWF 1999. WWF position statement on GMOs (www.wwf.no/english/aquaculture/wwf_gmostatement.doc).

The WWF has set up best practice guidelines on GMOs for several industries, which should support the moratorium on the use or release of GMOs into the general environment until ecological interactions have been fully researched and safeguards are put in place. These guidelines stress the importance of carrying out transparent, comprehensive environmental impact assessments of planned releases into the environment, to include considerations of the impacts of changing crop management practices, as well as the invasion of natural and semi-natural habitats or the competitive displacement of native species by transgenic plants and animals. The guidelines also insist on the avoidance of additional impacts through genetic modifications which:

[107] Henk Hartogh

- facilitate or stimulate greater use of chemicals;
- harm pest-controlling and other locally beneficial insects associated with crops:
- lack safeguards against gene flow into native organisms; and
- use artificially constructed genes (the effects of which are more difficult to predict and control)

According to the WWF, effective monitoring of the use and spread of GMOs is urgently needed, including effects on different habitats and species. (WWF 2000. Background paper on transgenic cotton: are there benefits for conservation? A case study on GMOs in agriculture with special emphasis on fresh water (http://www.panda.org/downloads/freshwater/ct_long.pdf)).

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STATE-OF-THE-ART ON CERTIFICATION

Definition of the problem
This quick-scan gives an overview of the current situation of certification schemes, both in forestry and agriculture, with respect to sustainable production chains. Especially in the agro-sector a bewildering number of certificates exist. One of the main questions covered in this quick-scan is how the certificates are embedded in the market and how the verification procedures have been organized. Furthermore, their relevance for the procurement of biomass is discussed.

Leen Kuiper and Marieke Meeusen, August 2005. Report on BUS-ticket C6, Probos and WUR-LEI

1. Introduction

Basically, there are three types of certificates, which differ in the way the verification and control methods have been organized: i.e. first grade, second grade and third grade certificates[108].
First grade certificates are being verified by an independent organization, acknowledged by the International Board for Accreditation. These certificates often work conform the European NEN-EN 45011 regulation, which describes how the certificates are to be warranted. Almost always the requirements have been subject to public debate. An example of this category of certificates in forestry is FSC and in agriculture the EKO-certificate and the AgroMilieukeur.
Second grade certificates are not verified by independent organizations approved by the Board for Accreditation, but by the sector itself. Often the sector has set their own requirements for the products and these standards have not always been subject to public debate. An example of this category in forestry is the American Tree Farm system and in agriculture ‘scharreleieren’.
The third grade certificates are not exposed to any form of external control and verification. This is more like a marketing instrument, typical for a liberal consumer market with no restrictions whatsoever.

2. Sustainable forest management certification

For sustainable forest management and sustainably produced timber many certification schemes exist (Lewandowski and Faaij 2003[109]; Centrum hout 2004 [110]) of which FSC and PEFC are the most important ones. By July 2005 over 215 million ha of forests have been certified worldwide. FSC is the best-known certification scheme with a 26% share (i.e. 57 million ha). However, at present (2005) the Program for the Endorsement of Forest Certification Schemes (PEFC) is the most widely adopted certification scheme with a 57% market share, totaling 123 million ha of certified forests. The Sustainable Forestry Initiative (SFI) ranks third with an area of 55 million ha.

The Dutch government prefers all timber, which is produced in or imported into The Netherlands to be sustainably produced, but this is merely a preference. However, the

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[108] Meeusen, M and S. Deneux 2002. Een babylonische keurmerkverwarring? Een studie naar de verwarring onder ketenactoren over keurmerken op voedingsmiddelen. Rapport WUR-LEI.
[109] Lewandowski, I. and A. Faaij (2003). An overview on approaches to assess sustainability made for Fair(bio)trade as preparation for the development of a certification system for large scale sustainable import of (energy from) biomass. Utrecht, Copernicus Institute.
[110] Duurzaam bosbeheer en houtkeurmerken, de stand van zaken, Centrum Hout, 2004

government requires from all market parties involved in the chain-of custody that timber and other forest products are proven to be of legal origin. To be able to verify future claims of sustainable produced timber, the Dutch government is actively involved to set up a National Assessment Guideline for Certification of Sustainable Forest Management and the Chain-of-Custody of wood from sustainably managed forests (Beoordelingsrichtlijn duurzaam geproduceerd hout; BRL Dupro hout), which hopefully will be approved and accepted by all stakeholders by the end of 2005. Until then, legal compliance is the only requirement for imported timber by the Dutch government.

Forest Stewardship Council (FSC)

FSC is a non-profit organization originally founded by the World Wildlife Fund (WWF). FSC's world wide certification scheme consists of 10 general principles en 56 criteria (http://www.fsc.org/en/how_fsc_works/ policy_standards/princ_criteria). On the basis of these principles and criteria national standards can be developed[111], in which the criteria are detailed and worked out in a set of indicators, adapted to the local situation. FSC accredits a limited number of certifying bodies. FSC has three types of certificates: forest management certificates, chain-of-custody certificates, and group-certificates. By July 2005 FSC has endorsed over 57 million ha of certified forest area and has issued a grand total of 4021 chain-of-custody certificates (www.fsc.org).

FSC certification

- The forest management certification only involves the on-the-ground assessment of landowner's forestry practices. It indicates that the forest is 'well-managed'.
- The chain-of-custody certification assures the consumer that the certified products they buy were indeed produced from wood originated in a certified forest because each step that the wood product goes from harvest to processing is monitored.
- Group certification has the advantage that groups (e.g. an forest owner association) can share assessment and audit costs.

Relevance for the procurement of biomass

- In principle, forest biomass can be certified according to the FSC standards, which gives the best available guarantee that the biomass is from undisputable origin.
- Principle 10 deals with criteria and indicators for plantation forestry. Biomass from dedicated energy crops, such as short rotation willow coppice, cannot yet be certified FSC. Some countries do not allow in their national standards the possibility of certification of plantation timber.
- FSC concentrates on wood products. Sawmill residues and charcoal are derived products, eligible to ware the FSC logo, i.e. if derived from wood from FSC certified forest
- So called 'non-timber forest products' (NTFP), such as sugar maple, bark, nuts and berries and latex, may be certified too by bodies accredited by FSC, (Brown, Robinson et al. 2002 [112],[113]). Forestry biomass is usually confined to wood products. In special cases FSC certification of forestry and wood processing byproducts may be an interesting option.

[111] The Dutch national FSC standard has been approved in May 2005, after ten years of negotiation with FSC headquarters.

[112] Even game hunted in FSC certified forests can be eligible to the FSC logo ("originating from well managed forests"). However, for game there is not yet a market demand for such a statement.

[113] Brown, L., D. Robinson, et al. (2002). The Forest Stewardship Council and non-timber forest product certification: a discussion paper. Bonn, FSC.

Program for the Endorsement of Forest Certification Schemes (PEFC)
By July 2005, a total of 123 million ha certified forest has been endorsed and 2285 chain-of-custody certificates have been issued by PEFC. Nine forest certification systems are currently undergoing the PEFC endorsement process. The Canadian National Sustainable Forest Management Standard (CSA) has been approved recently. The SFI system from the USA (Sustainable Forestry Initiative) has been submitted to the PEFC council for endorsement. Detailed information on all forest certification systems being assessed is available at the PEFC website at www.pefc.org.

3. Certification of agricultural products and production methods

Organic agriculture
Several systems exist which claim to guarantee a sustainable and environmentally friendly agriculture. Most of these systems focus on the certification of biologically or ecologically approved agricultural production methods and on the marketing of their products. Examples are the EU regulation on organic production methods and the international IFOAM standard (see Annex 1).
Organic agriculture includes ‘ecological’ and ‘biological-dynamic’ (BD) agriculture. Ecological products may carry the EKO-logo; BD-products may also be eligible to a ‘Demeter’ certificate. The organic agriculture sector has shown a significant growth rate in the past few years, to which the dairy sector and the horticultural sector have contributed most. The requirements to be met by the production, trade and processing of EKO-products, have to be in legal compliance with EU regulations, e.g. the NEN-EN 45011, which is being verified by SKAL, which is an independent certification organization accredited by the International Board of Accreditation.
The SKAL-standards are based on these EU regulations and include e.g. no use of chemical pesticides and fertilizers, maintenance of natural cycles, keeping the soil fertility in tact by the use of organic compost, taking care of animal welfare, allowing no genetic modifications or radiation treatment of EKO-products. The Demeter certificate has set additional requirements based on the anthroposophic philosophy. Demeter too is being verified by SKAL.

AgroMilieukeur
Upon request by a producer, the AgroMilieukeur certificate may be granted to products which are less damaging to the environment, i.e. compared with ‘regular’ products. AgroMilieukeur is valid for both food and non-food products. Stichting Milieukeur is the managing organization, founded in 1992 by the ministry of VROM, EZ and (later on) LNV. For each product group different environmental requirements are proposed with respects to the production, administration, selection of producers and the processing and packaging of products. The regulations and requirements to be met refer to the whole lifecycle of products and do not limit themselves to the production stage only. AgroMilieukeur meets the standards of the NEN-EN 45011 regulation.

Aarde &Waarde
This is an environmental quality certificate, developed and used by the Albert Heijn company, which is more strict than the government requires for AgroMilieukeur. For each stage in the product chain (production, transportation and distribution and processing) specific requirements are to be met. Verification is in the hands of independent organizations.

Steekeigen producten Nederland (SPN)
The Stichting SPN requires that the raw material and products are being produced in a sustainable and socially acceptable way. Specific requirements are to be met for nature, landscape, environment and animal welfare. Verification takes place by the Stichting Streekeigen Producten Nederland. This is a typical grade 2 label.

PVE/IKB

For meat the "Productschappen voor Vee, Vlees en Eieren" (PVE) has issued the PVE/IKB certificate, to guarantee the trace-ability and safety of various meat products. It is an identification and registration (track and trace) system covering the whole product chain, i.e. from the farmer to the butcher. PVE/IKB fulfills the legal requirements but has not set any additional environmental requirements. It does not work according to the NEN-EN 45011 regulation. However, some standards to the animal feed have to be met. Since the outbreak of various animal husbandry diseases in The Netherlands the origin of animal feedstock is matter of great concern. The "Productschap Diervoeder" has developed a chain-of-custody system, called the GMP system, which aims to warrant the quality of animal feedstock throughout the whole supply chain. It includes a quality standard for foreign suppliers (GMP13) and a standard for the production of foodstuffs (GMP11). Since July 2003 verification takes place by accredited certification organisations. It is mainly a 'track & trace' system and quality warranting system. Although the use of pesticides is mentioned explicitly, it has not set any requirements on other ecological aspects (such as biodiversity) nor on social issues. Furthermore, cattle breeders may only use the service of veterinarians who work according to the GVP standard (Goede Veterinaire Praktijkuitoefening).
For extensively raised cattle ('scharrelvlees') specific certificates may be granted, which are in accordance with the EU regulations on animal welfare, but the Dutch government has set even stricter requirements for animal welfare. This 'scharrelvlees' certificate does not work conform the NEN-EN 45011 regulation. Verification is by the producers themselves, but other organizations, such as GD-IC, KBBL, BIOCHEM, Delta-Con, TNO-Voeding and SGS Agrocontrol verify as well that all requirements are met. For eggs various certificates exist, including voliere-ei, scharrelei, graskipei. Verification takes place by the "Controlebureau voor Pluimvee, Eieren en Eiproducten (CPE)", which, however, does not work according to the European NEN-EN 45011 regulation.

For dairy products the "Keten Kwaliteit Melk"-certificate (KKM) has been issued, which is a quality certificate, with no additional environmental requirements other than the Dutch government has set. The system is comparable with the PVE/IKB.

For fish there is the Marine Stewardship Council certificate (MSC), granted for ecologically sound fisheries, which take into account the diversity of marine ecosystems and the maintenance of the fish populations. MSC was founded by World Wildlife Fund and Unilever. SGS Product and Process certification is accreditation organization, whereas SGS AgroControl is the auditing organization.

For vegetables and fruits the MBT certificate may be granted, which poses restrictions on the use of chemical pesticides, but which is less stringent than the requirements for Milieukeur. It has a distinct butterfly logo and verification takes place by SGS AgroControl.

For arable farming LTO-Nederland has developed the "Kwaliteits Project Akkerbouw certficate (KPA)", which includes a central registration system for data on then use of crop protection, artificial fertilizers and maintenance of soil fertility. At least one of the crops need to be produced conform the AgroMilieukeur production requirements and all crops will have to meet the general AgroMilieukeur standards.

Max Havelaar

Socially fair production and trade of coffee, cacao, honey, bananas and orange juice is being covered by the Max Havelaar certificate, which guarantees focuses on a reasonable price for small farmers in developing countries and on a fair trade. Sometimes Max Havelaar products are also eligible for an EKO-certificate, but this is 'standard' the case.

Roundtable on Sustainable Palm Oil
An interesting recent development is the Roundtable on Sustainable Palm Oil (RSPO). Palm oil production often is not considered to be sustainable by NGO's. Milieudefensie e.g. stresses the ongoing destruction of tropical rainforests and ther esulting decrease in biodiversity, social problems related to the compulsary purchase of land and the frequent use of pesticides and environmental polution associated with plam oilproduction. To counteract these negative impacts, the Roundtable tries to promote the growth and use of sustainable palm oil through co-operation within the supply chain and open dialogue between its stakeholders. RSPO tries to develop sustainability criteria for oil palm plantations, then first draft of which is available on: www.sustainable-palmoil.org.

4. Relevance for the procurement of biomass

What is the implication of all these labels and certificates which all claim more or less environmentally friendly production methods (i.e. sustainable management) and a traceable chain-of-custody, to be verified by transparent track and trace systems? Some of these certification schemes are first grade and very reliable; whereas others seem merely a 'green' marketing instrument with hardly any guarantees other than the ones the producers claims to provide.

The ambitions of the Dutch government on bioenergy are such that large amounts of biomass will have to be imported in the near future, given the very limited domestic availability and supply. The Dutch government and the renewable energy sector are becoming increasingly more aware of the fact that imported biomass should meet a minimum standard of socially accepted and sustainable production requirements. So far, the market demand for certificates for sustainably produced biomass is virtually non-existent, with the exception perhaps of Essent's Green Gold label (see annex 2). However, some of the stakeholders united in the "Transitie Biomassa" have already taken steps to formulate a transition experiment to be funded by the ministry of Economic Affairs in which a set of principles, criteria and indicators will be developed and tested to characterize and verify claims of sustainably produced biomass[114], [115].

5. Follow-up?

Many certification schemes exist both in forestry and agriculture. However, the main suppliers of biomass at the moment are not the forestry and agricultural sectors but traders in various kinds of waste products. They are very reluctant to engage in certification schemes and have no commercial interest to take steps to make their supply more transparent and traceable. It will quite a task to define criteria and indicators for a sustainable supply chain of waste products, given the fact that this involves a wide range of (often) heterogeneous products from various origins. Probably the best option for these categories of biomass is to try to reach consensus on a simple track-and trace system with maybe some quality standards built in. Trying to implement additional requirements on the sustainability of production, handling, transportation and pretreatment of waste products will be too ambitious for the moment. As a starting point Probos has already drafted a first version of a possible National Assessment Guideline for the certification of sustainably produced biomass (BRL-biomassa), in which, however, criteria and indicators for tracing waste products are still lacking. A possible follow-up study may take the first draft a few steps further and discuss it in a wider group of stakeholders.

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21

SCENARIO-TO-STRATEGY. A SCENARIO ANALYSIS FOR NEW BIOMASS AND BIOENERGY OPPORTUNITIES WITH BRAZILIAN PARTNERS

Definition of the problem
Brazil is one of the most important players in the field of biomass and biofuels and has long experience with conversion of biomass into biofuels, in particular ethanol. In 2004, the cabinet of president Lula decided to give a impulse to the production and export of biofuels. The Netherlands and its hinterland are considered as very important partners (by Brazil). The Netherlands has historically strong positions in agribusiness and energy (oil refining & natural gas production). Given its strong research base and strategic location (deep sea harbour and EU markets) new business opportunities arise for the Netherlands in transport and processing of biomass/biofuels from Brazil for production of electricity, transportation fuels and chemicals. The position of the Netherlands in this international value chain should be determined in the short term. The objective of the initiators is to let Dutch and Brazilian players (stakeholders from private and public sector and civil society) jointly determine their positions in this future value chain. By means of a "scenario-to-strategy cycle" alternative strategic scenario's can be developed, which serve as contextual frameworks for the analysis of feasibility and sustainability of several business cases. In this process research institutes (LEI, A&F, EMBRAPA, etc) and commercial organisations (port or Rotterdam and Santos, Petrobras, Shell, Vopak, etc.) will develop a common visions of the future and (alliance) strategies. It is necessary to describe the "scenario to strategy" and relevant background information.

Wolter Elbersen and Thomas Corver, November 2005. Report on BUS ticket no. C15, WUR-A&F

1. Rationale and question

Questions
Describe the "scenario-to-strategy" method for the case of Biomass and biofuel export from Brazil to Europe by means of the port of Rotterdam and indicate what will be necessary for the execution and what the expected results will be.

2. Approach

This quick-scan gives a short description of the biomass and biofuel situation in Brazil with a strong emphasis on ethanol and opportunities for export. A description is given of the scenario to strategy approach to determine and realize sustainable business concepts for the commercial conversion of biomass (sourced from Brazil) into bio-fuels (i.e. ethanol and bio-diesel) for consumer markets in Europe. This is followed by a short description of the factors that will have to be considered in biomass and biofuel export scenario's from Brazil to Europe.

3. Description of the Brazil and its biomass and biofuel potential and ambitions

Characterisation of Brazil and its biomass and bioenergy potential
Brazil is the fifth largest country in the world with a population of 170 million people and a GDP of 450 Billion $US (2002). The total land area amounts to 850 million ha (200x the Netherlands) of which 375 million ha can be used for agricultural production. Total agricultural area is 50 million ha of which 5 million ha is sugar cane.

Characterising Brazilian ethanol:
An excellent description of the development of the Brazil ethanol programme since 1975 is given by Koizumi (2003):
"The government of Brazil inaugurated the national ethanol programme (PROALCOOL) in 1975. The major target of the programme was to reduce its oil import bill because, in the mid-1970s, Brazil was strongly dependent on imported oil. An important direct effect of the programme was the creation of a huge domestic demand for its sugarcane market. The creation of PROALCOOL provides the much needed cures to its sugar producers who are frequently faced with problems due to excess sugar production and huge fluctuations in its price. With the second oil-shock in 1979, the government decided to enlarge the programme by providing enhanced supports to the large-scale hydrated ethanol producers to supply the neat and cheaper prices fuel. Two institutes played vital roles in implementing the national ethanol program. The Institute of Sugar and Alcohol (IAA) controlled sugar and ethanol production and exports through implementing a production quota and fixed purchasing price of ethanol. Petrobas, being a monopolistic state oil company, controlled domestic ethanol sales and distribution. The government set the sugarcane price to independent growers. A wide range of governmental investment support programmes were implemented in the 1980s. The national ethanol production capacity expanded to produce over 16 billion litres of ethanol per year.

Despite this achievement, the programme has faced criticism since the middle of the 1980s. Changes in the macro economic conditions were the first source of criticism. The 1982 the Brazilian debt crisis dried up the sources of finance, followed by the declining international oil prices that started from 1986. Inadequate ethanol supply and demand management raised serious market disruptions in the early 1990s and resulted in losing consumer credibility in ethanol fuel. The production of ethanol powered cars has been declining since then. Now only 1 percent of cars are ethanol powered. To forestall that trend, the government set the anhydrous ethanol blend to gasoline between 20 and 25 percent of the product, with a variation of plus or minus 1 percent as a means of balancing the relationship between supply and demand of sugar and ethanol. The government took radical programme reforms over the 1997-1999 period. In 1997, the price of hydrated ethanol was liberalized, followed by the 1999 price liberalization decision of anhydrous ethanol and the abolition of the distribution monopoly given to Petrobas, and the reduction in the subsidies to the ethanol blend gasoline producers. Currently, there are no restrictions on ethanol production, the only tool that is left to the government is setting the anhydrous blend ratio to gasoline. The actual percentage of the blend ratio is determined by the Ministry of Agriculture, as a means of balancing the relationship between supply and demand of sugar and ethanol. A blend ratio of 26 percent is set as the legal maximum blend ratio level. As of April 2003, the blend ratio was set at 20 percent and it will be increased back to 25 percent from July 2003."

Brazil ethanol facts

Production
Brazil has 5 million ha of sugarcane plantations. Most plantations and mills are located in the province of Sao Paulo (see figure 2). Sugar cane is produced in 6 year cycles in which 3 harvests takes place. Sugar cane is processed in some 320 mills. Some 1 million people are employed in the ethanol business. Most mills produce both ethanol and sugar giving higher overall efficiency and a high degree of flexibility to optimise production depending on ethanol and sugar prices. This also leads to a direct link between the oil, ethanol and sugar price. The volume of ethanol production in Brazil has increased steadily to 12 million tonne in 2003 (48% of world production) (figure 1), by 2015 some 23 million tonnes of ethanol are expected to be produced.

Ethanol production cost in Brazil has decreased dramatically over the last 30 years making Brazilian sugarcane ethanol competitive with gasoline at oil process of below 30$ per barrel (Corrêa Carvalho, 2005). With current 60$ per barrel ethanol has become very attractive.
The main ethanol export harbours are Santos (near Sao Paulo). Logistics for exporting ethanol can be one of the bottlenecks for development of ethanol exports in the coming years.

Figure 1: Development of sugar cane, sugar and ethanol production in Brazil (Figuerut, 2004)

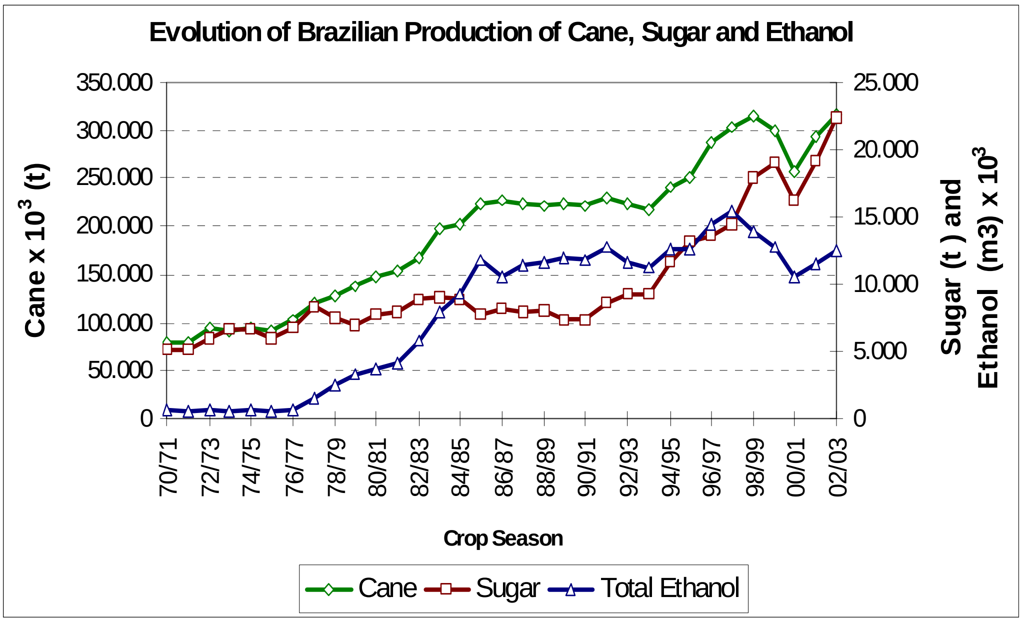


Figure 2: Main sugarcane growing area and processing mill are located in the south central region with Sao Paulo being the largest producer.

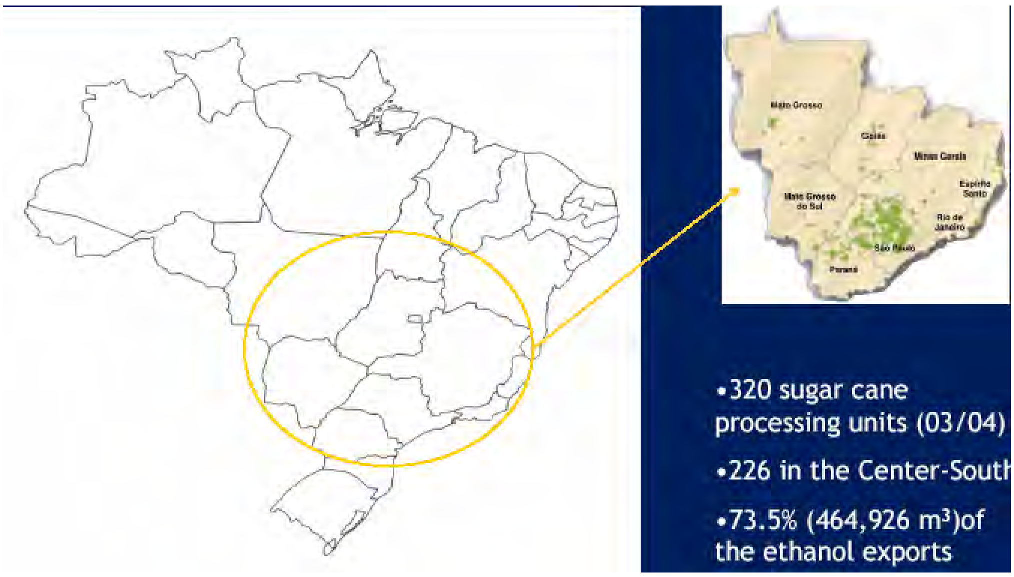


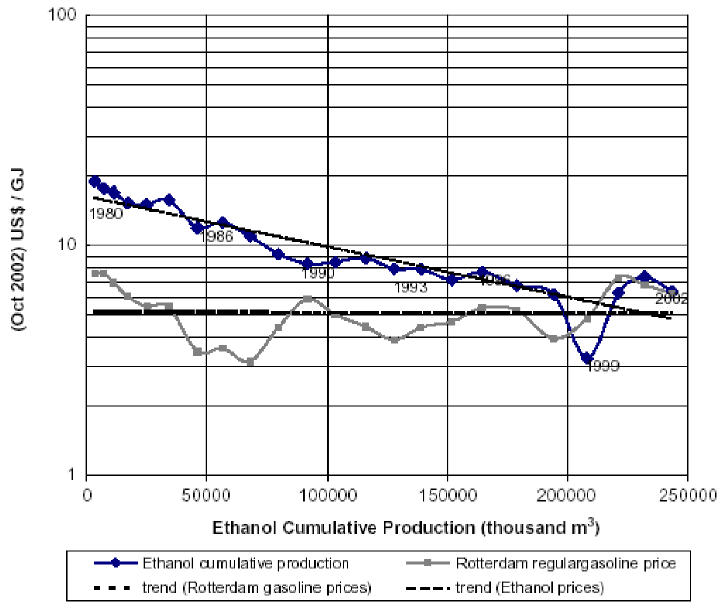
Figure 3: Biofuels cost estimates according to Ryan et al., 2005.

Table 1: Costs of biofuels

Biofuel	Cost at filling station (€2004/1000L)			
	Feedstock	Low	Best estimate	High
(a) Costs of biofuels produced using current technology				
	Sugar crops	865	1265	1855
	Starch crops	809	1173	1572
	Lignocellulosic crops	1148	1448	2435
	Lignocellulosic residues	1052	1316	2232
	Brazilian sugarcane	117	294	351
Biodiesel				
	Oil Seeds	755	945	1092
	Used oil/fat	354	454	545
(b) Costs of biofuels produces using future technology				
	Sugar crops	671	954	1432
	Starch crops	653	963	1287
	Lignocellulosic crops	699	884	1469
	Lignocellulosic residues	638	802	1358
	Brazilian sugarcane			
Biodiesel				
	Oil Seeds	753	888	1068
	Used oil/fat	317	395	504

Figure 4: Brazilian ethanol and gasoline prices are converging.

J. Goldemberg et al. / Biomass and Bioenergy 26 (2004) 301–304



Local ethanol market

Ethanol is used as anhydrous ethanol in mixed in to gasoline at 20 to 26 % (E20 – E26) or hydrous ethanol is used in 100% ethanol vehicles (E95). Some 3 million cars run on E95 which is 23% of the national fleet. In recent years flexible fuel cars are being introduced making it possible to run on a wider range of ethanol to gasoline mixes.

Biofuel policies and ambitions

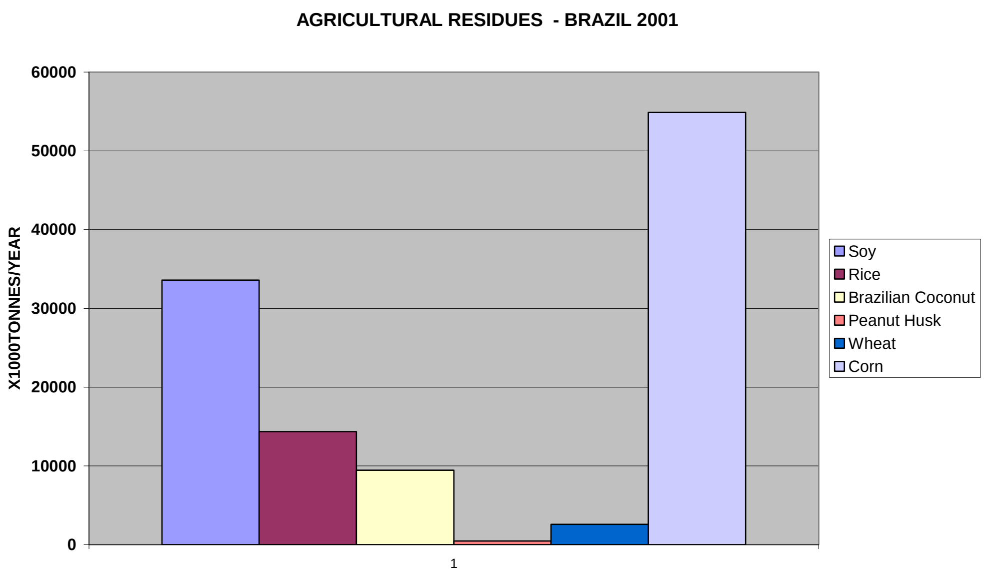
In the recent year Brazil has made public its ambitions to become an exporter of ethanol and biodiesel. The long list of trade talks in which export of biofuels from Brazil is an issue illustrates the trend. The USA will send a trade mission focused on renewable energy technology this year. Japan has discussed importing ethanol for fuel and is expected to import Brazilian fuel ethanol. China is expected to become an importer of ethanol and even Venezuela is importing fuel ethanol from Brazil. The Netherlands Trade Minster van Gennip will visit Brazil with a delegation. In this last mission a visit to a sugar/ethanol mill is planned.

Biodiesel is not yet well developed in Brazil but it is expected to increase very fast. Contacts exist with Germany to develop biodiesel further. President Lula recently opened the first biodiesel plant. A number of crops are potential sources for biodiesel including soya, Ricinus (Mamona), Palm oil, etc.

Lignocellulose

Brazil should also be an efficient producer of (lignocellulose) feedstock for second generation biofuels (lignocellulose ethanol and Fisher Tropsh diesel). Sugar cane bagasse is used for energy production for mill operations, greatly contributing to the CO2 efficiency of the sugar cane to ethanol process. With increased efficiency electricity can be exported to the grid, a potential that can be increased substantially (UNICA, 2004). With the banning of leaf straw burning before harvest this material will also become available for utilization. The exploitation of bagasse and leaf straw is just starting to be explored and ambitions to make better use of this material are clear Apart from sugar cane residues other (lignocellulose) residues are available as illustrated in figure 5.

Figure 5: Agricultural residues are a hardly exploited energy source in Brazil (Moreira, 2000)



4. Scenario to strategy approach

Purpose

Rationale for using the scenario-to-strategy methodology is the aim to have knowledge institutions (universities, think tanks etc) and business organizations (producers, service providers, investors, banks etc) work together (as strategic partners) in order to jointly determine and realize sustainable business concepts for the commercial conversion of biomass (sourced from Brazil) into biomass-based fuels (ethanol or bio-diesel) for consumer markets in Europe.

For this purpose the project will provide two separate deliverables:

- a set of alternative contextual scenarios and
- specific business strategies (or strategic options) that can operate under each of the scenarios.

The scenarios will serve to provide alternative cause & effect models based on a range of pre-identified key-uncertainties that will determine future business environments i.e. contextual environments that business organizations cannot effectively influence or control but will affect their businesses. Scenarios therefore are models for plausible future business environments. In the case of biomass-fuels, they may assess Production prices (global sugar and oil prices as well as regional demand & supply for ethanol or bio-diesel), Transportation costs (charges for road, rail, shipping or pipeline movement of bio-mass in Brazil), Harbour costs (port charges in Brazil, Rotterdam and duty free EU havens like Curacao), Ocean freight charges (shipping), Transaction costs (set by cultural, institutional and regulatory differences), Geo-political constraints for outsourcing (set by EU's common agricultural policy, WTO policies, Mercosur-EU negotiations etc.
The joint development of alternative scenarios by knowledge and business organizations (in series of workshops) is a learning process that will enable participants to better understand the consequences of critical uncertainties and inter-dependencies. This will allow them to more successfully select preferred strategic options.
As Scenarios are expressions of 'common ground'; they are excellent tools to communicate joint visions and complex realities to a wide range of stakeholders.

In the second phase, the scenarios are used to determine sustainable business strategies. The scenarios, which were developed as realistic alternative models for future business environments, help in this phase to test strategies for robustness and desirability.
For this purpose, a coalition of selected (private and public) business organizations (from Brazil, the Netherlands and other countries) will be formed to investigate effective ways to operate and coordinate biomass chains and clusters in future. Value chain concepts (from sourcing to markets) will help to analyse and coordinate the activities of all individual business organizations (notably SME's) that will participate. Value-adding steps can be identified in biomass sourcing, transportation, storage, treatment, certification, distribution, marketing etc.
The better business partners understand their roles and value-adding activities in each phase of the biomass chain, the more qualitative, cost-effective and competitive the overall biomass chain will become. An integrated strategic approach, supported by all partners will help to realize this objective.

Organisations involved in one / both project phases:
Knowledge institutions: WUR, Embrapa, consultancies, and others.
Business organizations: Agricultural producers, Energy companies (Petrobras, Shell), shipping lines, Port authorities (Port of Rotterdam, Port of Santos,), terminal & storage companies (Vopak), automotive industries (Daimler Chrysler, Volkswagen), Choren industries, etc.
NGOs?

5. Opportunities and key factors for scenarios

Decisions will have to be made on the boundaries of the scenario's:

- Time horizon: until 2012
- Technology development: For example; when will the second generation biofuels make an impact?

Factors that may be considered as key inputs for the scenario's include:

- WTO developments (see outcome of the Mecosur /EU negotiations)
- CAP reform in the EU
- Reforms of the EU sugar system
- The importance of biodiversity effects for potential biofuel customers
- Technology development, particularly second generation biofuels.
- Importance of food energy competition
- Competition between potential customers Japan, China, USA and Europe
- Competition between potential suppliers Brazil, Argentina, Colombia, Thailand, etc.

It may be interesting to make use of simulation models for sugar and ethanol markets (Koisumi, 2003).

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22

MOBILIZING EXTRA WOOD IN EUROPE: GETTING HARVEST CLOSER TO GROWTH

Definition of the problem
In this paper, we will consider the state of the forests in 30 European countries with 175 million ha of forest, which grows 750 million m3 increment per year, and has 400 million m3 of annual fellings. The forest consists of a growing stock of 25 billion m3, and this is increasing.

Questions

- What are the differences between harvest and growth in Europe?
- Is a harvest increase realistic?
- What are the risks for loss of sustainability of forest management?

Ad Olsthoorn and Gert-Jan Nabuurs, November 2005. Report on BUS ticket no. C12, WUR-Alterra

Background

The demand for wood products is expected to continue to rise with 0.7 to 2% per year. This is derived from Historic fellings. The EU white paper on bioenergy may cause an extra demand increase of 164 million m^3 y-1 by the year 2010! The wood products trade takes place, mainly within Europe. Europe is approximately self sufficient. (Data from COMTRADE Data, Michie, EFI).

There are conflicts over forest management, as we live in an urbanized society, where most people have lost the relation to the base of our natural resources. At the same time, society (and thus policy) wants closer to nature forestry, limiting harvest levels in a period of 40 to 50 years (Ph.D. Thesis Nabuurs, 2001). In the 30 countries, there are 10.7 million private forest owners, who own 96 Mha of forest. They have a (very limited) gross income of 65 Euro/ha.yr from the forest and are a very small economic factor in society in most countries.

A forest is a very inert system, so a tree species change takes a long time. As an example: when 10 Central European countries would convert 50% of all coniferous stands at clear-cut into deciduous stands, the percentage of coniferous stands would decrease by only 10% in 100 years time!

European Forest Information Scenario Model (EFISCEN)

The EFISCEN model is the only dynamic European forest resource model, that is jointly developed at EFI and Alterra. It aims to make European wide (harmonised) forest resource projections, based on a detailed forest resource database with all the 30 countries with 140 million hectares of forest. The model largely depends on the EFISCEN's European Forest Resource Database (EEFR). This database contains descriptions of 2689 forest types within 140.4 Mha, with data from 30 forest inventory institutes. Included are the age class distributions of these European forests per country between 1985 and 1995. This ranges from "young" forest countries, like Ireland or Portugal, with mainly young stands, to established forestry nations, like Central Europe with more evenly distributed forest ages. For each of the forest types, a simple growth model is described, where growth with increasing age depends on tree species, site quality, ownership, and region (in large countries). Each forest type with age is attributed to a specific surface area.

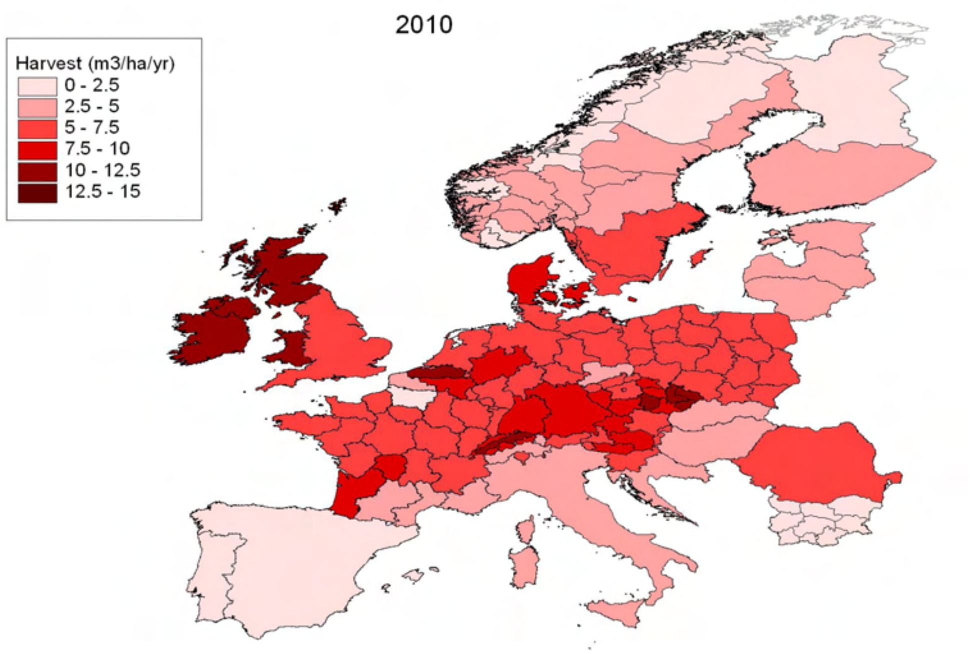
EFISCEN model runs

The EFISCEN model was used to predict the harvest levels in Europe in 2010, 2020 and in 2060. We used a base line scenario, with a small steady increase in demand, and aiming at a larger harvest in 2060. We could calculate the differences between harvest and growth in Europe in 2010, 2020 and in 2060 (see Table 1 for the total results for all 30 country countries). See Figure 1 and 2 for the situation per country in 2010 and Figure 3 and 4 for the situation in 2060 (N.B. Because of the jagged coast line of Norway, the colour locally seems almost black).

Table 1: EFISCEN predictions for 2010, 2020 and 2060

Year	Harvest	Growth	Ratio
2010	515000	810000	0.63
2020	610000	850000	0.72
2060	1080000	1005000	1.07

Figure 1: Harvest from forests in 2010



Many countries harvest between 5 and 7.5 m^3/ha.yr (Figure 1). Some countries harvest over 12,5 m3/ha.yr. The total forested area in each region cannot be seen in these pictures. Sometimes forest occupies only a small percentage in the region. With the forested area, the total harvest can be calculated per area or country. Figure 2 shows what part of the increment is harvested. When the colour is green, the harvest to increment ratio is below 1 (harvest is less than increment). When the colour is red, the harvest is calculated to be larger than the increment at that time. When there has been a period of low harvest levels, a temporary high harvest level should not cause damage to the forest.

EFISCEN results

Figure 3 and 4 show the result of the calculations for 2060. There is a slow increase of the harvest to increment ratio to above 1 (see Table 1). In the model this harvest level is forced on the forest. EFISCEN tries to allocate this harvest, based on trade relations and forest conditions at that time. The number of countries with a ratio above 1 (red colours) is still limited. With other scenario's, the harvest to increment ratio would vary considerably (see e.g. Nabuurs et al., 2003b).

Figure 2: Harvest increment ratio

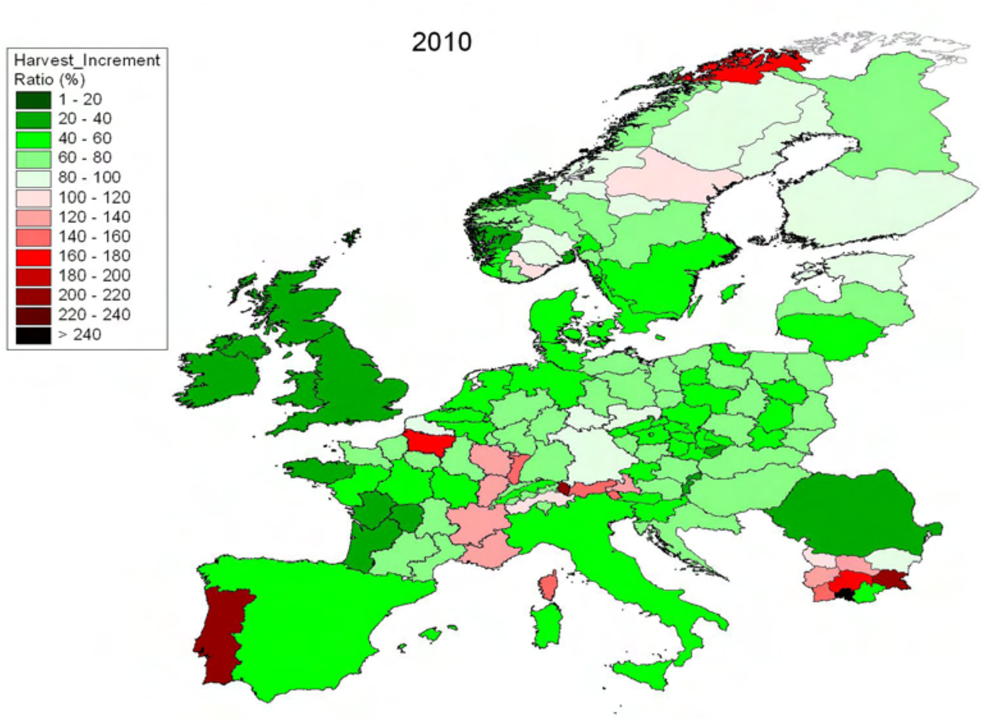
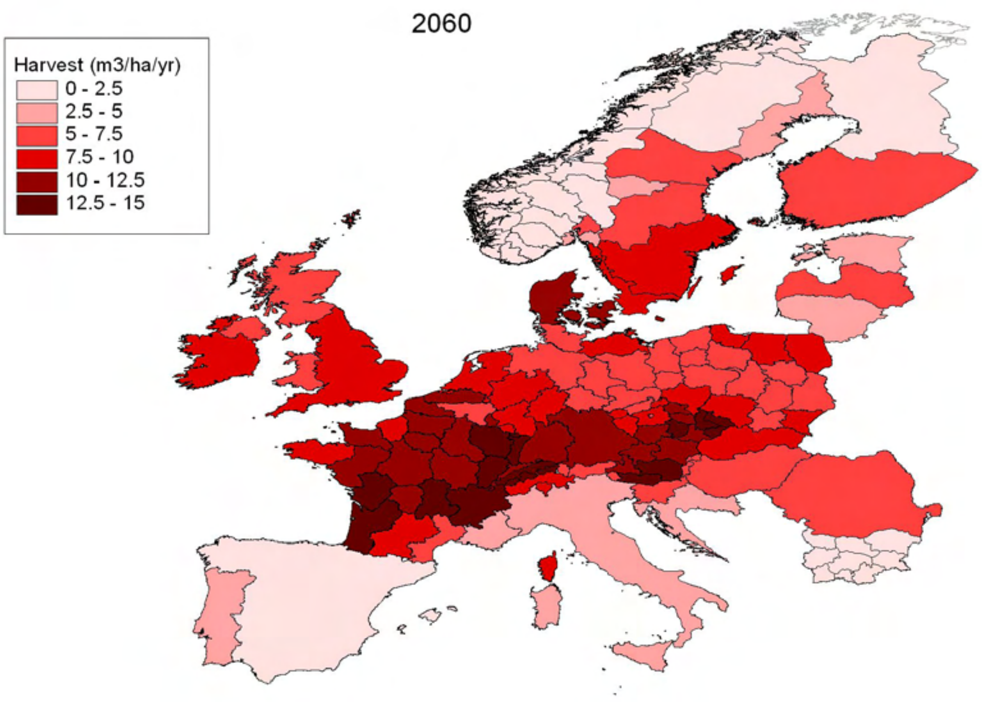
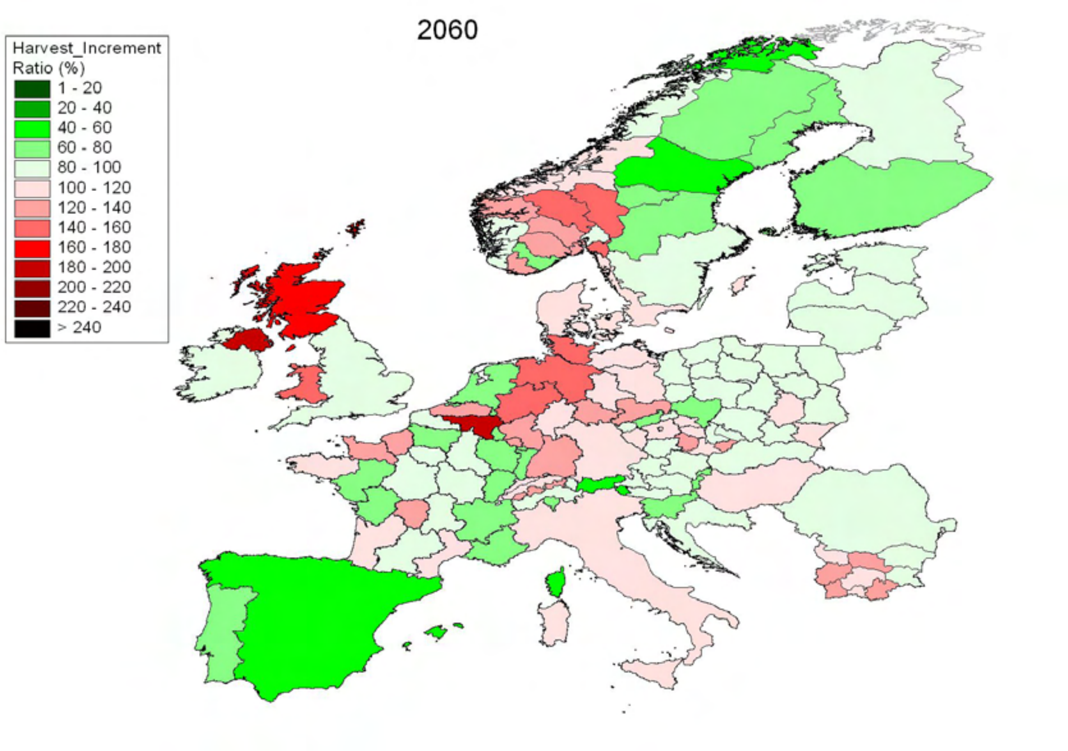


Figure 3: Harvest from forests in 2060



.*Figure 4: Harvest increment ratio*



Is a harvest increase realistic?
There are many reasons to be pessimistic. When thinning, many of the professional foresters are too careful in the volume they are marking, even if they would like to harvest the total growth. Some owners do not want to harvest at all because of aesthetics reasons: the forest looks damaged. Roads are damaged by the timber transport, and they need more maintenance. In addition to this there are nature reserves without any harvest. In total, Wiesenthal et al. (2005) estimate that 15% of the forest surface in Europe is not available for harvest (see also Lindner et al., 2005). Because of these effects, CEPI (the European paper industry) expects that even a rise in price will not result in a larger harvest level (Nabuurs et al., 2003a).
How high does the price need to be to increase the harvest? It is difficult to estimate this. Because of the lack of (real) economic reasoning with forest owners, the principle of price elasticity "cannot" be used for the timber trade within Europe (Slangen, 1987). Also, the contact between the forest owners and the timber trade has become less direct, as forest cooperatives take over the contacts. They stimulate the forest owners to aim for other goals, such as higher nature value because of local subsidies for this, etc. So even at higher prices, professional foresters might still stick to the normal marking (See also De Baaij et al., 2004). When prices would double (this is still not very high), a low percentage of forest owners might consider harvest: those who have no harvest now.

There is reason to expect a harvest increase when the level of expertise of the owners would go up (confirmed by several sources, pers. comm.). They will try to aim at harvest levels closer to the increment level. The aspect of increasing timber trade with higher prices needs more work for better insight.

What are the risks for loss of sustainability of forest management?
We can only give a general answer, from experience in our National forest reserves (Bijlsma, 2005). An undisturbed forest limits the possibilities for forest undergrowth species because of a high competition level (for light, water, nutrients). It appears that some disturbance is positive for biodiversity. Thinning can be seen as mimicking disturbance.

The Dutch forest has always had some kind of disturbance in the last millennium, up to overexploitation and degradation. However, it is difficult to establish a tolerance level for this disturbance. More study is needed, e.g. in relation with site quality.

Conclusions

- The harvest to growth ratio has been calculated for countries in Europe, based on a scenario with slowly increasing demand. In 2060 the harvest levels would need to be higher than growth, to meet this increasing demand
- Levels of harvest are only indirectly connected to price level, so this outcome is probably not realistic.
- More study is needed to define tolerance levels of biodiversity with higher harvest levels. A small increase in harvest level seems no risk.

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23

JATROPHA CURCAS AS A BIO-ENERGY CROP

Definition of the problem
In recent years a global interest is increasing for the shrub *Jatropha curcas L.*, as a source of biodiesel. The plant grows in semi-arid and arid areas of the world. The shrub originated from Central America & the Caribbean and is recognized as as a multiple purpose shrub used for fencing, shading, medicine and as a resource for soap and lamp oil in Africa, South America and Asia. It produces seeds (and leaves) that are generally toxic for humans and most animals. Interest is growing as the oil extracted from the seeds seems a good alternative for fossil fuels. This report evaluates its relative potential as a crop for bio-energy production, to obtain insight into the agronomical, economical and environmental potential of the crop as an alternative energy crop

Questions
Why is jatropha a good alternative resource for bio-diesel in the tropics?
Which vital factors determine if jatropha can be introduced successfully on a larger scale?

Wolter Elbersen, Hugo Lamers and Tjeerdjan Stomph, November 2005. Report on BUS ticket no. D21, WUR-A&F

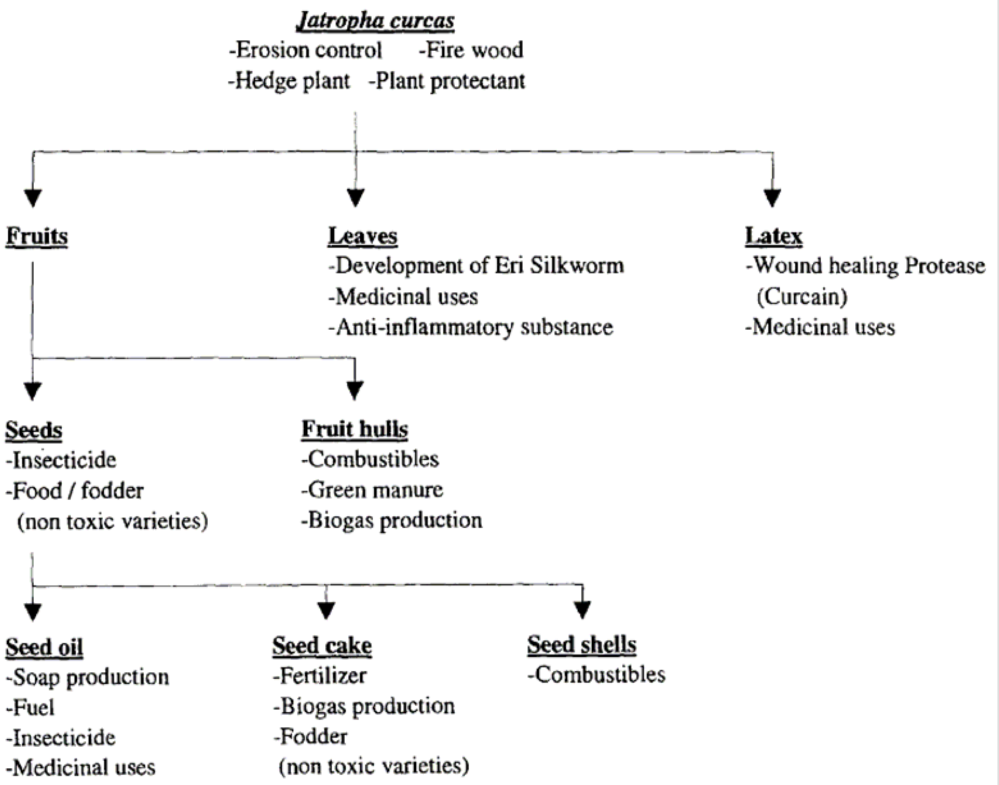
To answer these questions a short overview is given of the plant jatropha curcas, according its physical & ecological characteristics and specific production and processing characteristics.

1. Ecological and physical aspects of Jatropha curcas

Jatropha curcas L. is a drought resistant shrub or small tree, belonging to the family of *Euphorbiaceae* (and is a close relative of the castor bean), which can easily be propagated by cuttings and seeds. Like many other Jatropha species J. curcas is a succulent that sheds its leaves during the dry season. It is, therefore adapted to arid and semi-arid conditions. The current distribution of jatropha curcas shows that introduction has been most successful in drier regions of the tropics with an average annual rainfall of between 300-1000 mm (Heller; 1996). Nevertheless, the shrub also occurs in areas with higher precipitation rates.

Naturally the shrub or small tree can reach an age of 50 years old and can grow up to 5-6 meters tall. The plant grows best on lower altitudes (< 1000 m above sea level), is considered frost sensitive and needs good drainage as the plant is averse of water logging (i.e. high groundwater level or rainfall water logging sites) (personal communication with W. Rijssenbeek; 2006) It grows in areas with an average annual temperature well above 20 °C and up to 28 °C and is not sensitive to daylength (Heller; 1996).
The shrub is well adapted to marginal (rocky) soil conditions with lower nutrient levels If carefully planted, jatropha hedges not only project gardens from hungry livestock but also reduce damage and erosion from wind and water (Henning; 2002). In West Africa, traditionally the seeds were harvested by woman and used for medical treatment and local soap production. An overview of its applications was given by Gubitz et al; as shown in Figure 1 (Gübitz et al.; 1999).
As described by Gübitz et al. the oil, leaves and latex (milky fluid from the stems) has various local recognised medical uses as purgative, skin treatment, cough treatment, pain soothing, wound healing etc. Preliminary research is executed by various researchers on the active substances, shown in Gübitz et al. Besides medicinal treatment, the oil and extracts of jatropha curcas are used to control various pests and the wood of especially older trees is incidentally used as firewood/combustible, although it's lower quality due to soft wood characteristic and high water contents. (personal communication Rijssenbeek; 2006).

Figure 1: Utility overview for the shrub Jatropha curcas.



Resource: Güblitz et al. 1999

The toxicity of the seeds (and leaves) is mainly due to a toxic protein (curcin) and diterpene esters (Heller; 1996). The GTZ[116] financed a study on detoxifying the seed cake and the mutation potential of the diterpeniods in the oil, which was executed by the University of Heidelberg in 1993 (Wink; 1997). Nevertheless, a non-toxic variety is known from Mexico, according Wink (1997), which does not contain phorbol esters, and the seeds (and leaves) can be eaten after proper processing (boiling or roasting).

As fodder use of the cake is generally restricted given its toxic properties, the cake is currently generally used as green fertiliser. The nitrogen contents, ranging from 3,2 - 3,8%, seems similar to that of the seed cake of castor beans and chicken manure (Heller; 1996), see table below. Field trails have been executed by the African Centre for Fertilizer Development (ACFD) in Zimbabwe 2001 showing comparable results between inorganic fertilisers and press cake of J. curcas. A study executed in Mali showed higher economic profitability for J. curcas press cake compared with mineral fertiliser due to higher purchasing costs of mineral fertiliser (Henning; et al.; 1995).

2. Agronomical aspects; production

The plant jatropha curcas was distributed by Portugese traders in the second half of the 19th and first half of the 20th century operating from the Cape Verde Islands, from where it spread to countries in Africa and Asia. First production on a larger scale was in Cape Verde itself, where the cultivation of J. curcas by large plantations was of significant economic importance (Heller, 1996). Seeds were exported at that time to Lisbon and Marseille for oil

[116] GTZ; German Technical Assistance is a German Organisation for Development Cooperation

extraction and soap production and cake used as fertiliser for potatoes. The economic relevance in the rest of the world was still negligible. (Heller; 1996)
Since the 1990's, larger plantation have been developed and re-established for erosion control (Cape Verder), for the production of jatropha plant oil[117] (Mali, Burkina Faso, Tanzania, Zimbabwe), for oil production in marginal areas (India) and jatropha based energy plantation for methyl ester production in Nicaragua. An overview of projects developed is given in Table 1. Focus for production of existing projects is generally on increasing seed yields per hectare.

Table 1: History overview of larger scale production of jatropha curcas

Year	**Purpose**	**Region**	**Refs**	**Remarks**
1880-1940	Soap/oil	Cape Verde	Heller; 1996	export
1988	Erosion/oil	Cape Verde		
1992	JPO/erosion/biodiesel	India		Various regions
1992		Senegal	Heller	Reserach
1994	Bio-diesel	Nicaragua		Germany
1996	JPO/erosion/biodiesel	Mali/Senegal/Burkina	Folkecenter Mali	Henning
1997	JPO/erosion.biodiesel	Zimbabwe	POPA	2000 hectare
2002	JPO/ Bio-diesel	Tanzania	Diligent/FACT	
2002	Bio-diesel	India/Africa/America	D1	UK

Source: various

Although first established plantations are recorded manifold last years, reliable figures on exact yields in kg of seeds per hectare are still scarce or difficult to verify. Instead of new data, old figures are often re-interpreted or simply scaled up which complicate the evaluation of the exact yield potential of J. curcas. The seed yields reported vary from 0,5 ton to 12 ton per year per hectare, depending on soil, nutrients, age of the plant and rainfall, according Becker et al. An average annual seed production of about 5 ton/ha can be expected on good soil when rainfall is 900-1200 mm (Becker et al.; 2005). What is the expected oil content. D1 oils plc (ref) expects a yield of 100.000 tons of oil on 40.000 ha in India. This gives an oil yield of 2.5 tons per ha. Given the yield reported in the table these yields expected by D1 oils plc are at the higher end. And will need improved agronomic practices.
Average yields of 3-5 ton of seeds/ha are estimated in semi-arid regions (600-1200 mm), according Rijssenbeek; 2006. For appropriate estimates these averages exclude first year (no harvest) and second year harvest (probably much smaller), when the plant is still in first development. Estimated average yields are given in table 2.

Table 2: Estimated average production figures of jatropha curcas (age > 2 year) per hectare (in kg/ha)

Country	**Climate zone**	**Rainfall (mm)**	**Yield (seeds)**	**remarks**	**Oil yield**	**Ref.**
India	Arid, marginal soil	300-1000	1500-2250	Non-irrigated, no fertiliser	500 to675	Becker et al. 2003
Mali	Semi-arid	600-1200	3000 (2000-4000)	Irrigated plantation + mineral fertiliser	1000	FACT 2006
India	Semi-arid	900-1200	5000 (4000-6000)	Irrigated plantation + mineral fertiliser	1500	Becker et al. 2005
Tanzania	Semi-arid					
	Sub-tropics	1200-1500	?			?

[117] JPO means Jatropha Plant Oil; the pure plant oil after extraction existing out of triglycerides. Bio diesel is further refined JPO existing out of methyl esters and comparable/mixable without problems with fossil diesel. JPO has, just as all vegetable oils, a higher viscosity than bio diesel.

Fruit development needs 90 days from flowering until seeds mature. Experience in semi-arid conditions in Mali reported two flowering peaks, on in November and the other in May, giving two harvests per year. (Heller;1996 & pers communication Rijssenbeek; 2006) Newly seeded plants bear fruits for the first time in the second year (after the second rain season when planted at the start of the rain season) Heller; 1996. Seedlings from cuttings show higher seed yields in the first harvest year, but lack often a vertical tap root making them more drought sensitive.

Seed yield of J. curcas seems to have an optimum in water need, ranging somewhere in between 600-1200 mm. Higher water availability does not seem to increase yields further, but will stabilise or even decline seed yield. In extreme humid tropics (Belize) with annual rainfall > 1500 mm the shrub shows no flowering at all and barely produces seeds. (Personal communication Rijssenbeek; 2006) The fruit is harvested by hand and fruit hulls and seeds are generally separated manually. Out of 30 kg of collected fruits, one can harvest 18 kg of seeds. (Heller; 1996)
An agronomic handbook, including an ecological production scheme with generative stages of the plant is currently improved and developed by FACT[118]. (Personal communication Rijssenbeek & van Eck; 2006)

3. Processing of Jatropha curcas

To extract the oil mechanical cold press expellers can be used or so-called ‘warm’ press technology using solvents (like hexane) and which requires refining afterwards. The first method can be executed with mechanical expellers after which the oil is settled and filtered producing an oil of natural (diversified) quality, hereby called JPO (Jatropha Plant Oil). Return (oil recovery per kg of seed) of this method is lower than by solvent extraction, which extracts the complete oil content from the seed and gives a standardised product quality of JPO. Solvent extraction needs larger investments and higher standard of technology, while mechanical extraction is less capital and technology intensive. In equivalent terms, the energy needed to produce Jatropha oil in mechanical presses amounts to about 10% of the oil obtained (Henning; 1998).

The seeds when extracted by mechanical expeller, give about 30% oil that can be converted into bio-diesel by esterification with methanol or ethanol. . The yield of bio diesel is about 92% of the initial weight of the JPO. (Becker et al.; 2005) Some characteristics of JPO, bio-diesel and fossil diesel are compared in table 3.

Table 3: Characteristics of Jatropha bio-diesel compared to European specifications

Parameter	JPO	Jatropha Bio diesel	European standard	Remarks*
Density (g cm-3 at 20°C)	0,920	0,879	0.860 – 0.900	+
Flash Point (°C)	240	191	> 101	+
Cetane no. (ISO 5165)	-	57-62	> 51	+++
Viscosity (mm2/s at 40°C)	52	4.20	3.5 - 5 (40°C)	+
Net Cal. Val. (MJ/L)	-	32.80	-	-
Iodine No.	-	95-106	<120	+
Sulphated ash	-	0.014	<0.02	+
Carbon residue	-	0.025	<0.3	++

Source: Becker et al. 2003; Gübitz et al., Bioresource Technology 67, 73-82, 1999
* : + indicates better performance compared with the European standard fore FAME (diesel).

[118] FACT is a foundation which want to provide an information point on research data and information on jatropha curcas and other bio energy resources for actors involved. http://www.fact-fuels.org

4. Economic potential

To evaluate the economic potential of J. curcas one need to consider the following economic considerations:

1. comparative advantage against fossil fuels/palm oil/rapeseed
2. comparative advantage against other crops (peanuts, castor, sorghum/millet, maize)
3. comparative advantage in plant utility (fuel, lamp oil, soap, biomass)
4. Impact of economic factors (inflation, oil prices, labour/land/capital costs)
5. Impact of socio-cultural setting & best related management design

This is executed by cost price analysis and revenue analysis. Focus is in the end to find the best management design for production & processing with highest endogenous combination of complementary properties.

Cost prices of jatropha based bio diesel for India, range from 0,39 to 0,43 $/kg of bio diesel (see table 4). Another calculation made by FACT, based on the result of a plantation in Mali, results in a preliminary costs price of jatropha based bio diesel of 0,34 to 0,38 €/litre (0,36-0,41 $/litre). (personal communication Rijssenbeek; 2006) In both analyses the revenues received by the sales of cake and glycerol are taken into account.

Table 4: Production costs of jatropha based bio diesel in India ($/kg of bio diesel)

	Rate	**Quantity (kg)**	**Costs**
	US $ kg^{-1}		US $
Seed	0.11	3.28	0.36
Cost of collection and oil extraction	0.05	1.05 from 3.28 kg of seed	0.06
Less cake produced	0.02	2.23 from 3.28 kg of seed	−0.05
Transesterification cost	0.15	1.0	0.15
Cost of glycerol produced	0.88 to 1.3	0.095	−0.08 to 0.13
Cost of biodiesel per kg			0.39 to 0.43 $/kg

Source: Subramanian et al.; 2005. Engines Laboratory, Indian Institute of Petroleum, Dehradun 248 005, India. *Utilization of liquid biofuels in automotive diesel engines: An Indian perspective*

Table 5 shows that jatropha based bio diesel is fairly competitive against other vegetable oil based fuels. Although, palm oil production is known as the most productive oil crop with an average production of 3500 litre of oil/ha in Indonesia and Malasia, J. curcas seems cost price competitive. Fossil fuels cost price remains most competitive as tax exemptions are not included. Nevertheless this makes jatropha curcas as source for bio fuel interesting, when considering expected raising oil prices in the future.

Table 5: Comparision of diesel costs in Euro/litre

Country	**origin**	**Cost price**	**Oil prod. litre/ha**	**Source**
Europe	Rapeseed	0,60 – 0,65	1500	Rabobank
Indonesia	Palm oil	0,40 – 0,45	3500	USDA
India	Jatropha	0,36 – 0,40	500-1700	Subramanian
Mali	Jatropha	0,34 – 0,38	1000	Fact foundation
Europe	fossil	0,25 – 0,35	Without tax	
Euope	fossil	0,?? – 0,??	Including tax	

Source: various

According calculations made by Becker et al., economic internal rate of return on an plantation based on marginal soils in India equals 20,6% on average over 30 years. Yearly total costs were estimated on 1459 $/ha and yearly total revenue around 2190 $/ha (including revenues of inter-cropping), resulting in a yearly profit of 731 $/ha. (Becker et al.;2003)

Direct competition on arable land exists particularly with castor beans, cotton, peanuts, sorghum/millet and maize. Although, inter-cropping is possible on the better soils with especially the annual food crops which generally only grow during the rain season (peanuts, sorghum/millet and maize). Compared with the perennials like castor beans and cotton, J. curcas shows higher drought tolerance and shows better adaptation to marginalised soils, giving J. curcas an advantage.

Highest costs within jatropha production are the costs for labour (harvesting) and costs of fertiliser. (Personal communiciation with Rijssenbeek; 2006) Especially, when opportunity costs of labour are high (due other activities generating more money) it can be difficult to find sufficient labour for harvesting. Investigation on simple mechanisation solutions for harvesting could bring yield per labour hour on a higher level improving its comparative advantage against other labour opportunities. Cost of fertiliser can brought down by using the press cake for own plantation.

5. Environmental and climate impact

Jatropha curcas, is a well adopted species for erosion control. The cake residue is used as organic fertiliser.

According a field test executed by GTZ in Zimbabwe a gift of 5 ton jatropha cake/ha subsequanlty equals a gift of 100 kg of mineral fertiliser (100 kg of ammonium phosphate and 50 kg urea/ha) and results in a seed yield of around 5000 kg/ha. Nevertheless, when you need a gift of 5 ton of cake fertiliser to replace the use of mineral fertiliser, this means with an average revenue of 5 ton of seeds/ha, resulting in 3300 ton of cake you will always need to add extra fertiliser (1700 kg of cake)
When concerning processing of jatropha seeds, Van Grieken assessed the energy efficiency of the methyl ester production process of jatropha with an energy input-output ratio of 1:5.2 (fossil oil is around 1:5 and rapeseed is somewhere around 1:3)

6. Conclusions

Jatropha curcas is a highly adaptable species, but its strength as a crop comes from its ability to grow on marginal, dry sites (Heller; 1996). Comparison on productivity with palm oil shows that the advantage of J. curcas is highest when focusing on drier areas and not on the wet tropics, where palm oil generates much higher oil production yields per hectare. Nevertheless, J. curcas seems economically competitive with palm oil (just as against fossil fuels and rapeseed oil production) when produced on larger scale plantations in semi-arid zones due to low production costs.
Competition on land with other crops (like millet, ground nuts, cotton and maize) is also lowest in the drier areas, as J. curcas can be characterised as an ‘edge’ vegetation, which still can grow productively in areas where other food & cash crops fail.

As concluded by Heller, large scale plantations are only appropriate for marginal lands on which annual food crops cannot be produced. If high pressure for arable land exists, J. curcas would normally be planted as a hedge to fence in fields. (Heller; 1996)

J. curcas was traditionally a multipurpose crop, although focus for large scale production is currently solely on seeds production for bio diesel. It may be interesting to combine biodiesel production with exploration of other plant parts like leaves and latex. Cake residue seems most valuable as fertiliser, due its economic competitive character against mineral fertilisers and problems of erosion & marginalisation in the arid soil zones.

Some questions remain:
Are other cheaper or more effective resources for green fertilisers or fodder crops accessible and applicable in the drier areas? In which application has J. curcas its comparative advantage, as fertiliser, animal fodder or biomass energy resource? Soap, lamp oil competitive prices and added value?

7. Further research

The low yields and high variations within one field between yields per plant revealed in several projects may have been caused by the fact that unadapted provenances had been used. Also, the traditional way of reproduction by using cuttings instead of seedlings can explain part of this. Further investigation on its genetic diversity and its yield potential covered by adequate scientific research, can help to overcome these problems.

- Research on improving seed productivity and development of better varieties.
- Agronomic production methodologies; acquire reliable yield data & develop best production strategies.
- Comparative analysis of the costs and economic value of using the cake for fertiliser, animal feed or biomass energy production.
- Research on lowering labour costs in harvesting and developing best production models for bio energy production out of its biomass.

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Company D1 oils plc has a target to plant 267.000 ha Jatropha in 2006 in India for biodiesel production. Yield expectation is 100.000 tons per 40.000 ha. http://www.d1plc.com/

24

THE HARVEST OF FOREST RESIDUES IN EUROPE

Definition of the problem
The Dutch forest owners reacted very reserved on the question whether they would be willing to harvest forest residues (tops and branches) from their forests. In other European countries, such as Sweden and Finland, forest residues to some extend are being harvested. The harvest of forest residues represents a large biomass potential which at present is hardly used.

Questions
1. Which European countries do harvest forest residues?
2. Is there any opposition against this harvest?
3. Has research been performed to determine the consequences of harvesting forest residues (e.g. soil fertility, sustainability)? If yes, what are the results?
4. What is the technical potential within the EU-25?

Leen Kuiper and Jan Oldenburger, November 2005. Report on BUS ticket no. D15a, Probos

1. Approach

In order to answer the questions above a literature study has been done.

2. Results

2.1 Harvesting forest residues

Before answering the questions mentioned above some backgrounds of the harvest of forest residues are presented in this paragraph. Forest residues can be defined as all above-ground biomass left on the ground after timber harvesting operations (e.g. branches, tops, small unmarketable logs and undergrowth trees). On average 10 to 15 % of the total above ground biomass is left behind as forest residues during regular harvesting activities (20–30% in the first commercial thinning but only 4–5% in the final cutting). It should be kept in mind that these figures are from countries with forests mainly consisting of coniferous species and are for this reason related to coniferous species.
Forest residues have a great biomass potential. Especially in Europe where due to the high degree of utilization of industrial wood processing residues sources, of woody biomass for energy purposes are becoming scarce. Forestry residues than come into the picture.

Usually, high costs are involved in the procurement of forest residues from the forest. For this reason a number of technologies have been developed and should be further optimized in order to reduce the costs of harvesting forest residues. Also a number of logistical supply chains have been developed to remove the residues from the forest and transport them to the energy plant. Four logistical supply chains are commonly used: the terrain chipping method, the chipping in road side-method, the bundling method and the loose residues method. Which method and technologies should or can be used depends on ecosystem conditions, infrastructure, forestry traditions and the desired level of integration of the regular harvest system with the harvest of forest residues.

The four forest residue supply chains:

1. the terrain chipping method: residues chipped inside the forest stand – transported by truck to the energy plant
2. the chipping at roadside method: forest residues pilled up at the roadside – chipping at the roadside – transported by truck to the energy plant
3. the bundling method (figure 1): bundling the forest residues inside the forest stand– bundles pilled along the forest road – bundles transported to the energy plant – chipping at the energy plant
4. the loose residue method: extract forest residues from the forest stand – forest residues pilled up along the forest road – transport the forest residues to the power plant - chipping at the energy plant

A problem with the use of forest residues for energy purposes is the presence of needles (and in some cases of leaves). Needles burn better than wood, but they contain chlorine. Chlorine increases the possibility of corrosion inside the combustion chamber also dioxides are produced. The disadvantage of leaves is that they burn less well than wood. This problem can be solved by leaving the forest residues in the forest for a while to dry. Furthermore, most of the needles and leaves will be shed off during the harvesting operation.

Figure 1: The bundling method the most recent developed method to extract forest residues from the forest stands (Alakangas, VTT)

2.2 Countries that do harvest forest residues

The Scandinavian countries are the leading countries in the use of forest residues for energy production. Especially Finland and Sweden use large amounts of forest residues. Countries like the United Kingdom, Ireland and Germany are increasing their use of forest residues for energy purposes.
The views of several Dutch experts on the situation in the Netherlands regarding the harvest of energy wood and forest residues are presented in a recent article by Juijn that has been published in the “Vakblad Natuur Bos Landschap” January 2005, which is attached as an annex to this report. The article concludes that some energy wood is being harvested in the Netherlands, but forest residues are not harvested during regular thinnings. Only in those cases that clearfellings are performed forest residues are being harvested. Clearfellings are

not common forest management practice in the Netherlands, but are sometimes performed if a piece of forest has to be cut e.g. to develop a building site. Most energy wood from forestry in the Netherlands comes from pre-commercial thinnings. The removal of forest residues after regular thinning is too expensive.

Sweden

The utilization of fuel chips from forest residues has been going on for some 30 years in Sweden. This utilization is ever increasing: some sources claim that it's growing by an annual 10 % and will continue to grow at the same rate for the upcoming years. Bio-energy from forest residues is an important part of the Swedish energy system, and Sweden is a world leader in this field. Most of the residues (>71%) are derived from final fellings. Sweden has a theoretical potential of 20 million m^3/a of forest residues when ecological and technical constraints are applied (Richardson *et. al.*, 2002). Applying economical constraints will further reduce this theoretical potential.

Finland

Finland is the world leader in utilization of bioenergy. The role of wood as a source of energy is more important than in any other industrialized country, as 20 % of the primary energy consumed is derived from wood-based fuels. The target of the Finnish energy and climate strategies is to raise the annual production of forest chips to 4.6 million m^3 or 37[119] PJ by 2010. In 2001 already 1,3 million m^3 of forest residues were used.
The total amount of stemwood residues (excluding crown mass) from annual logging operations in Finland is 4–5 million m^3, but as it is scattered over an area of 600 000 ha, the yield per site is too low to make the collection of these residues feasible. Profitable harvesting of forest residues for energy purposes requires higher yields. This can be achieved with simultaneous recovery of residual stemwood and crown mass.
In Finland the technical availability of logging residues from final harvests is about 40 PJ per annum (5 million m^3/a), of which 48–66 % (3 million m^3) is presently economically harvestable.

Denmark

In Denmark the importance of chips as a fuel has continued to increase over the past 20 years, and today approx. 200,000 m^3 of solid wood equivalent of forest residues is produced each year. Chip production equipment has been improved considerably in recent years, and this has helped to keep fuel prices at a reasonable level. Chips are mainly utilized for heat purposes, but the wood chips are also used in co-generation, district heating and CHP plants. In the 1990´s approx. 30 coal fired plants were converted into wood chip fired plants, in an effort to utilize a larger amount for CHP plants.
Denmark has a potential of 11 PJ/a of forest residues of which 75% is actually used (8.5 PJ/a or 1.1 million m^3) . This amount of forest residues comprises 23% of the total amount of biomass used for energy production.

United Kingdom

The total forest area in the United Kingdom has a technical potential of app. 2.2 million m^3 per annum of forest residues. This figure is an estimate of the annual sustainable production that can be made available taking account of technical and environmental constraints. Economic factors determine how much of it can be technically utilized.

Ireland

In 2000 Ireland had a technical potential of 43 PJ (6.9 million m^3) from forest residues. The quantity of forest residues present in Ireland is given as 675,000 m^3, this was calculated as a percentage (20%) of the annual total of harvested timber in Ireland. Forest residues are

[119] Conversion factor: 1 PJ equals 0.125 million m^3 fresh wood chips

not currently exploited as a biomass resource as they are considered to play an important part in the overall forest life cycle.

Germany

Germany has a potential of 178 PJ (22.2 million m^3) from forest residues. The use in 2000 was 55 PJ (6.9 million m^3) of forest residues; i.e. 28% of the total amount of biomass that is used for energy purposes.

2.3 Status of the harvest of forest residues: is there any discussion?

In general it can be said that there is little or no discussion about the removal of forest residues in countries where this removal is common practice. Especially in countries which start or are willing to start with this removal some doubts are expressed. The main question that is asked about the removal of forest residues is what the impact of this removal is or will be on soil fertility and on the sustainability of forest management? Paragraph 4.4 deals with the research that has been performed on this subject.

2.4 Performed research and results

Especially in Sweden and Finland a lot of research has been done into the subject of removing forest residues from the forest. In other countries research has not been done specifically on the subject of the removal of forest residues, but deals with the removal of forest products in general. The main findings of this research are presented here.

Compared with tree stems, crown material and particularly the foliage component, is rich in nutrients. Consequently, that crown mass removal increases the loss of nutrients from a forest ecosystem, if the removal of forest residues for energy purposes becomes a common practice in forest management. Certain restrictions and site specific management are needed to minimize the negative impacts of intensive harvesting on nutrient cycling and biodiversity.

Studies in many countries show that crown mass removal may endanger the sustainability of production capacity, depending on the site characteristics and amount and composition of removed biomass. However, field experiments usually incorporate uniform distribution of material after logging in control plots and complete removal of crown components from whole-tree logging plots. Since this degree of precision is impossible in operational forestry, experimental results tend to over-estimate the negative impact of forest residue removal on the growth potential of the site. No technology is able or intended to remove all crown mass from the site. For example, in Finland the salvage of logging residues from the final harvest, irrespective of the system applied, accounts for only some 70 % of the crown mass (Alakangas, 1999).

Negative ecological impacts can be reduced by careful planning and the adoption of appropriate technology. Examples of available methods are:

- the appropriate timing of operations
- minimizing the nutrient removals from the forest sites
  Summertime transpiration drying is an effective way of achieving the simultaneous reduction in moisture content and partial defoliation in small whole trees and logging residue heaps on the site. Most of the essential nutrients are stored in the needles and leaves. However, the flow of fuel from the logging site to the energy plants is slowed, and the recovery of biomass is reduced. An other way is the development of foliage trimming techniques
- recycling of ash from the combustion installation.
  By returning wood ash from the combustion installation to the forest the nutrient loss from the ecosystem is minimized

These methods will not completely compensate the nutrient loss, but will certainly reduce it. The removal of forest residues from poor sites should be avoided in all cases, because this would further reduce the nutrients availability in these already nutrient poor sites (Sikkema, 1998, van Belle and Temmerman, 2001, Burgers, 2002, Hakkila, 2002).

2.5 The technical potential within the EU-25

The theoretical energy potential of forest residues from logging and tending operations in the EU countries are estimated to amount to 1028 GJ. These residues are located primarily in Germany, France, Sweden and Finland. This potential can, of course, not be utilized entirely, since ecological, technical and economic barriers constrain its recovery (Richardson *et. al.*, 2000). Furthermore supply and demand do not always match geographically.
To illustrate what the potential impact of the use of the energy potential available in forest residues would be, the following assumptions are made. The use of one third (343 GJ) of the energy potential in forest residues would reduce CO2 emissions by 30 million tons annually. This is a reduction of 2-3% of the total CO2 emissions from power generation in the EU countries.

During a study performed by Ecofys, EFI and Probos the EFISCEN model was used to estimate the amounts of recoverable logging residues in the EU-15 member states. The results are shown in table 1. The amount was estimated by assuming a 15% recovery rate. The report on BUS ticket D15b will further deal with the technical potential of forest residues within the EU-25 member states and will be able to use different assumptions. For this reason this report will not further elaborate on the technical potential within the EU-25 count

Table 1: Amounts of logging residues potentially available for renewable energy when assuming a 15% recovery rate. Data for EU-15 Member States (Meuleman et. al.*, 2005)*

Member State	**Recoverable logging residues (m^3)***
Austria	1,094,425
Belgium	239,061
Denmark	137,695
Finland	2,318,877
France	4,930,198
Germany	3,150,163
Greece	739
Ireland	206,577
Italy	1,318,613
Luxembourg	32,332
Netherlands	91,196
Portugal	282,945
Spain	853,388
Sweden	2,942,641
United Kingdom	745,361
Total EU-15	**18,344,231**

* m3 round wood equivalents
Source: EFISCEN-model

3. Conclusions

1. In general the harvest of forest residues is performed in clearfellings only and is less suitable for thinnings. The reason is that space to move around in the forest during thinning operations is limited which causes higher costs. Consequently the harvest of forest residues is mainly done in countries where clear- or final fellings are still performed.
   This is the main explanation for the huge gap between the technical potential of forest residues for energy purposes and the actual amount that is harvested in the EU.
2. A method that can be used during thinning operations is the full tree method in which the whole tree is extracted from the forest and chipped. This method is particularly suitable for young stands with small trees that do not have a commercial roundwood value (i.e. pre-commercial thinnings).
3. Logging residues should be harvested in an integrated harvesting system, where just as much attention is paid to the organization of the residues and to the organization of the timber harvested.
4. Residues, which are to be harvested for energy purposes, should not be used to drive on by harvesters and forwarders. Some of the branches can be used, but especially the tops should be put aside. (Residues are commonly used to drive on in order to prevent soil compaction.)
5. The availability of logging residue chips is, in practice, not as plentiful as suggested. Some of the logging sites are out of question due to small size, long distance, difficult terrain or ecological restrictions, and in all cases it is recommended that 30 % of logging residues are left at site. If residues are left to dry and shed part of the needles before haulage to road side, the yield of biomass is further reduced.
6. Although present research results show only a slight reduction in site production due to the removal of forest residues from forest stands if a large part of the foliage is left behind, it is not possible to draw the conclusion that the effect on the long term will be negligible. Long term biological research is needed inside permanent plots situated in intensively harvested forest stands in order to be able to determine the long term impacts of forest residue harvesting.

4. Follow up

A number of questions still remain unanswered:

- What is a realistic assumption for the percentage of forest residues that can be used for energy purposes in EU-25 states (modelling with EFISCEN)? Considering the ecological, technological and economical constraints.
- Which forest area in the Netherlands is not available/suitable for the harvest of forest residues? Where are these forest area’s situated?
- What is the weakest or most expensive link in the forest residue supply chain in the Netherlands?
- Which logistical solutions can be found in order to make the harvest of forest residues from thinnings possible in the Netherlands? Develop the most promising solution into a field trial in order to see if it really works.

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Follow-up studies

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POSITION PAPER ON FORESTRY RESIDUES

Leen Kuiper, October 2005. Follow-up BUS report, Probos

1. Why this position paper?

Following a brainstorm session at the seventh BUS-meeting on August 26, 2005 the steering committee invited Probos to report on the opportunities and threats of the forestry sector in The Netherlands with respect to the production of woody biomass for energy purposes, i.e. 'energy wood'. The central questions are: What affects the sustainable use of forestry residues for bio-energy? What are the main bottlenecks? What are the possibilities to overcome these barriers?
A provisional list of critical success factors resulted from a brainstorm at the seventh BUS meeting, using Hi-View software (annex 1). Probos was asked to review the list and to develop research questions addressing these factors and to identify market opportunities in the field of forestry residues.

Scope
The scope of this position paper on forestry residues is limited to residues resulting from timber harvesting (mostly thinnings) in conventional production forests. It covers the supply chain until the gate of the primary wood processing plant, e.g. sawmills for round wood (logs). All activities mentioned here refer to the sustainable management of woodlands and include timber cruising (selection of harvestable timber), harvest operations, timber extraction to forest roads, hauling and transportation of the woody biomass by lorries (logistics), chipping, drying and storage. The focus is on biomass procurement in the Dutch forestry situation, but includes as well a brief outlook to imports from Europe and overseas and short rotation energy coppice.

2. Main factors affecting the supply of forestry residues for energy use

The following main factors have been identified by the BUS group, not necessarily ranked in decreasing order with respect to the impact they may have on biomass supply and procurement:
1 Market and economy
2 Transportation and logistics
3 Quality traits
4 Sustainability issues
5 Forest management goals
6 Public perception
7 Government policies

Obviously, the economics of production, harvesting and logistics very much determines how much energy wood will become available to the bio-energy market. The end-users require certain quality standards, which, in most cases, can easily be fulfilled because energy wood derived form the forest is a clean source of biomass with virtually no contamination, if properly handled. The forest management and exploitation activities will have to take place on a sustainable basis in order to fulfill government policies, forest management goals and the perception by the general public. Hence, all these factors are clearly related to each other. What are the most relevant research questions?

3. Relevant research topics

3.1 Dutch woodlands

1 Cost reduction in the supply chain of energy wood.
Currently, a lot of time is lost by lorry drivers in trying to find their way in the forest. To reduce the costs for transportation, lorries can be equipped with GPS systems to optimize their route planning in the forest and to find the shortest way to scattered stacks of woody biomass. In Sweden GPS equipment is already standard in lorries; in The Netherlands this could be a time saving option too. What would be the expected cost reduction?

2 Stimulating wood harvest in multifunctional forests with full service contracts.
Platform Hout in Nederland (a coalition of partners from the Dutch forestry and wood processing industry) observes a declining interest by forest owners to harvest more wood from Dutch forests, even though sustainable management would allow a much higher utilization rate.[120] Offering full service contracts to forest owners and communicating the positive ecological impacts of regular thinnings on forest development may help to bring about a shift in mentality. Some of the environmental impacts are obvious, others still have to be studied in more detail. Communication strategies will have to be developed and tested to reach forest owners with the positive message to harvest more wood (including energy wood).

3 Is it possible to carry out early thinnings in a more cost-effective way?
The thinned material (small sized trees) usually remains in the forest. When taken out as a bio-energy feedstock, it does not compete with conventional wood uses. Contractors sometimes agree to carry out these non-commercial thinnings to keep their men and machines busy in periods of low work.

4 SWOT-analysis of the Dutch forestry contractors sector
The contractors sector is under pressure. In due time this may affect the possibilities to harvest (more) energy wood. E.g. the rising costs for motor fuels (diesel) already has caused some companies to balance at the verge of bankruptcy. Relevant questions in this assessment are: How many companies are involved in the contractors business? Where do they work, mostly in Holland or increasingly abroad? What machines do they use? Which harvesting methods do they employ? What number of hours are they working/annum? At what cost price per hour? What is their revenue? Which chippers do they use? What are their strong points and what their weakest points in terms of competition? What do they themselves perceive as opportunities to improve their performance? Is sufficient capacity available to increase the harvesting rate? Based on this SWOT analysis a vision on the future can be given.

5 Which factors determine the contractibility of energy wood?
Supply potentials of woody biomass often do not match with the actual contractibility. There is a huge gap between the amount of wood waiting to be harvested and the volumes actually available on the market. Will contractibility increase if the energy wood market is made more transparent?

6 Questions with respect to government policies
What will be the impact of the recommendations in the PNH 'Vision on wood harvest' on the future availability of woody biomass? Does the EU subsidy for the establishment of energy crops apply to the Dutch situation? Why has no one taken advantage of it?

[120] Visie op de houtoogst. Report PHN and Ministry of LNV, Wageningen and Den Haag, 2005

7 What more can be done to raise public support for bio-energy?
Why not organize a field trip for a group of journalists showing them various aspects of the harvest and logistics of energy wood? Different kinds of communication strategies may be applied to enhance the public perception: e.g. organize a symposium, present the mobile display of the State Forest Service on Energy wood at various occasions, hold a competition to design the most sustainable energy wood supply chain, write an article about upstream biomass and the relevance of the BUS in one of the journal of the State Forest Service, etc.

3.2 Imports

1 From which European forest areas more energy wood may realistically be supplied?
In the European forest area about 400 million m3 of the annual increment is not harvested at present. To exploit part of this unused potential would provide a tremendous source of woody biomass, without distorting the existing wood market. In many parts of Europe the costs of harvesting may be substantially lower than in The Netherlands, because of the larger scale of the operations and the use of modern technology. This is especially the case in Scandinavia. In Eastern Europe wages are considerably lower and an unknown proportion of the wood is derived from illegal logging, and thus cheap. On the other hand Eastern Europe has the drawback that the political situation is rather insecure, the technology often is outdated, logistics and infrastructure is poor and the mentality of forest owners is not oriented towards a market economy. Nevertheless, in Eastern Europe the forest resources are large and much gain can be expected from trying to optimize wood harvesting.

2 From which countries imports of large amounts of woody biomass will be sustainable?
If only a fraction of the Dutch 2020 demand for biomass will be supplied by energy wood, very large amounts will have to be imported, given the limited resource base in The Netherlands. The country may be self-sufficient in its biomass supply for about half a million odt/a, whereas a minimum of 8 million tons of dry matter will be needed by 2020. Assuming that 40% of the biomass demand will be wood, about 2.5 million dry tons of energy wood will have to be imported per year.[121] In other words: the demand will be huge and the resources should be proved to be sustainably managed. Which countries are able to supply this amount of wood, preferably with a certificate for sustainable forest management? A useful source of information could be a series of country reports describing the actual situation in the forestry and wood processing sector in the most important production countries (such as Germany, Belgium, France, Sweden, Finland, Canada, Baltic states and parts of Russia) and of promising new countries with potentials (Poland, Romania, Bulgaria, Chile, Brazil, Russian Federation). For these countries, later to be expanded towards South America and Africa, relevant information will be provided on forest area, certified forest area, national forest policy, logistics and infrastructure, timber market, forest management regimes and the organization structure of the wood supply chain.

3 Are the (rather strict) requirements for sustainable forest management a problem for the provision of energy wood?
As a co-product of conventional forestry, energy wood may easily join in with the existing certification schemes, such as PEFC and FSC. Once the Dutch Assessment guideline for certification of sustainable forest management is approved[122] a common standard exists with which criteria and indicators may be compared and tested. For energy wood, as is e.g. the case for wood products based on pulpwood fibers, only a certain percentage of the resource has to be certified for sustainable forest management, including the associated

[121] Projections for 2040 suggest that a total biomass volume of 20 million tons of dry matter/a will be needed
[122] The approval of which, according to the ministry of VROM, is probably due by the end of 2005

chain-of-custody. But what about imports of energy carriers derived form forestry residues (pellets, briquettes, pyrolysis-oil)? What criteria and indicators can realistically be applied without jeopardizing imports volumes?

4 Does a track- and-trace system provide enough guarantees or does the whole supply chain have to be certified?

The import experiments of the Biomass Transition, the tender of which is going to be opened soon, may be an interesting opportunity to the BUS to be involved with these kinds of research topics (e.g. by forming a consortium of project partners or by providing a contribution from the BUS participation fund).

5 How much woody biomass is currently available with an FSC certificate (both potential and contractible amounts) in the wood exporting countries?

6 Why timber plantations are subject to debate within the FSC?

What will be the impact for the supply of energy wood derived from sustainably managed forest resources if plantations are no longer eligible for FSC certification?

3.3 Dedicated energy crops

1 What will be the contribution of short rotation coppice to the biomass supply by 2020?

Dedicated energy crops have a low return on investment: it takes about 12 years before the break even point is reached. As an agricultural business this not an appealing alternative to farmers. However, from the point of view of forestry short rotation coppices may provide an intensive management system with a relatively short return on investment. To further improve the economics of energy cropping up scaling is needed and modern technology will have to be applied. Silvicultural risks can be minimized by smart plantation design and integrated pest management. Establishment cost may partially be covered by subsidies. With the current incentives provided e.g. by the EU it would certainly merit a business economic comparison between rape seed and arable energy coppice. Another interesting research question are:

- Under what conditions may short rotation willow coppice be eligible as a new nature target type ('bosdoeltype') in the SAN regulation (Subsidieregeling Agrarisch Natuurbeheer), which will be evaluated in 2006.
- How do woody energy crops perform in relation to conventional agriculture in the new EU Member States?
- Is willow coppice an option for agriculture land put in fallow in the EU-25? In which countries the best conditions may be found? What will be the area of fallow land available for alternative uses?

4. What next?

In the previous paragraph 13 suggestions have been given for possible follow-up studies on the supply and procurement of forestry residues both in The Netherlands and abroad. In previous BUS meetings already a large number of BUS-ideas, more than 150, have been formulated of which thus far only a limited number have been worked out in a quick-scan. Already 25 appealing ideas relevant to forestry residues have been identified. They fall into the following main categories:

Availability:	9x
Market & economy:	6x
Silvicultural techniques:	5x
Government policies:	2x
Public perception:	2x
Sustainability:	1x

Apparently, factors determining the availability of woody biomass have been considered most relevant by the BUS-participants. On the second place are topics on market and economy. Silvicultural techniques rank third. Surprisingly, no ideas have been formulated on wood quality traits, on processing and storage of forestry residues and on public support and only very few on the ecological aspects of sustainability (maintaining soil fertility, water balance, etc), e.g. the "Monitoringsprogramma Flevo-Energiehout".

The forestry related quick-scans approved so far all belong to the category "availability and supply":

- How to get more timber from Dutch woodlands?
- Possibilities of social-forestry/agro-forestry for the production of biomass in the Tropics
- What are the possibilities and sustainability risks of harvesting more wood from European forests?
- Potential en techniques of energy cropping on salty soils

5. Missing information?

This analysis does not suggest that the themes identified so far are the only relevant research questions, but they certainly will contribute to our understanding of the possible impacts of the use of woody biomass on our society, environment and economy. Forestry residues, in combination with 'other woody biomass' (e.g. post consumer wood, demolition wood, wood processing residues and dedicated biomass crops) will play a very important role in our future biomass supply, especially when the market for second generation (lignocelluloses) motor fuels and bio-based (composite) products will have developed somewhat further.

Annex 1
List of critical success factors for the use of forestry residues in energy applications

Transports and logistics			Remarks
	Technique		
	Capacity		In addition to regular production targets, exploitation and infrastructure
	Machines		
	Collecting		
	Infrastructure		
	Storage		
	Pre-treatment		Ref: logistics, market and economy
Quality			
	Variables		
	Chem. composition		
Sustainability			
	Water management		
	Mineral balance		
	Biodiversity		
	People		
		Income	
		social circumstances	
	Soil quality		
	CO_2 balance		
Market and economy			
	Costs		
		Main product	
		Subsidies	
		Technology	scale of harvest
	Markets		
		Certification	
		Continuity	Security
		Demand/supply	
		Chain (organization)	
		Competition	Land use / timber use
	Attitude		Forest owner
	Forestry tradition		Lack of confidence between new partners
	Exploitation targets		money/ fun/ nature conservation/ recreation / emotional bonding / status
	Recreation		
Public perception			
	Society		desires / emotional bonds with traditional values of the forests
	NGO's		
	Media		
	Traditional ideas		
	Subsidies		
	Laws		

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BIOSALINE (AGRO) FORESTRY: A LITERATURE REVIEW

Leen Kuiper and Jan Oldenburger, April 2005. Follow-up BUS-report, Probos

1. Introduction

Bio-saline forestry projects deal with marginal areas, characterized by saline soils and brackish water and species that have the ability to cope with high salinity levels. Although halophytic tree species spend part of their energy on internal salt management and therefore usually have lower production levels than species grown under fresh water conditions, salt affected areas do provide an interesting opportunity to develop commercially, because large areas are concerned where agricultural use or nature conservation values are of minor interest. The decision to invest in these areas will be based on the aggregated socio-economic and environmental benefits, the increasing pressures on agricultural land and on fresh water resources, and the increasing demand for biomass that is foreseen in the next decades. Although the lack of alternative economic use of these areas suggests that bio-saline (agro) forestry may become economically feasible, even with lower production levels, it is important to continuously try to improve the production level of salt tolerant tree species. An initial study carried out by Probos[123] suggests that it is possible to improve production levels by developing appropriate salt-management systems, by selection and breeding and by developing and applying appropriate sylvicultural techniques.
After a case study on mangroves[124], a follow-up study was proposed to assess the possibility that in the next few decades bio-saline (agro) forestry may become an attractive alternative form of land-use in salt affected areas and that appropriate agro-forestry systems and tree plantations can be developed which contribute to the sustainable production of biomass.

Long-term perspective

The global afforestation rate of 'regular' forest stands is about 10 million ha per year, whereas the actual establishment of fast growing tree plantations is approximately 1 million ha per year. In a long-term perspective, on saline sites the annual afforestation rate may amount to 5% of the total world-wide afforestation efforts, i.e. 500,000 ha per year. However, before such a level of afforestation can be achieved, considerable efforts on R&D, field experiments and on-farm testing of the most promising tree species and cultivation methods will have to be undertaken, in which a step-wise up scaling can be considered: e.g. (step 1) from 20 ha of field trials to (step2) 200 ha farm-size demonstration plots, to (step 3) semi-commercial planting schemes of about 2000 ha, and (step 4) commercial operations under practical conditions with 20,000 to 50,000 ha planting units. It will take at least 20 years before step 4 can be achieved, which implies significant funds and a long-term commitment by all stakeholders. However, given the scope and urgency of the salinity problem, no time should be wasted to take the first initial steps, i.e. to establish a series of field trials.

2. Method

123 Quick-scan on measures to enhance the productivity of tree plantations, report Probos, November 2004.
124 In addition, the BUS has done a quick-scan on salt water forestry with a case study on mangroves (BUS-report 24, 2004) with the recommendation to do a more extensive literature review on other salt tolerant tree species.

A literature review was performed to provide information about potential tree species to be used to establish tree plantations on saline (and often waterlogged) soils. For this review the library sources of the Wageningen University and Research center were used such as: Agralin, Artik and CAB-abstracts, Biological Abstracts, Agricola and Agris. In addition, the internet was searched with the search engine Google.

While doing this literature review, it soon became apparent that different methods are used to determine the electrical conductivity (EC) of the soil, which makes results in the literature very difficult to compare. For this reason, a short description of salinity measures, units and classes is presented in annex 2, mainly derived from the Department of Agriculture of Western Australia.

3. Current research on biosaline (agro) forestry

A selection of organizations that are involved in current research on afforestation of salt affected soils is given in table 1.

Table 1: Organizations which perform research on afforestation of salt affected soils

Organization		Country	Website
CSSRI	Central Soil Salinity Research Institute	India	www.icar.org.in/cssri/cssri.html
CSIRO	Commonwealth Scientific and Industrial Research Organization Forestry and forestry products	Australia	www.ffp.csiro.au/
ICBA	International Center for Bio-saline Agriculture	United Arab Emirates	www.biosaline.org/
DDC	Desert development center Of the American University of Cairo	Egypt	www.aucegypt.edu/academic/ddc/
IAR	The Institutes for Applied Research Ben-Gurion University of the Negev	Israel	www.bgu.ac.il/IAR/index.php
KIS	Kuwait Institute for Scientific Research	Kuwait	www.kisr.edu.kw
USSL	United States Salinity Laboratory	United States	www.ussl.ars.usda.gov
PARC	Pakistan Agriculture Research Council	Pakistan	www.parc.gov.pk
LDD	Land development department	Thailand	www.ldd.go.th/index_lddeng.htm
TERI	The Energy recourses Institute	India	www.teriin.org

4. Plantation establishment techniques for salt tolerant tree species (salinity management)

The method showing the best results to establish tree plantations on salt affected soils is the <u>furrow method</u>. This method shows the highest sapling survival in different field studies (Tomar, 1997) and is recommended by the handbook of Quershi and Barret-Lennard (1998). It is an example of how to control soil salinity in the root zones (salinity management). The furrow method works as follows: furrows about 0,6 m wide and 0,2 to 0.3 m deep are created with a tractor mounted furrow maker. The furrows are used for irrigating the saplings for at least two years. The seedlings are planted at a uniform distance. The place where they are planted, depends on the degree of internal drainage of the soil. In soils with good internal drainage the seedlings should be planted at the bottom of the furrow. In soils with poor drainage the saplings are planted on the shoulder of the furrows so that they are not affected by water logging after irrigation. In waterlogged soils the trees should be planted on buds or mounds to avoid water logging. The trench-ridge technique is widely used in Pakistan and India on waterlogged soils. As soils are heavier, more salt-affected and waterlogged mounds should be taller and wider, and have a distinct trough. Such double-ridge mounds have proven very effective by providing (1) site drainage, (2) elevation of the seedling above the water table (thereby increasing oxygen availability) and (3) salt leaching from the root zone. These mounds are particularly useful where there is sufficient rain and/or irrigation water before planting time to leach salts from below the trough at this critical time. It is best to construct mounds several months before planting. Single-ridge and flat-topped mounds are not as effective, but are better than no mounds. Several techniques are available for mechanically forming mounds. Equipment includes: press wheels attached to the mounds of the plough, modified direct seeding machinery and twin discs (Marcar and Crawford, 1996, Lambert and Turner, 2000).

Results of the study by Minhas et al (1997) indicate that irrigation should at least be applied in the first two years after planting. In most cases the trees have developed their rooting system after two years and are able to reach the groundwater. Irrigation should be managed for trees on saline soils in such a way that it avoids water logging and aeration problems, and the accumulation of salt in the root zone. These objectives are met with the furrow irrigation method (Tomar, 1997). With the furrow irrigation method, saline waters of EC up to 15 dS/m in sandy loam and on loamy sand soils can be used (see annex 1). In finer textured soils, waters of EC up to 8-10 dS/m can be used for irrigating saplings. The recommended irrigation interval for brackish water is the same as for normal water. In India they have the following scheme: a monthly irrigation during Oct-Mar, and fortnightly irrigation during April-June (Tomar, 1997).

The distance between the saplings in a row and between rows is dependent on the species, but also on whether the trees are to be planted in blocks, mixed with shrub species, or used in alley cropping.
In case of the presence of a dense soil layer or hardpan the furrow planting method is combined with the auger hole method. Auger holes (0.2 m in diameter and 1.2 m deep) are dug at the sill of the furrows spaced at the desired intervals. These holes may be refilled with a mixture of original soil, farmyard manure, super-phosphate, zinc sulphate and iron sulphate to give the saplings a good start.

5. Agro-forestry systems

Many of the species that may be suitable for the establishment of tree plantations on salt affected soils are used in agro-forestry systems, especially in arid regions. In agro-forestry systems the trees are used as sources of fodder, during the dry season when there is no grass, they serve as windbreaks and hedges and they provide shade. If the trees are used as fodder or as shade trees, they can be planted scattered over the fields that are used as pastures, but can also be planted in blocks or as timber belts. The trees can be directly browsed by cattle, or the leaves and pods can be harvested to feed cattle.
A well-known species that is favored in agro-forestry systems is *Prosopis cineraria*: it fixes large amounts of nitrogen and does not affect growth of plants under the canopy (Qureshi and Barrett-Lennard, 1998).

Salt tolerant trees can also be used in agro-forestry systems with the purpose of managing dry land salinity. Dry land salinity generally results from the build-up of salts in surface soil, usually as a result of a rising water table and subsequent groundwater seepage. Water tables can rise due to the removal of deep rooting native vegetation, as is e.g. the case in Western Australia. Due to the removal of this vegetation large volumes of rainfall are leaking through the upper soil and recharge the groundwater. This results in raising water tables especially in discharge sites bringing dissolved salts to the surface layer of the soil. Trees can be used to lower these risen water tables. They are relatively deep rooting and can therefore reduce water leakage, they may use water all year around whenever it is available, and intercept a significant fraction of rainfall before it reaches the soil. In this way, strategic tree planting being part of agro-forestry and farm forestry systems, can contribute to lowering risen (salt)water tables.

Agro-forestry (sometimes called: alley cropping) combines trees and shrubs with pastures and agricultural crops to maximize productivity and water use. Planting layout and density is flexible; 100 to 450 trees/ha in multiple rows up to 50 m apart will provide a satisfactory ratio of trees to pasture/crops. Tree belts in alley cropping systems have the potential to use saline groundwater. The key issue generally is to maximize the distance between tree belts in order to reduce production losses due to competition between trees and pasture or crops and to balance the local recharge of groundwater with groundwater use by the trees in the belts. Qureshi and Barrett-Lennard (1998) indicate that its better to use a few wide belts of trees than using a lot of narrow belts of trees. Using a few wide belts of trees reduces the area at which an edge effect is experienced by the pasture or the crop. In this way, the area at which loss of crop growth caused by competition with invading tree roots and by shading takes place is minimized.

The extension of tree roots depends on tree species and tree size. The roots of most trees extend 1.5 tree heights from the base of the tree. Competition between tree roots and crops occurs most often within 1.5 heights of the base of the tree. However, the roots of some species such as *Acacia* spp. and *Prosopis juliflora* may extend three to five times the average tree heights.

A number of authors refer to the accumulation of salt in the root zone of tree plantations using saline groundwater (Mahmood, 2001, Qureshi and Barrett-Lennard, 1998). This salt may eventually accumulate to salt concentrations which adversely affect tree growth, health and survival. However, this may only be the case under steady-state moisture conditions in which no leaching of the root zone due to flooding, irrigation or seasonal rainfall takes place. Further research has to be done into this process.

Potential salt tolerant pasture and crop species that can be used in agro-forestry systems on salt affected soils are listed in table 2.

Table 2: Salt tolerant crops (based on: Lambert and Turner, 2000)

Crop	**Scientific name**	**Use**
Alkaligrass, Nuttall	*Puccinellia airoides*	forage grass
Asparagus	*Asparagus officinalis*	vegetable
Barley	*Hordeum vulgare*	grain
Bermuda grass	*Cynodon dactylon*	forage grass
Cotton	*Gossypium hirsutum*	fibre crop
Kallar grass	*Diplachne fasca*	forage grass
Saltgrass, desert	*Distichlis stricta*	forage grass
Sugar beet	*Beta vulgaris*	Tuber
Wheat, semidwarf	*Triticum aestivum*	Grain
Wheatgrass, fairway crested	*Agropyron cristatum*	forage grass
Wheatgrass, tall	*Elytrigia elongata*	forage grass
Wildrye, Altai	*Leymus angustus*	forage grass

6. Promising tree species for bio-saline (agro) forestry

A large number of species are reported in literature as being salt tolerant. However, the level of salt tolerance differs between species, but also within species and between provenances. For instance different provenances of *Eucalyptus camaldulencis* (Dehnh.) show different levels of salt tolerance.

Promising salt tolerant trees species, subdivided into three different salinity classes are summarized in table 3. A species is marked with a ‘W’ if it is tolerant to water logging. A ‘I’ indicates that a species is suitable for irrigation with saline/brackish water.

Table 3: Salt tolerant tree species

Tolerant (25-35 dS/m or more)			
Acacia	*Farnesiana*		
Melaleuca	*halmaturorum* (F. Muell)		
Parkinsonia	*aculeata L.*		
Prosopis	*juliflora* (Swartz) D.C.		I
Tamarix	*aphylla* (L.) Kartsen / *articulata* (Vahl.)		
Tamarix	*Troupii*		
Moderately tolerant (15 - 25 dS/m)			
Acacia	*ampliceps* (Maslin)		
Acacia	*nilotica* (L.) Del.		I
Acacia	*stenophylla* (A. Cunn. ex Benth.)*		
Acacia	*tortilis* (Forsk.)		I
Casuarina	*equisetifolia* (L.)		
Casuarina	*glauca* (Caloundra)*	W	
Casuarina	*obesa* (Miq.)	W	
Eucalyptus	*camaldulensis* (Dehnh.)*	W	I
Eucalyptus	*campaspe* (S. Moore)		
Eucalyptus	*kondininensis* (Maiden & Blakely)		
Eucalyptus	*occidentalis* (Endl.)*		
Eucalyptus	*platypus* (Hook) var. heterophylla Blakely		
Eucalyptus	*sargentii* (Maiden)	W	
Eucalyptus	*spathulata* (Hook)	W	
Leucaena	*leucocephala (Lam.) de Wit*		
Melaleuca	*lanceolata* (Otto)		
Melaleuca	*lateriflora*		
Pithecellobium	*dulce* (Roxb) Benth		
Prosopis	*cineraria* (L.) Druce		I
Moderately sensitive (10 - 15 dS/m)			
Cassia	*siamea*		I
Casuarina	*cunninghamiana*		
Dalbergia	*sissoo*		
Eucalyptus	*tereticornis* (Sm.)	W	I
Melia	*azedarach* (L.)		
Samanea	*saman*		
Sesbania	*bispinosa* (Jacq.) W.F. Wight	W	
Sesbania	*sesbana* (L.) Merr.	W	

*) Species known for their difference in the level of salt tolerance between different provenances.
W means it is tolerant to water logging; I indicates that a species is suitable for irrigation with saline/brackish water

In a number of studies field trails have been performed to determine the level of salt tolerance of different tree species and their provenances. The field trail with 31 tree species of Tomar *et.al.* (2003) recommends the following species to be planted in arid regions with moderate levels of saline irrigation (EC 8.5-10.0 dS/m) with the furrow planting method: *Tamarix articulata, Acacia nilotica, Prosopis juliflora, Eucalyptus tereticornis, Acacia tortillis, Acacia tortillas* (hybrid) and *Casuarina glauca* (see Table 3). These species not only produce economic yields (>20 tons/ha) but also improved soil conditions, i.e. in terms of organic matter.

Fagg and Stewart (1994) give a number of *Prosopis* and *Acacia* species that are salt tolerant and are well suited for afforestation of salt-affected soils in arid regions with the furrow planting method. For Prosopis these species are: *Prosopis juliflora, P. glandulosa, P.*

tamarugo, P. cineraria, P. pallida and P. farcta. For Acacia spp. it are: Acacia nilotica, A. tortillis, A. ampliceps B.R. Maslin, A. maconochieana L. Pedley, A. stenophylla A. Cunn. ex Benth. and A. silicina. However, they do not report the salinity levels up to which these species are tolerant.

Experiments by Van der Moezel et al (1991) in Australia on seedlings of *Eucalyptus* and *Melaleuca* showed that the most tolerant species under salt and water logging conditions were: *E. occidentalis, E. sargentii, E. spathulata, E. striaticalyx, E. tereticornis, Melaleuca lateriflora, M.* sp. aff. *lanceolata* and *M. thyoides*. In this experiment salt concentration increased every week by 7 mS/cm until a concentration of 35 mS/cm was reached. Under these well-drained salt conditions, survival rate of all species remained high, but a significant growth reduction took place. The species which grew best under these adverse conditions were: *E. yilgarnensis*, *E. micranthera*., *E. myriadena*, *Melaleuca adnata*, *M. eleuterostachya*, *M. lateriflora*, *M.* sp. aff. *lanceolata* and *M. thyoides.*.

Species from the following genera have shown to be salt tolerant: *Acacia*, *Eucalyptus*, *Prosopis*, *Tamarix*, *Casuarina* and *Melaleuca*. The characteristics and silvicultural measures for the most important species are summarized in a provisional database (Annex 1). However, it should be noted that the tolerance of these species to soil salinity (which , by the way, may vary throughout their lifecycle) and the relation between soil salinity and growth and yield are not well understood and hardly documented yet. Important indicators for the maximum biomass production obtainable by bio-saline tree species are the salinity threshold and salinity curves:

The salinity threshold represents the maximum degree of salinity at which the tree still produces at 100%. The salinity curve is a measure of decline in biomass production once the salinity threshold is passed (and salinity increases). True halophytes such as *Tamarix aphylla*, are able to maintain their productivity throughout the whole salinity spectrum, or show only a slight decrease in productivity at the higher end of the spectrum, i.e. under extreme saline conditions. However, most bio-saline trees are not true halophytes and they produce reasonably well in the salinity range of 15 – 25 dS/m. (the salinity of seawater is about 50 dSm). To prevent salt accumulation in the root zone of trees, effective salinity management is needed, which include irrigation and drainage. This, of course, is a capital intensive management system which needs to be very productive in order to cover the costs. Hoek et al 2004 suggest that a maximum production level of 15 odt/ha/a is considered realistic for salinity levels in the range 10-20 dS/m[125] (i.e. brackish water) and that even higher potential production levels can be obtained with tree improvements (selection and breeding) and by appropriate salinity management. This seems a rather optimistic viewpoint, which definitely need to be checked by field trials under various conditions, closely working together with international research institutes focusing on dry and saline environments, which already exist e.g. in the Unites Arabic Emirates, Kuwait, France, Spain, Turkey, Mexico, USA, India, Thailand and Australia (table 1).

ODE envisions thousands of hectares of hot, dry and salt-affected wastelands being transformed into irrigated bio-saline woodlands producing a variety of products and services, which include biomass for energy. Today's discarded saline land and water resources will become the input for new productivity, restoration of reserved natural areas and for postponing desertification [3]

[125] Hoek, J. et al 2004. Bio-saline biomass. Energy for the Netherlands in 2040. Report Ocean Desert Enterprises.

Prospects for the future

In the long run (2040) an estimated 300 million ha of salt affected soils with sufficient water available may be potentially available for dedicated biomass production, with an average production level of perhaps 5 odt/ha/a. This would imply a technical production potential of 30 EJ, which corresponds with 7% of the current global energy production (Hoek et al 2004). However, technical potential does not mean that the same area is available for exploitation in an economic viable way. The economics of bio-saline forestry will depend on the aggregated costs of the whole biomass supply chain, including the extra costs involved in biomass pre-treatment and conversion to reduce chloride levels. The farm gate costs depend on a number of parameters, such as price, yield, investment costs (e.g for the irrigation and drainage system) and annual production costs for labor, harvesting, fertilizer, pest control, etc., which are highly site specific. Especially the cost of salinity management will weigh heavily on the production costs. For bio-saline biomass to be competitive on the future commodity market, the farm gate price should not exceed 2 euro/GJ (i.e 36 euro/odt). According to Hoek et al (2004) in most cases, the farm gate price will be substantially higher (the most optimistic scenarios assume a price of 3 euro/GJ at production levels of 15 odt/ha/a), which means that bio-saline biomass plantations cannot survive on farm economy alone. However, if in the near future production levels will increase by technical measures, if the price for biomass is going to rise, if government support will be available for investments in infrastructure and appropriate harvesting equipment and if externalities are being valorized properly, the economy may change in favor of bio-saline energy crops. Bio-saline forestry and agro-forestry systems do not only try to produce biomass at competitive prices , but also play an important role in reclaiming degraded areas by using brackish water and affluent water, thereby substituting scarce fresh water resources which, in turn, can be used for other purposes.

7. Conclusions

1. Bio-saline biomass production is an appealing option based on a clear vision.
2. However, ODE’s view on the productivity and viability of bio-saline (agro) forestry systems seems rather optimistic.
3. At best biomass will be a co-product resulting from the management of restored natural areas
4. Its contribution to the Dutch demand for biomass will be limited.
5. It will require a lot of work and extensive international collaboration to develop the appropriate (agro) forestry production systems and to test these concepts in reality in a range of (salt) conditions, which will require huge funds and a long-term commitment by research organizations, governments and the industry.
6. To establish new woodlands under such adverse site conditions will be quite an achievement in itself, with great benefits to society.
7. Their main asset will be the upgrading of wastelands, previously considered valueless, and improving the ecology and living conditions at a landscape level (‘greening the desert ‘)
8. The afforestation of abandoned agricultural lands and of degraded lands not affected by salt will be a more viable option, contributing more to the development of the emerging biomass market. In other words: dedicated biomass production has better chances for success in less hostile environments.
9. Marginal sites are marginal for a reason: they do not offer the best opportunities for a substantial increase in productivity / cost reduction and increase the silvicultural risks considerably.

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Annex 1
Provisional database on salt tolerant tree species

Acacia
Acacia ampliceps (Maslin) (Qureshi and Barrett-Lennard, 1998)
Salinity: Grows successfully in highly saline (ECe > 15 dS/m), sodic and alkaline soils (pH values up to 9.8), but is intolerant of acid soils and water logging. The growth is reduced at salinity levels ECe 10-15 dS/m. Fagg and Stewart (1994) report that this species is suitable for planting on alkaline/saline soils, where it has access to brackish groundwater.
Fuel: calorific value of sapwood: 18.9 to 19.9 MJ/kg.
Planting: The rows should be 2-3 meter apart with plants also 2-3 meters apart (1600-2500 trees/ha). It can spread by root suckering resulting in dense stands.
Production: There is little data available on the productive capacity of this species. A field trail in Sind indicates that 2 year old trees at a density of 2500 trees/ha (2 x 2 m) had an average weight of about 23 kg/tree (i.e. 5.7 tons/ha per year) (Qureshi and Barrett-Lennard, 1998)

Acacia nilotica (L.) Willd. ex Del. (Qureshi and Barrett-Lennard, 1998)
Salinity: can tolerate moderately saline (ECe = 8-15 dS/m) and sodic conditions (SAR = 25) as well as soils with a hard pan. 40% growth reduction at an ECe of 8 d/Sm (Singh *et.al.*,1991). It is tolerant to alkalinity up to pH values of 10. Relatively tolerant to water logging. The water use efficiency with saline water (EC = 10.4 dS/m) irrigation lays between 3.6 and 5.0 Mg/ha/m (Minhas *et.al.*, 1997).
Fuel: calorific value of sapwood: 20.1 to 20.7 MJ/kg.
Planting: Furrows 10 meter apart and distance between plants: rotation 20 years 8-10 meters (125-100 trees/ha) and rotation 7-10 years 3-5 meters (333-200 trees/ha).
Productivity: With a rotation of 20 years and stem number of 100 to 125/ha wood production varies between 4 and 15 m^3/ha (not including biomass removed due to lopping). A fuel wood yield of 13 tons/ha from cuttings of side branches during a 40 month period is reported by Singh et. al. 1993. In the three years after establishment in a plantation with three years of furrow saline irrigation (EC = 10.4 dS/m) biomass yield can be 7.9 tons/ha dry weight (Minhas *et.al.*, 1997).

Eucalyptus
Pepper and Craig (1989) tested 12 *Eucalyptus* species. The best survival, health and growth of species at high soil salinities was by *E. occidentalis* Endl. (Provenance: Near Borden, WA) , *E. sargentii* Maiden (Provenance: Near Wyola, WA) and *E. platypus* Hook. var. *heterophylla* Blakely (Provenance: Como, Perth, WA). These species resisted ECe (electrical conductivity of saturated soil extract) values greater than 30 dS/m.
On saline sites in Australia, the establishment of wide spaced eucalypts allows significant grazing value while providing a resource for wood products. When tree rows are spaced 20 m apart (100-150 trees/ha) and oriented north-south it maximizes inter row exposure to sunlight and also increases water use which helps lower the underlying water table (Dooley, 1995). On mild (EC = 2-10 dS/m) to moderately (EC = 10-30 dS/m) saline sites eucalypt woodlots can be planted usually 500 to 1000 stems per hectare (Dooley, 1995).

Eucalyptus camaldulensis (Dehnh.)
Salinity: data on salt tolerance of this species is rather confusing. This may be caused by the large variation between provenances. Marcar *et.al.* (2003) report a number of CSIRO clone provenances (15272, 14007, 15024, 15195, CML512) that show good survival and considerable height and diameter growth on a moderate saline soil (root-zone ECe 4-8 dS/m). In this field trial the height of the trees ranged from 2.44 to 3.41 m and the dbh ranged from 3.0 to 5.0 cm after 6 years of growth.
Fuel: calorific value of sapwood: 20.5 MJ/kg it is also good for charcoal. The wood of young trees (dbh < 20 cm) has a density of 650 kg/m^3.

Planting: The trees are usually planted with 1600 trees/ha (3 x 2 meter).
Production: The species grows quickly. The average yields vary between 10 and 25 m^3/ha/year. The species is suitable for coppicing. It can be harvested six times in a 7-10 year coppice rotation. *E. camaldulensis* is a good agro-forestry tree when widely spaced, but shows heavy competition with crops for moisture and nutrients.

Prosopis
Beneficial effects and potential uses of *Prosopis* species are: agroforestry systems, control of soil erosion, sand dune stabilization, desalinization, prevention of salinisation, nitrogen fixation, recycling of nutrients. Prosopis can grow in a soil salinity regime up to sea water salinity. All species of Prosopis can tolerate ECe = 10 dS/m salinity with no reduction of growth. In India the most common Prosopis species are *P. juliflora* and *P. cineraria*. These species are used for the revegetation of salt lands. Prosopis growth on salty soils results in their amelioration to such an extent that it can even be used for arable farming after removing Prosopis trees (Singh and Singh, 1992).
Agro-forestry*:* The potential of Prosopis leaves, seeds and pods has been vastly underestimated. The pod yields varies considerably since there are no well established cultivation standards. Pod yields of less than 2 tons/ha and up to 8 tons/ha in optimum circumstances have been cited. Many rangelands in the semi-arid areas produces less than 2500 kg/annum of pasture biomass of which only 200-400 kg is harvested by grazing cattle (Dutton *et.al.*, 1992).
Drawback*: Prosopis* must not be grazed when pods are falling because of the spread of seeds through the faeces of cattle and other ruminants which might result in its spread as an unmanageable weed. However, within tree plantations Prosopis is rather easy to be managed (Dutton *et.al.*, 1992).

Prosopis cineraria (L.) Druce (Qureshi and Barrett-Lennard, 1998)
Salinity: Grows successfully in highly saline (ECe > 15 dS/m) and alkaline soils (pH values up to 9.8). It is highly drought tolerant; its taproot can reach groundwater at 20 meters depth.
Fuel: It is an excellent fuel (calorific value of sapwood: 20.9 MJ/kg), and also gives high-quality charcoal (5,000 kcal/kg).
Planting: Furrows 10 meter apart and distance between plants: in 20 year rotations 8 to10 meters apart (125-100 trees/ha) and in 7 to10 year rotations 3 to 5 meters apart (333-200 trees/ha). If not planted with the furrow method, initial spacing of 2 x 2 m is recommended. Annual yields of stacked firewood is 3 m^3/ha. The heartwood is very hard and heavy (769-945 kg m^3).
Production: Under favorable conditions trees can reach a height of 7 meters in 11 years time (60 cm/year). Yields of 3-5 m^3/ha per year are common.
Agro-forestry: Due to its deep root system, mono-layered canopy and ability to fix atmospheric nitrogen P. cineraria is extensively used as an agro-forestry tree throughout arid and semi-arid India. The tree has a boosting effect on the yield of crops growing in its vicinity. The crops draw their moisture and nutrients from the top 50-60 cm of soil while the tree gets its nutrients from a deeper horizon. In addition, the tree provides shade to crops during summer (Dutton *et.al.*, 1992). The tree is favored for agro-forestry as it fixes large amounts of nitrogen and does not affect growth of plants under the canopy. The tree coppices readily.

Prosopis juliflora (Swartz) D.C. (Qureshi and Barrett-Lennard, 1998)
Salinity: Grows under conditions of moderate to high salinity (ECe = 8 - >15 dS/m) and sodicity (SAR = 25 - >45), high alkalinity (pH values up to 9.8) and intermitted flooding. Singh and Singh (1992) report that *P. juliflora* still has a considerable height growth and survival on a slightly saline (EC = 0.89 and 2.84 dS/m) and very alkaline soil (pH 9.3 and 10.4 respectively).

It can be quite successful in lowering water tables on dense saline-sodic soils with shallow groundwater. Plantations can be grown with irrigation with saline groundwater or even sea water. However, under these conditions a 25% reduction in shoot extension and biomass production with irrigation water of EC 30 dS/m seems likely. Fagg and Steward (1994) report that the production is decreased by about 25% as the soil pH increases from 8 to 10.5.
Fuel: The generally crooked stems and branches make good firewood with a calorific value of: 18.9 to 19.9 MJ/kg and provide excellent charcoal. Charcoal from *P. juliflora* wood is used extensively in the USA as barbecue fuel; about 30% of the charcoal sold for this purpose originates from *P. juliflora* from the Sonora Desert in northern Mexico.
Planting: Has a good capacity to regrow after coppicing. It also spreads by making suckers. Thinning and pruning of the trees is extremely important for obtaining a thick straight trunk and for developing shade trees. Next to this it is necessary to keep the stands accessible and to prevent it from becoming a weed. Spacing depends on the use intended for the trees. In South America when grown for fuelwood, a spacing of 2 x 2 m or wider is used. In agro-forestry systems in association with grasses and other crops, the spacing may be up to 10 x 10-15 m. When the emphasis is on seed pod production, the spacing used is usually 5 x 5-10 m.
Production: It yields about 5 kg of dry wood per plant per year. The density of this wood depends on plant age; it is initially relatively light (650 kg/m^3 in year 1) but increases in density with time (950 kg/m^3 in year 10). On a 15 year rotation the expected yield of fuelwood is 75-100 tons/ha (i.e. 5-7 odt/ha/year); on a 10 year rotation this may be 50-60 tons/ha (i.e. 5-6 odt/ha/year). In India a planting of 2500 plants/ha gave about 13 odt/ha from cut side-branches after 40 months of growth. Singh and Singh (1992) report the growth and biomass production of *P. juliflora* on a ten-year-old plantation in India (pH = 10.4). The tentative biomass production in ten years was 260 odt/ha. The height was 12.9 m, the DBH 12,5 cm, bole weight 112.6 kg/tree and the branches and leaves weight was 43.2 kg/tree. (In comparison: Acacia nilotica 215 odt, *Eucalyptus tereticornis* 188 odt and *Casuarina equestifolia* 148 odt/ha.). *P. juliflora* planted at 10,000 plants per hectare on a high alkaline soil resulted in an annual increment of 47 odt of biomass each year with a rotation of 7 years. The annual increment in a plantation with 5000 plants per ha under the same conditions was 28 tones per ha (Singh and Singh, 1992).
Drawback: *P. juliflora* is an aggressive species it is difficult to eradicate and because it may eliminate native species, it should be only sown or planted in arid problematic areas, where soils must be recovered or protected from erosion (Singh and Singh, 1992).

Prosopis flexuosa (D.C.) is regarded as an especially attractive species for the productive recovery of arid and salt-affected areas. The study of Catalán *et.al.* (1994) has shown that seedlings of this species could be used for afforestation of salt-affected areas, because the salt tolerance at seedling stage appeared to be greater than at germination stage. (Seeds from 2 areas 1700 and 900 m above sea level) Salt concentrations ranged from 0 to 0.4 M NaCl.

Casuarina
Casuarina equisetifolia Forst. (Qureshi and Barrett-Lennard, 1998, Vimal and Tyagi, 1986, Midgley *et.al.*, 1983)
Salinity: Grows in calcareous and slightly alkaline soils (pH values up to 10), where it withstands salinity but not water logging. It can survive salinities of 56 dS/m under drained but not waterlogged conditions this salinity level equals that of sea water. A decrease in height and diameter of 16-18% is reported if irrigated with saline water EC = 9-10. It can tolerate drought for 3 months. It grows well on sandy soils near the coast where it can withstand salt-laden wind.
Fuel: The wood ignites readily even when green, and ashes retain heat for long periods. It has been called 'the best firewood in the world' and also produces high-quality charcoal.

The calorific value of sapwood is 20950 kJ/kg and that of the charcoal exceeds 7 000 kcal/kg. Density 1000 kg/m^3.
Planting: Plantations of 2000 trees/ha are commonly used but some farmers plant up to 8 000-10 000 stems/ha when fuel wood and small poles are the required product. Pruning is necessary up to 2 m to make plantations accessible for maintenance.
Production: Volume yield is maximum with a rotation of 15 to 20 year (7-10 m^3/ha per year) or 30 years (6-18 m^3/ha/year). Plantations are usually managed on a rotation of 7-15 years.
In India, a 6-8 year old plantation of C. *equisetifolia* on a saline soil produced about 15 tons of fuel wood and small timber per hectare.
On this same soil *Acacia nilotica* produced about 20 tons of wood and *Prosopis juliflora* produced 25-30 tons of wood. It coppices only to a limited extent and best results are obtained when cut young. Under favorable conditions, early growth rates are about 2 m/year in height and the trees have good form in cultivation. On favorable sites, it can yield an annual increment of 15 m^3/ha of wood in 10 years. In India, plantations using 1 x 1 m or 2 x 2 m spacing on 6-15 year rotations yield 8-13 tons/ha/year. Dry weight per tree ranges from 15 to 25 kg at 3 years of age, depending on site quality. In South China, where an estimated 1 million hectares in shelterbelts along the coastal dunes have been established since 1954, heights of 7-8 m and diameters of 5-7 cm are achieved in about 4 years. The rotation length ranges from 4-5 years for fuel wood and 10-15 years for poles. Mean annual increments usually fall in the range of 4-5 m^3/ha per year.

Casuarina glauca (Sieb.) (Midgley *et.al.*, 1983)
Irrigation is required to establish trees in desert areas. Moderately fast growing: at the age of 7 years, the tree reaches an average height of 5 m with a 72% survival rate.
Fuel: The wood has a calorific value of 4 700 kcal/kg, splits easily, and burns slowly with little smoke or ash. Can also be burned when green. Produces excellent charcoal. After 4 years, trees begin to shed about 4 t of cones/year.
Production: By the age of 12 years, a yield of 295 m^3/ha of wood and 34 tons/ha of green foliage is expected. This corresponds with a biomass production of 24 odt/ha/year. In Israel, *C. glauca* outperforms other casuarinas, reaching 20 m in 12-14 years, even on saline water tables. Coppices easily and produces root suckers vigorously. Inoculation of seedlings with symbiotic nitrogen-fixing bacteria is recommended when introducing the species to new areas.

Tamarix
Salt cedar (*Tamarix spp*.) is a deep-rooting deciduous shrub/tree that is easily propagated from cuttings. Over 50 salt-tolerant species found on seacoasts and inland deserts throughout the world show considerable promise for shelterbelts, hedgerows and erosion control as well as the rehabilitation of saline wastelands (reducing saline water tables) and sand dune stabilization. *T. ramosissima* (tolerates up to 20-25 dS/m) and related species are being used in northwestern China to stop desert expansion and increase agricultural productivity with direct economic benefits from much-needed timber and fuel in these low-vegetative environments. Field tests suggest that some of the more productive species, *T. aphylla, T. chinensis* and *T. nilotica*, can be irrigated with seawater. *T. stricta*, native to the Middle East, has the desirable qualities of rapid growth and uniform branching with the formation of dense canopies (weedy tendencies) (Bio-saline awareness project, 2005; Hoek, 2004).

Tamarix aphylla(L.) Karsten (Qureshi and Barrett-Lennard, 1998).
General: Also known as *Tamarix articulata* or *Tamarix orientalis*. It is a large shrub or small coniferous-looking tree, which grows to a height of 10-15 meters.
Salinity: It can tolerate high levels of salinity and sodicity. It is a common tree of salt-affected wastelands.
Fuel: *Tamarix* is slow to catch fire but has good burning quality. The wood can be used to prepare charcoal (calorific value, 4835 kcal/kg).
Planting: Plants are established in rows 3 meters apart , with plants at 2 meters apart within the rows. Under natural conditions, the crop is harvested in a 20-year rotation. However, under irrigated conditions, this time can be reduced to 10-12 years. Weeding is necessary to facilitate proper growth at the early stages of establishment but eventually its litter suppresses the weeds. Drastic thinning is done when the plants have grown for over 2 years to get 37-50 trees/ha. Pruning is necessary to prevent development into a shrub with many weak main stems,which are subject to splitting and breaking off at ground level.
Production: Wood production of 5-10 cubic meters per hectare per year have been reported.
Drawback: Salt drip from the leaves kills all ground vegetation beneath the tree and together with its salt litter it increases the salt concentration in the soil. Planting op the trees under natural circumstances might for this reason result in a decrease in biodiversity in the area where it is planted. It can act as a aggressive weed.
The species has extensive surface roots, which makes it unpopular for intercropping due to excessive competition for water and nutrients with crops.

Leucaena
Leucaena leucocephala (Lam.) de Wit (Qureshi and Barrett-Lennard, 1998)
General: *L. leucocephala* is a fast growing, tropical leguminous tree that originated from central America. The species is planted for soil improvement, reforestation, fire breaks wood and animal feed. The tree as a whole is used in alley cropping, as an over story plant for shade loving crops and in reforestation. The foliage is used as mulch or is incorporated as green manure. *L. leucocephala* is also a prime candidate for various reforestation programs because it not only encourages growth of hardwoods, but it can also be used to choke out aggressive grasses like *Imperato* that take over barren lands left behind by slash and burn cultivation. The species is also highly valuable as fodder for ruminants (Anthraper and DuBois, 2003).
Salinity: Grows well on light textured saline soils that are well drained. However, it is sensitive to water logging. In irrigated sand and gravel cultures, water with EC 9-10 dS/m did nod adversely affect growth. It grows on soils with a pH of 5.5 to 8.
Fuel: calorific value of sapwood: 18855 to 19903 kJ/kg.
Planting: Plantations of 2500 to 5000 trees/ha are commonly used.
Production: In general yields of less than 15 m^3/ha per year are considered poor. For fuel wood plantations a short rotation of 2-3 years is practiced. In general yields will be greater for coppice regrowth where weed competition no longer exists and existing root systems are well established. Coppice shoots in 1.5 year grow equal to 3 year old original trees (Vimal and Tyagi, 1986). One ha of *L. leucocephala* foliage can produce about 500 kg of nitrogen roughly equivalent to 2500 kg ammonium sulfate.

Parkinsonia aculeata L. (Qureshi and Barrett-Lennard, 1998)
Salinity: Grows well under conditions of high salinity, but is sensitive to waterlogged conditions.
Fuel: The wood is considered moderately hard, heavy and brittle and is used especially for fuel wood.
Production: It is a relatively fast growing tree.

Annex 2
Salinity measures, units and classes

Most salinity measures use electrical conductivity to estimate salinity of soil and water. These measures are cheap and easy to do, and can even be done (with some care) in the field.
To understand the 'saltiness' of a salinity reading, it makes a big difference to measure soil or water properties, the way in which it was measured (or estimated in most cases), and the units which were used. For example, moderately salty soil could be presented as 600 mS/m (ECe), 125 mS/m (EM-38 hor), or 60 mS/m (EC1:5 (w/v) loam).

Salinity measures include electrical conductivity of a solution or soil and water mix, weight of salts in a given amount of water, and the quantity of molecules of salts in a solution. Each of these measures have particular uses. A popular measuring tool is the EM^{3}8 (ElectroMagnetic Induction Meter).
Units includes grains per gallon, milligrams per liter, milliSiemens per meter, deciSiemens per centimeter and many more.
Classes range from non-saline to extremely saline. In the Australian standards which are described here and which are often used or referred to in international publications, the salinity classes refer to plant tolerances to salt.

Note that the salt tolerance of plants is affected too by factors other than the salinity reading: e.g. by water logging, soil type, sodicity, depth to water table, salinity of the water table, rainfall and other factors. Water logging interacting with salinity is probably the most important influencing factor on most sites.

Soil Salinity

EC 1:5
Soil samples can be measured by the '1:5' w/v method: one part by weight (g) air dried soil to five parts by volume (ml) distilled water, which is agitated then allowed to settle. The solution is measured for Electrical Conductivity (EC 1:5). This measure is used to allow for soil texture differences. Sand particles will not hold as much salt from the soil water as will clay. Therefore, sand will give apparently lower readings than from clay, even though the salt concentration in the soil water is the same.[126]

ECe
The Electrical Conductivity of a saturated soil extract (ECe) is the most useful and most reliable measure of salinity for comparing between soil types. The 1:5 reading can be used to estimate the ECe. Conversion factors from EC 1:5 to ECe are given in table 4. Note that these are guidelines - the actual conversion figure can vary quite widely for particular soils. Note also, that proper measurement of the ECe is a laboratory technique, and an expensive one.
A technique for converting reported ECe to EC 1:5 can be used in the reverse direction for converting EC1:5 (less than 350 mS/m) to ECe. The technique is based on a limited data set, and care should be taken extrapolating the technique.

[126] Some field surveys estimate an EC 1:5 based on volume: volume (v/v). That is, one scoop of soil to five scoops of water. This can lead to large errors in reporting in comparison with the w/v method and between samples from the same site, especially for clay soils. It is important to 'calibrate' any EC 1:5 estimated from the v/v technique against the w/v estimated technique. Unfortunately, this is often not the case. The technique is not recommended for critical measurements.

Table 4: Conversion factors to estimate ECe from EC 1:5 (w/v) in relation to soil texture

Soil texture	**Multiply EC 1:5 (w/v) by factor**	**Example**
Sand	15	10 mS/m (EC1:5) = 150 mS/m (ECe)
sandy loam	12	10 mS/m (EC1:5) = 120 mS/m (ECe)
loam	10	10 mS/m (EC1:5) = 100 mS/m (ECe)
clay loam	9	10 mS/m (EC1:5) = 90 mS/m (ECe)
light/medium clay	8	10 mS/m (EC1:5) = 80 mS/m (ECe)
heavy clay	6	10 mS/m (EC1:5) = 60 mS/m (ECe)

EM38
Another measure, which is increasingly becoming common, is the EM 38 or EM 31 using Electro-Magnetic induction. EM readings are useful to compare within and between similar sites, but use EM readings with caution unless they are calibrated against soil salinities (ECe for preference) and other influencing factors. The EM38 is quite an expensive unit, but relatively easy to use in the field, and gives estimates of salt concentrations at the root zone.

Water Salinity
Nearly all testing methods use electrical conductivity. The results are reported in various units, although the official standard is *milli-Siemens per meter (mS/m)*. Other units, which are still used are: deci-Siemens per meter (dS/m); 'parts per million' (ppm), which can be thought of as the same as milligrams per liter (mg/L); osmotic potential (OP); Percentage of Total Soluble Salts and grains per gallon (gpg).

Conversion factors:
- mS/m x 0.01 = dS/m (deci-Siemens per meter). For soil or water measures
- mS/m x 5.5 = mg/L = ppm (assuming sodium chloride is the only salt present; this figure increases with other common salts and may be as high as 6). For water.
- mS/m x 0.42 = gpg (Grains per Gallon. This conversion is rough, and the factor depends on salts present). For water.
- mS/m x 0.0034 = % TSS in soil from a EC1:5 (w:v) measure (conversion varies based on salts present). For soil.
- mS/m x 0.00055 = % TSS in water from an ECw (conversion varies based on salts present). For water.
- mS/m x 10 = mmol/dm^3 NaCl = mmol/liter NaCl. For water.

All these salinity measures are trying to relate plant growth to a certain salinity level. Some of these measures are more useful in predicting plant growth (for instance EM38), others are cheap and easy (eg EC 1:5 v/v). The ECe figures are widely accepted by research and are 'standards', but the groundwater, EM38 and EC 1:5 measures can vary between sites for the same apparent salinity.

Table 5: Salinity classes for plants. Note these are specific to soil or water measures

Class	**ECe (dS/m)**	**ECe (mS/m)**	**ECgw (mS/m)**	**EM-38 hor (mS/m)**	**NaCl (sol. mmol/l)**	**EC 1:5 (w/v) loam (mS/m) approx**	**EC 1:5 (v/v) loam (mS/m) approx**	**Total Dissolved Solids (TDS %)**
	Soil (a)	Soil (b)	Water (c)	'Soil' (d)	Water (e)	Soil (f)	Soil (g)	Water
Non-saline	<2	<200	<500	<50	<20	<20	<40	<0.275%
Slightly	2-4	200-400	500-1000	50-100	20-40	20-40	40-80	0.275-0.55%
Moderately	4-8	400-800	1000-2000	100-150	40-80	40-80	80-160	0.55-1.1%
Very	8-16	800-1600	2000-3000	150-200	80-160	80-160	160-320	1.1-1.65%
Extremely	>16	>1600	>3000	>200	>160	>160	>320	>1.65%

(a) Based on USDA 1954 categories: Used by CSIRO Canberra and others in Australia.
(b) Units used in Western Australia
(c) Groundwater from within potential rooting distance of plant (bores). Suitability for 'tree' growth.
(d) From D Bennett and R George, DAWA Bunbury.
(e) 'Irrigation' water used in pot trials.

Note that the tree species mentioned in table 3 under the category “species moderately sensitive to salt” fall in the salinity class “Extremely saline” (dS/m > 16). For tree species a further classification can be useful, e.g. into moderate salt tolerant species (16 –25 dS/m); and salt tolerant species (dS/m > 25). Seawater has an electrical conductivity of >45 dS/m.

Soil texture effects on ECw/v measures and salinity class
Because ECw/v measures are very commonly used to estimate salinity from field samples, an additional table 5 is included. These measures are usually done in a laboratory.
Note that these values are estimates of salinity in the plant root zone. When salinity is measured from the surface layer, the estimate of salinity at the root zone may be incorrect. Note also, that the EC1:5 is one part soil by *weight* to five parts of water by *volume*. When the EC1:5 volume: volume technique is used in the field, it is prone to large errors.

Table 6: Soil salinity measurements using EC1:5(w/v) in mS/m

Salinity Rating	Sand	**Sandy loam**	**Loam**	**Clay loam**	**L/Med Clay**	**Heavy Clay**
Non-saline	<13	<17	<20	<22	<25	<33
Slightly	13-26	17-33	20-40	22-44	25-50	33-67
Moderately	26-52	33-67	40-80	44-89	50-100	67-133
Very	52-106	67-133	80-160	89-178	100-200	133-267
Extremely	>106	>133	>160	>178	>200	>267

http://agspsrv34.agric.wa.gov.au/environment/salinity/measurement/salinity_levels_for_revegetation.htm

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UNDERSTANDING THE FACTORS WHICH DETERMINE BIOMASS AVAILABILITY

Marieke Meeusen and Frank van Tongeren, May 2005. Follow-up BUS report, WUR-LEI

1. Reason for this study

Many studies have been devoted to understanding the potential amounts of biomass present at various levels. Several BUS tickets have been worked out in order to determine which portion of this potential biomass actually becomes available. These tickets make it clear that economic factors must also be taken into account in order to understand the amount of biomass that can actually be expected to become available. The BUS tickets that have been worked out also make it clear that the result of the economic analysis differs per biomass flow, per region etc. This is largely due to the alternative application of the biomass flow and the (economic) objective of the (potential) provider of the biomass. It is therefore clear that - if we are to obtain any real insight into the amount of biomass available - the already existing studies must be expanded to include economic factors. In addition, the amount of potentially available biomass should also be evaluated within the context of renewable/sustainable energy policy. After all, the ultimate goal of using biomass as a source of energy is to contribute to a sustainable society. In other words, we need to obtain a better understanding of the factors which determine whether, and to which extent, the potential amount of biomass can become available: a) practically speaking, and b) in a socially responsible fashion.

2. Goal

This paper answers the following questions:
Which factors influence the availability of biomass? The factors considered do one of two things: a) they determine social support/acceptance for describing the biomass as being a 'sustainable' source of energy b) they determine the economic feasibility. Both types of factors differ per flow of biomass.
Which (economic) models and studies can be used to supplement the existing studies in order to obtain more insight into the conditions, which determine whether the potentially available biomass actually becomes available?

The follow-up results in a phased plan or checklist, which lists the factors that can provide insight into the actual availability of 'socially responsible' biomass, per biomass flow and per region. The checklist makes it possible - on the basis of a potential quantity of biomass - to (quickly) find out which part of that biomass will actually become available. The checklist is generally applicable for all biomass flows in all regions of the world. The checklist also contains tools, which can be useful in further working out these issues.

The checklist focuses on several types of biomass flows, namely:
1. biomass cultivated specifically for bio-energy;
2. the residual flows which become available (at the production level) during the production of biomass (e.g. straw as a by-product of grain production);
3. the residual flows which become available (at the processing level) while processing biomass (e.g. flakes, cacao shells).

Other flows - such as wood, residual materials, which become available during tree farming and aquatic cultivation of biomass - are not dealt with in this paper.

3. General approach: relevant themes

The availability of 'socially responsible' biomass demands a broad-based approach. This issue involves new applications in new markets, with regard to which sustainability is often a very important factor. When discussing the position of biomaterials, it therefore makes sense to emphasize the 'sustainability' factor. A second factor, which determines the actual availability of biomass for bio-energy is its competitive position compared to other applications and the motives/considerations involved in that comparison. Finally, the prices and demands set by the market will also influence the economic feasibility. We are therefore dealing with three themes when it comes to determining the actual availability of sustainable biomaterials within the context of the bio-energy market.

- Social support/acceptance and sustainability;
- Market analyses;
- Economic analyses.

These three themes are not independent of each other but are rather interconnected.

4. Social support

4.1 Introduction

The bio-based economy is driven by developments on the supply side. In the Netherlands, for example, the sale of residual flows in existing markets (in particular for cattle feed) is running into limitations. These limits are determined by the requirements related to food safety and the (diminishing) size of the livestock. At the same time, there are developments on the demand side which determine the demand for bio-based products. The major issue in that respect is the assumed contribution to a sustainable society. The demand for bio-based products is stimulated by such factors.

Two important aspects must be kept in mind when considering the position of sustainable products:

- Sustainability alone is usually not enough to ensure access to a (large) market. It should be emphasized that such products must (also) score well with regard to the 'normal' quality requirements (ease-of-use, functionality, etc.). The sustainability factor must be an added benefit compared to the alternative and cannot replace the normal requirements.
- The marketing of sustainable products requires social support. When is a product considered to be sustainable? Such questions can only be answered via feedback from and interplay with social forces. Within the context of the bio-energy discussion, we have seen that a one-sided focus on the CO2 contribution is not sufficient to elevate bio-energy to the role of a 'sustainable' source. In other words, the import of bio-energy must certainly be viewed within a broader sustainability perspective. The 'people' component of sustainability also needs to be considered. A stakeholder analysis and dialogue can be very helpful for obtaining insight into the relevant issues regarding sustainability and the positioning of various products. This provides insight into the issues considered relevant by stakeholders. In this way, social support can be mobilized for the strategy that needs to be followed, which will minimize the risk of market failures.

4.2 Tools, checklist methods

In determining social support, the first step is the stakeholder analysis, followed by the stakeholder dialogue. In this paper, the stakeholder analysis is worked out further.

A large variety of stakeholders are involved in sustainability issues. Four different groups can be differentiated in this regard, each with its own role, responsibility and importance:

- The business world, focused on organizational continuity and the (financial) profit required to ensure continuity;
- Government, focused on the interests of its citizens and the shared interests of society;
- Nongovernmental organizations, focused on the (sub) interests of a specific group of members of society;
- Knowledge oriented institutes and bodies, focused on contributing to the social debate with facts and knowledge.

Of course, it is impossible to involve all the stakeholders in the decision-making process related to all the (strategic) sustainability issues. A selection must be made. In making a selection, two criteria can be of help:

- The degree to which the stakeholders can influence matters;
- The degree to which the stakeholders have an interest in the matter.

Table 1: Positioning of stakeholders with regard to influence and involvement

	Little influence	**Much influence**
Little interest	A	B
Much interest	C	D

Cell A includes stakeholders who do not have much interest in the subject and also have little influence. The stakeholders in cell B also have little interest but do have considerable influence. The stakeholders in cell C have much interest in the subject but only limited influence. Cell D includes stakeholders who have a considerable interest in the matter as well as influence. It should be evident that the stakeholders in cells B, C and D - in particular - are important. Their opinions and wishes should also be taken into account. The stakeholders selected are then asked under which conditions they would consider biomass for bioenergy to be a sustainable solution, which underlying problems they think can be solved in this manner, and in which areas solutions might be found for possible bottlenecks. In selecting the relevant sustainability issues, the checklist used by Ten Pierick and Meeusen (2004) may serve as an aid. This checklist is included as annex 1. It includes all the sustainability issues which - from the Triple P viewpoint - could play a role in sustainable agro-food chains. The stakeholder analysis provides a description of the limiting conditions under which biomass for energy could really be considered to be 'socially responsible'. An example for imported biomass has been worked out further in the box below.

Box 1: Example of a list of limiting conditions under which stakeholders consider the import of biomass to be 'socially responsible'

Planet (environment)

- CO_2 emission throughout the entire chain (C cycle).
- Other emissions to air, water and soil throughout the entire chain.
- Other activities with environmental impact throughout the entire chain.
- Biodiversity.
- Use of space.

This implies that the entire chain - from production up to and including consumption - must be improved with respect to all the various environmental themes. Attention should also be paid to the use of crop protection agents, artificial fertilizer, water and energy in the production phase. In doing so, one must consider not only the environmental effects on a local scale but also the effects on a global scale.

People (social-cultural)

- Development of rural areas and employment.
- Transparency and validation of information throughout the chain.
- The personal responsibility of citizens and businesses with regard to climate change and emissions.

With regard to the people-based component, the contribution to the development of rural areas, in particular, is mentioned. Bio-energy becomes an attractive option when it contributes to employment

both quantitatively and qualitatively.
Profit (economic aspect)
- Price of energy.
- Security of supply.
- Incomes and living standard for links in the chain.
- Developing and expanding knowledge.
- Innovation.

Profitability is taken into account for all links in the chain. Bio-energy is an attractive option only if it contributes to the profit of actors in the chain and preferably contributes *more* than other activities. At the same time, the goal is to keep supply costs as low as possible in order to be able to offer the consumer energy at a price not much greater than normal. In this respect, consideration must also be given to the impact on other parts of the world. With regard to the profit aspect, for example, the development of knowledge for the Dutch economy is also a factor to be taken into account. Innovation and new technologies, which can lead to knowledge export are also considered positive.

5. Market analysis

5.1 Introduction

A farmer can utilize his land for various products, as he can choose from a wide range of crops to cultivate. These crops can also be sold in various markets. The same is true for the owner of residual flows. He can also choose from various applications. Quite often, a selection is made from several 'F applications': farma, food, feed, fuel. The various markets differ in many ways: size, sale price, quality specifications desired, supply amounts desired, continuity desired etc. An evaluation of the various options based on these aspects determines which application and which market provide the most attractive possibilities for the biomass produced or - in case of residual flows - the biomass for sale.

By obtaining an external perspective on the opportunities and threats concerned, one can obtain insight into the attractiveness of a particular market. At the same time, it's also necessary to obtain an internal perspective with regard to strengths and weaknesses in order to evaluate whether, and to what degree, it will be possible to benefit from or deal with opportunities and threats. Ideally speaking, the producer will compare the various options for his biomass flow and choose the option which best fits his company strategy. For the purchaser of biomass, this means that he should be aware of the fact that the farmer's production factors (land, capital and labor) can be used for a variety of applications, of which bio-energy is just one out of many. The same is true for the owner of residual flows. He also has a range of options for selling his residual flows, of which bio-energy is also just one option out of many.
The following question then becomes very relevant: how does bio-energy score in comparison with other markets? Economic attractiveness (see below) is thereby a very important factor. To a great degree, the behavior of economic actors is determined by the economic attractiveness of one alternative compared to another alternative.

5.2 Tools, checklist methods

The objective of a SWOT analysis is to provide insight per application area into the opportunities and threats, on the one hand, and the strengths and weaknesses, on the other hand - thereby making it possible to choose the most attractive market option. In the first place, the SWOT forms the basis for a set of Critical Success Factors, which must at the very least be complied with in order to successfully utilize the application in a given market. A company can then ask itself whether it is able and willing to go down that particular road.

The external environment analysis (opportunity and threat analysis) includes the macro-environment forces (demographic, economic, technological, political-legal and social-cultural) and significant micro-environment actors (customers, competitors, distributors, suppliers) that affect its ability to earn profits. The analysis results in two matrices: an opportunity matrix and a threat matrix:

Table 2: An opportunity matrix (Source: Kottler, 2003)

High success probability High attractiveness	Low success probability High attractiveness
High success probability Low attractiveness	Low success probability Low attractiveness

In the opportunity matrix the best marketing opportunities are listed in the upper-left cell; management should pursue these opportunities. The opportunities in the lower-right cell are too minor to consider. The opportunities in the upper-right cell and lower-left cell should be monitored for any improvement in attractiveness and success probability.

Table 3: A threat matrix (Source: Kottler, 2003)

High probability of occurrence High seriousness	Low probability of occurrence High seriousness
High probability of occurrence Low seriousness	Low probability of occurrence Low seriousness

The threats in the upper-left cell are major threats, because they can seriously hurt the company and have a high probability of occurrence. To deal with these threats, the company should prepare contingency plans that spell out changes it can make before or during the threat. The threats in the lower-right cell are very minor and can be ignored. The threats in the upper-right and lower-left cells do not require contingency planning but need to be monitored carefully in case they become more serious.

Once management has identified the major threats and opportunities facing a specific business; it can characterize that business's overall attractiveness. The following options are possible:

- An ideal business is high in major opportunities and low in major threats;
- A speculative business is high in both major opportunities and threats;
- A mature business is low in major opportunities and low in threats;
- A troubled business is low in opportunities and high in threats.

It is one thing to identify attractive opportunities but quite another to be able to take advantage of them. An internal environment analysis helps a business to do the latter. To carry out such an analysis, a business needs to evaluate its internal strengths and weaknesses. Table 4 gives a checklist for performing a strengths/ weaknesses analysis.

Box 2: An example of a SWOT for residual flows

The market orientation analysis reveals: (a) which application options are available for the product (b) the opportunities, threats, strengths and weaknesses per application. For example, a given residual flow may have two different potential applications, which differ with regard to market size, price and quality requirements. On one side of the scale, we find a market large in size and low in price, which requires a company to 'do little work'. On the other side of the scale, we find a market which is smaller in size, offering a higher price, which requires a company to invest time and energy in analyzing and developing the opportunities for unlocking the value of the residual product in order to provide a valuable new product for the purchaser (i.e. product development). It should be clear that the first market referred to will require a minimum investment of time and energy but will also provide the least reward. The latter market offers a more attractive pricing point, but requires the provider to invest time and energy in thinking about and developing new networks with new customers. The choices involved for a company are strategic ones: does the company wish to enter into new and less familiar markets with new networks, and is it prepared to invest the necessary time and money to do so?

Table 4: A checklist for performing strengths/weaknesses analysis (Source: Kottler, 2003)

	Performance	**Importance**
Marketing • Company reputation • Market share • Customer satisfaction • Customer retention • Product quality • Service quality • Pricing effectiveness • Distribution effectiveness • Promotion effectiveness • Sales force effectiveness • Innovation effectiveness • Geographical coverage		
Finance • Cost or availability of capital • Cash flow • Financial stability		
Manufacturing • Facilities • Economies of scale • Capacity • Able, dedicated workforce • Ability to produce on time • Technical manufacturing skill		
Organization • Visionary, capable leadership • Dedicated employees • Entrepreneurial orientation • Flexible or responsive		

6. Economic feasibility

6.1 Introduction

Once a (provisional) choice has been made regarding a market and application, the question of economic feasibility becomes very relevant. To answer this, a cost/benefit analysis is done. What costs are involved in marketing and selling the biomass flow and what are the benefits provided in return? Ideally, this analysis is carried out for the various application options, after which the economically most attractive option can be selected. The party requesting the biomass should be aware that he is also in competition with other possible purchasers for the same biomass.

A characteristic of biomass that deserves specific attention is the fact that it consists of several components, each of which may be interesting for specific markets. Ideally, a solution is found which optimizes the potential for all the components from a particular residual flow or from a particular crop. However, as it turns out, this aspect is not yet always taken into account in actual practice. Generally speaking, the economic player (the producer, processor) bases his economic actions primarily on the returns provided by the main product. The economic player remains focused on his core business. For him, the by-product is literally a by-product: it is something that is also produced on the side. For the potential purchaser of by-products, it is therefore also important to keep abreast of market developments for the (related) main products. After all, it is these main products that determine whether the by-product will or will not become available.

Generally speaking, the greater the purity of a product, the more interesting it will be for a specific application. However, the cost of obtaining the (pure) product will also increase with the degree of purity. A cost/benefit analysis is therefore definitely relevant here. Another related aspect is the mutual interdependence of the market potential for the various component products. In the final analysis, one strives to realize an optimum combination of market potential for all the component products that can be derived from the biomass. For example, if there is an option of realizing a pure biomass flow, which also provides a large amount of residual product with (much) lower market potential, the initial rosy perspective becomes much less attractive. It should be emphasized that the market potential for the various component products must be evaluated while taking into account the mutual interdependencies. The risk factor is also relevant here. If an entire array of biomass flows is dependent upon a single promising market - which is considered a risky one - then the perspective is less attractive than would be the case in a 'more secure' market. As a result, a choice is often made to deal with unlocking the value of a limited number of biomass flows.

6.2 Tools, checklist methods

The model 'Unlocking the Value of Organic Residual Flows' is a useful tool for evaluating which processes for unlocking the value of residual flows are the most attractive from an economic viewpoint. This involves an integrated evaluation of all the costs and benefits involved in processing the materials as well as the (various) resulting products. In doing so, the model identifies the conditions under which processes are economically the most attractive as well as the related sensitivity to pricing and the economic breakeven point.

The following illustration is an example of how the model can be helpful. It involves a comparison of two different options for unlocking the value of residual flows. The first option, A, involves a process which costs € 2 per unit of residual flow and which provides two products in a particular ratio. The second option, B, involves a more expensive process, which costs 5 € per unit of residual flow and which provides four products in a different ratio. The products from option B command a different price than the products from option A. The evaluation involves a comparison of costs and benefits for both options, whereby all flows are taken into account.

Table 5: Net benefits from unlocking the value of 100 kg of residual flow in € per ton

	Option A	Option B
Costs	200	500
Benefits	Fiber: 20 * 11 = 220 Protein: 10 * 12 = 120 Wastewater effluent: 70 * -1 = -70	Fiber A: 10 * 2 = 20 Fiber B: 30 * 3 = 90 Protein: 40 * 1 = 40 Coloring agent: 5 * 150 = 750 Wastewater effluent: 15 * -5 = -75
Total	70	325

Its clear that in the final analysis process B, although more expensive, is more attractive than process A, as long as there is a market for coloring agent B. If the market for coloring agent B disappears, then process A becomes more attractive than process B. This illustration shows how risky a particular choice can be and how great the influence can be of the sales opportunities for a particular product.

In the model 'Unlocking the Value of Organic Residual Flows', the user has the option of evaluating the possibilities provided by various products and processes (economically speaking) in greater detail. The model also makes it clear that the price of a product depends on market size: pricing elasticities are built into the model.

For the potential producer of biomass for bio-energy, the following question is central to the economic evaluation: how can I generate as much added value as possible with my (scarce) production factors (land, labor, capital). For the potential provider of residual flows for bio-energy, a different question is central to the economic evaluation: how can I market the residual flows as attractively as possible?

The answer will differ from company to company, depending upon the particular company strategy chosen. An economic analysis therefore requires an overview of all the costs and benefits for the player involved per alternative. For the producer, this means that various crops and marketing options must be compared with each other. For the owner of residual flows, this means that various marketing options for the residual flow are compared with each other.

7. An integrated approach: GTAP

An integrated global economic approach, differentiated per region
In the comparison between the various applications, economic attractiveness plays a decisive role. Production and consumption of biomass are driven by technical as well as economic considerations. Technical feasibility does not imply that new developments are actually taken into production, and long-term projections based purely on technological potential have time and again proven to be off-mark. The utilization of biomass potential for (bio)energy depends on a number of factors, including:

- Agronomic features, including land availability and growing conditions
- (supply) response of farmers, i.e. the decision to grow bio-energy relevant crops
- Technical substitutability of biomass energy for conventional energy sources
- Economic substitutability of biomass energy for conventional energy sources
- National and global policies
- Social considerations
- Environmental considerations

Economists and economic models have something to say about items 2, 4 and 5 on the above (non-exhaustive) list. Agronomic, biophysical and technical aspects are typically included in these models in a cursory fashion. Agricultural economists, however, have a tradition of including agronomic production features in their models, and recent developments in the EU attempt integrated modelling of economic, agronomic, environmental, climatic and social issues. (e.g. SEAMLESS and SENSOR, which are both so-called integrated projects sponsored by the FP6 of the European Union).
Key to fruitful long-term projections of biomass issues is a proper modelling of the supply side of biomass and a proper representation of the demand side for bio-energy. In both demand and supply, technical and economic considerations play a role, and therefore a multidisciplinary approach is warranted.

However, additional actions on the theme of 'bio-energy' remain necessary
The GTAP model is a global economy-wide model that covers worldwide production, consumption and trade. It is a general equilibrium model, based on the micro-economic foundations of production- and consumption behavior. It captures backward and forward linkages within each of the regional economies through an input-output structure. In the general equilibrium structure, both prices and quantities are endogenously determined as outcomes of the model after a perturbation of exogenous variables, such as policies, technological changes, taste changes etc.

Since its inception in 1992, the explicit aim of the GTAP project has been the lowering of entry barriers to global trade analysis. Much of the focus of GTAP is directed towards the analysis of agricultural policy and trade, but there are also applications in non-agricultural trade-related issues as well as environmental policy analysis. More recently, database development and modelling have also expanded in the direction of energy usage and climate change. Therefore, the GTAP modelling framework is a potentially useful starting point, but it would need to be adapted for the specific issues at hand (See Annex X)

Box 3: Further notes on GTAP

The project is now supported by a consortium of 18 national and international agencies and provides financial support as well as guidance to the Center of Global Trade Analysis at Purdue University (USA). The consortium includes some of the major players in global trade analysis (World Bank, WTO, UNCTAD). The GTAP website provides more information on the consortium, conferences, courses and other activities and is a repository of resources: http://www.gtap.org/. The current version of the database (version 6) has coverage of 87 regions, 57 commodity groupings and 5 primary factors (Land, Skilled and Unskilled Labour, Capital and Natural Resources), and is benchmarked to 2001 US dollar values. See Annex X for a country and commodity listing.

The main components of the database consist of bilateral trade, transport and protection matrices that link the country/ regional input-output (IO) databases. Although the commodity coverage has a deliberate agricultural bias with 12 primary agricultural sectors (8 food processing sectors, 1 forestry sector and 1 fishing sector), within the remaining commodity groupings, there is significant disaggregation of manufacturing, services and fossil fuel sectors. The database contains energy use data for 5 energy commodities (coal, oil, gas, petroleum commodities, electricity), and a special model version (GTAP-E) is geared towards modelling energy and climate issues (this model has been used extensively in the IPCC context).

Given its current low share in global energy use, the database does not include separate information for biomass energy.

8. Phased plan

8.1 Determine which sustainability issues are relevant

- Select the stakeholders who have influence on and an interest in the themes of sustainability, agro-food chains and bio-energy
- Be aware of the complex and inclusive nature of sustainability within the framework of the discussion on agro-ood – biomass – bio-energy. Use a checklist (Ten Pierick and Meeusen, 2004, for example)
- Together with the stakeholders, select the factors, which determine the social support base for the use of biomass for bio-energy.

Result: a list of sustainability issues, which determine the social support base for the biomass-bio-energy chain to be selected

8.2 Determine the critical success factors which determine whether the primary producer will or will not cultivate biomass for bio-energy

- Try to put yourself in the shoes of the potential provider of the biomass, in other words the farmer with land at his disposal on which he can cultivate various crops for various applications, which will provide him with various net yields;
- Determine the potential applications for the available production factors;
- Determine the strengths and weaknesses per application;
- Determine the opportunities and threats per application;
- Put yourself in the shoes of the farmer and choose the application you think he will choose;

- Determine what additional things you need to do, as a player on the demand side of the biomass equation, to make the bio-energy market (more) attractive for the farmer.

Result: insight into the critical success factors, which you, as a potential purchaser of biomass, can influence in order to make the bio-energy market more attractive for the primary producer

8.3 Determine the critical success factors which determine whether residual flows - at the level of the producers and processors - will or will not be utilized for bio-energy

- Put yourself in the shoes of the potential provider of the biomass: the owner of the residual flows (farmer or processor), who has products available which he can try to sell in various markets, each of which involve varying levels of investments and net returns;
- Determine the potential applications for the residual flow;
- Determine the strengths and weaknesses per application;
- Determine the opportunities and threats per application;
- Putting yourself in the shoes of the residual flow owner, choose the application you think he will choose;
- Determine what additional things you need to do, as a player on the demand side of the biomass equation, to make the bio-energy market (more) attractive for the owner of residual flows.

Result: insight into the critical success factors which you, as a potential purchaser of biomass, can influence in order to make the bio-energy market more attractive for the primary producer

8.4 Determine whether, as a potential purchaser of biomass, you wish to positively influence the critical success factors on the supply side in order to ensure that the potential biomass actually becomes available.

References

Kottler, P. (2003) **Marketing management, Prentice Hall**

Annex 1
List of sustainability issues, divided into Peaople, Planet and Profit indicators

Dimension	***Category***	***Aspect***	***Sub-aspect***	***Indicator***
People	Working conditions	Health and safety of workers	Safety	Reducing the number of worker accidents.
			Health	Reducing the number of sickness-related and other types of absenteeism related to working conditions.
		Secondary terms of employment	Training and education	Average number of hours spent on training as a result of this project.
			Worker facilities	An increase in the number of employees making use of (not legally mandated) facilities for realizing a better fit between their roles as private persons and as employees (for example via child care, parental leave, care leave etc.). An increase in the number of employees making use of (not legally mandated) facilities for assisting them in developing career opportunities or ending their active work career.
	General social themes	Norms and values	Emancipation	Reduction in number of complaints regarding unequal treatment.
			Human rights	Decrease in number of complaints regarding non-compliance with human rights. Reduction in number of complaints regarding forced labor and child labor.
		Transparency	Labeling and hallmarks	Increase in number of products with a label and/or hallmark.
			Reporting	Increase in number of GRI indicators included in annual report.
	Agro-specific social themes	Animal welfare	Animal health	Decrease in average number of days that animals are sick or wounded. Decrease in wastage percentage.
			Natural behavior	Increase in average number of days that animals can display natural (species specific) behavior.
			Accommodations	Increase in average space available per animal.
			Care	Decrease in number of instances in which animals are hungry and/or thirsty. Decrease in number of instances in which animals suffer from fear and/or stress.

Dimension	***Category***	***Aspect***	***Sub-aspect***	***Indicator***
People (continued)	Agro-specific social themes (continued)	Animal welfare (continued)	Care (continued)	Decrease in number of animals that undergo an amputation or other treatment for the sake of simplifying maintenance of the animals involved.
		Quality of local environment	Historic buildings	Increase in number of historic buildings and/or monuments which are restored to and/or maintained in good shape.
			Recreation	Increase in number of visitors to recreational facilities.
			Noise nuisance	Decrease in number of complaints regarding noise nuisance.
		Food safety	Food safety	Decrease in number of complaints regarding health and safety issues.
				Decrease in number of punishments and size of penalties imposed.
				Decrease in number of product recalls.
Planet	Compartments	Soil	Use of land	Decrease in amount of land used for production activities and mining/exploitation activities.
			Soil quality	Decrease in emissions of heavy metals.
				Decrease in emissions of other substances, which impact the environment.
			Soil erosion	Increase in cover percentage.
		Air	Air quality	Decrease in emissions of greenhouse gases.
				Decrease in emissions of gases, which negatively impact the ozone layer.
				Decrease in emissions of other substances, which impact the environment.
			Odor nuisance	Decrease in emissions of odor-causing substances.
		Water	Water use	Decrease in water usage.
				Decrease with regard to groundwater and surface water.
				Increase with regard to recycled and reused water.
			Water quality	Decrease in emissions of substances impacting the environment.
				Decrease in unintentional emissions of substances impacting the environment

Dimension	*Category*	*Aspect*	*Sub-aspect*	*Indicator*
Planet (Continued)	Environmental themes	Waste	Waste	Reduction in amount of waste.
				Reduction in amount of waste through waste prevention.
				Increase in waste processing.
				Increase in recycling of waste or materials.
				Reduction in amount of hazardous waste.
		Biodiversity	Biodiversity	Decrease in number of animal and plant species (IUCN Red List).
				Increase in amount of land in accordance with natural category target.
				Stopping activities in nature areas.
				Starting activities in nature areas.
		Energy	Energy consumption	Reduction in energy consumption (excluding fuel for transport).
			Energy produced by players themselves	Increase in use of energy produced by players themselves.
			Sustainable energy	Increase in use of sustainable energy.
		Crop protection agents	Emissions of crop protection agents	Decrease in number of locations negatively impacting the environment.
				Decrease in amount of crop protection agents.
		Raw materials, additives and other materials	Raw materials, additives and other materials	Decrease in amounts of raw materials, additives and other materials.
			Renewable raw materials	Increased use of renewable raw materials.
		Minerals	Mineral emissions	Reduction in degree of saturation.
		Transport	Transport	Reduction in fuel consumption for transport.
				Reduction in number of transport kilometers
	Other	Environmental awareness	Environmental awareness	Increase in overall amount spent on the environment.

Dimension	*Category*	*Aspect*	*Sub-aspect*	*Indicator*
Profit	Competitive strength	Ability to adapt to market conditions	Service	Increase in customer satisfaction regarding service.
			Responsiveness	Reduction in number of days between start of product development and market introduction.
				Number of product introductions.
		Efficiency	Employee productivity	Increased turnover per fulltime equivalent.
			Price/quality ratio	Increased customer satisfaction regarding price/quality ratio.
		Chain harmonization	Information exchange	Increased number of contacts between chain partners.
				Number of complaints regarding information exchange.
				Number of complaints regarding timeliness of information exchange.
			Cooperation	Increased formalization of agreements between chain partners.
		Strategic potential	Flexibility	Reduction in number of days between the last possibility for a purchaser to change specifications and order delivery.
			Financial health	Increase in ratio between company net capital and total capital.
			Innovativeness	Number of patents filed.
			Absorption potential	Reduction in age of machinery.
	Costs and returns	Returns	Turnover	Increase in net turnover (per organization submitting; inside and outside the Netherlands).
		Costs	Costs	Costs (per organization submitting; inside and outside the Netherlands; in developing countries).
	Employment	Quantity of employment	Quantity of employment	Increase in number of full-time equivalents (per organization submitting; inside and outside the Netherlands; in developing countries).
		Quality of employment	Quality of employment	Increase in employee satisfaction regarding work content.
	Other	Competition	Competition	Reduction in number of complaints regarding non-compliance with competition laws.

Annex 2
Questionnaire for stakeholder analysis

Figure: example of a questionnaire

Taking stock of the parties involved
- Which parties play a role with regard to the import of biomass and which of these are the most important ones?
- What are their standpoints with respect to the discussion on the import of biomass?

Exploration of success factors
- What is needed to ensure that the discussion on the import of biomass is successful?
- What is needed to ensure that the developments with respect to the import and use of biomass are successful?
- Which conditions does the result have to comply with?

Exploration of problems
- Which problems arise with respect to the import and the use of biomass?
- *(may include standpoints of political parties, insufficient insight into risk factors, high financial risks run by business persons, support from environmental organizations, involvement of private parties, public involvement, insufficient trust between various parties, insufficient linkage between the various parties (cultural differences)*
- How would you order your own priorities regarding the list of problems?
- Which consequences does that have regarding the progress made?

Exploration of expectations of stakeholders
- What expectations do you have regarding the import and use of biomass?
- What expectations do you have regarding the use of biomass as a source of energy?
- What specific expectations do you have regarding a possible pilot?
- What expectations do you have of the different parties in the various phases?

Determining responsibilities
- What is the objective of your contribution to the discussion surrounding the import and use of biomass; what are you interested in?
- What do you see as your responsibility in this area?

Exploration of possible solutions to the problems mentioned
- Which solutions do you see for the problems mentioned?
- Which parties play a role in the above?
- Are there any parties presently involved who you think should (be allowed to) have hardly any or no involvement at all?

Taking stock of 'missing pieces' with regard to supporting the process
- What is your opinion of the process surrounding the discussion on the import and use of biomass? Do you think there is an organized stakeholders' dialogue?
- Are any aspects of the process receiving too little attention?
- Which aspects of the entire process should receive more attention?
- Which players could take the initiative with regard to the above?

Main role

In your opinion, which party is doing most of the pushing when it comes to developing biomass applications?
- Which party or person would you prefer to see pushing the development of biomass applications?

Taking stock of questions regarding actions and knowledge
- Which actions are needed to achieve a sensible resolution of the discussion regarding the import and use of biomass?
- Which information (knowledge) is needed to support these actions?

Annex 3
An example "Unlocking the value of residual flows"

The following illustration is an example of how different options for unlocking the value of residual flows can be compared with each other. The first option, A, involves a process which costs € 2 per unit of residual flow and which provides two products in a particular ratio. The second option, B, involves a more expensive process, which costs 5 € per unit of residual flow and which provides four products in a different ratio. The products from option B command a different price than the products from option A. The evaluation involves a comparison of costs and benefits for both options, whereby all flows are taken into account.

Table: Net benefits from unlocking the value of 100 kg of residual flow in € per ton

	Option A	**Option B**
Costs	200	500
Benefits	Fiber: 20 * 11 = 220 Protein: 10 * 12 = 120 Wastewater effluent: 70 * -1 = -70	Fiber A: 10 * 2 = 20 Fiber B: 30 * 3 = 90 Protein: 40 * 1 = 40 Coloring agent: 5 * 150 = 750 Wastewater effluent: 15 * -5 = -75
Total	70	325

It's clear that in the final analysis process B, although more expensive, is more attractive than process A, as long as there is a market for coloring agent B. If the market for coloring agent B disappears, then process A becomes more attractive than process B. This illustration shows how risky a particular choice can be and how great the influence can be of the sales opportunities for a particular product. In the model 'Unlocking the Value of Organic Residual Flows', the user has the option of evaluating the possibilities provided by various products and processes (economically speaking) in greater detail. The model also makes it clear that the price of a product depends on market size: pricing elasticities are built into the model.

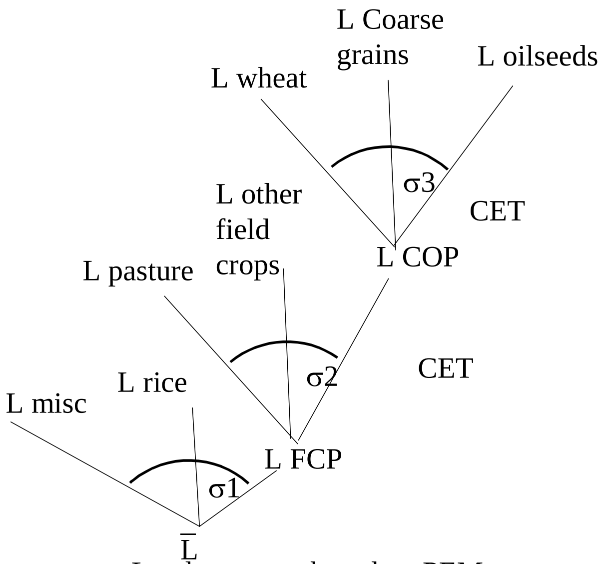
Annex 4
GTAP commodity breakdown

Primary agriculture	
	Paddy rice
	Wheat
	Cereal grains nec
	Vegetables, fruit, nuts
	Oil seeds
	Sugar cane, sugar beet
	Plant-based fibers
	Crops nec
	Cattle, sheep, goats, horses
	Animal products nec
	Raw milk
	Wool, silk-worm cocoons
Natural resource based activities	
	Forestry
	Fishing
	Coal
	Oil
	Gas
	Minerals nec
Processing agriculture and food	
	Meat: cattle, sheep, goats, horse
	Meat products nec
	Vegetable oils and fats
	Dairy products
	Processed rice
	Sugar
	Food products nec
	Beverages and tobacco products
Manufacturing	
	Textiles
	Wearing apparel
	Leather products
	Wood products
	Paper products, publishing
	Petroleum, coal products
	Chemical, rubber, plastic prods
	Mineral products nec
	Ferrous metals
	Metals nec
	Metal products
	Motor vehicles and parts
	Transport equipment nec
	Electronic equipment
	Machinery and equipment nec
	Manufactures nec
Services	
	Electricity
	Gas manufacture, distribution
	Water
	Construction
	Trade
	Transport nec
	Sea transport
	Air transport
	Communication
	Financial services nec
	Insurance
	Business services nec
	Recreation and other services
	PubAdmin/Defence/Health/Educat
	Dwellings

Annex 5
Further notes on GTAP

Modelling the supply side of biomass

A crucial aspect of modelling the supply of biomass crops is the allocation of land. In conjunction with the OECD secretariat, LEI has undertaken to model the agricultural supply side in GTAP in a specific way that allows us to capture the limited substitutability of land across alternative crops (and livestock for feeding purposes). In a nutshell, the land allocation is driven by relative returns that can be earned, while taking into account the fact that not all crops can easily be grown on alternative soils. The following figure illustrates the concept:



Land structure based on PEM

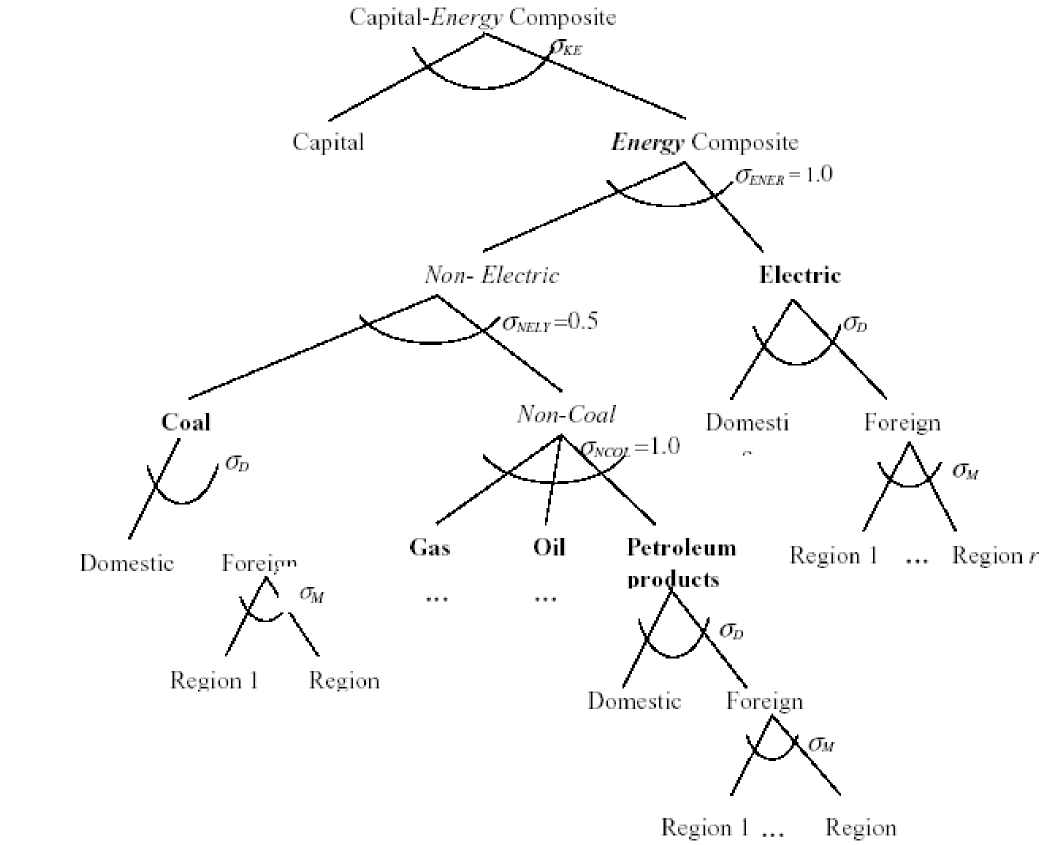
Total available land L is allocated over 3 broad ‘nests’. Within each nest, the allocation is guided by constant elasticities of transformation σ_1, σ_2, σ_3. For example in the upper nest, land can easily be transformed between wheat, coarse grains and oilseeds (the COP complex), but it will require big shifts in relative returns to move land out of COP’s and into pasture. In this way, alternative crops can be seen to be competing for the available land resources. The relative returns of alternative uses depend on market returns and the policy chosen.

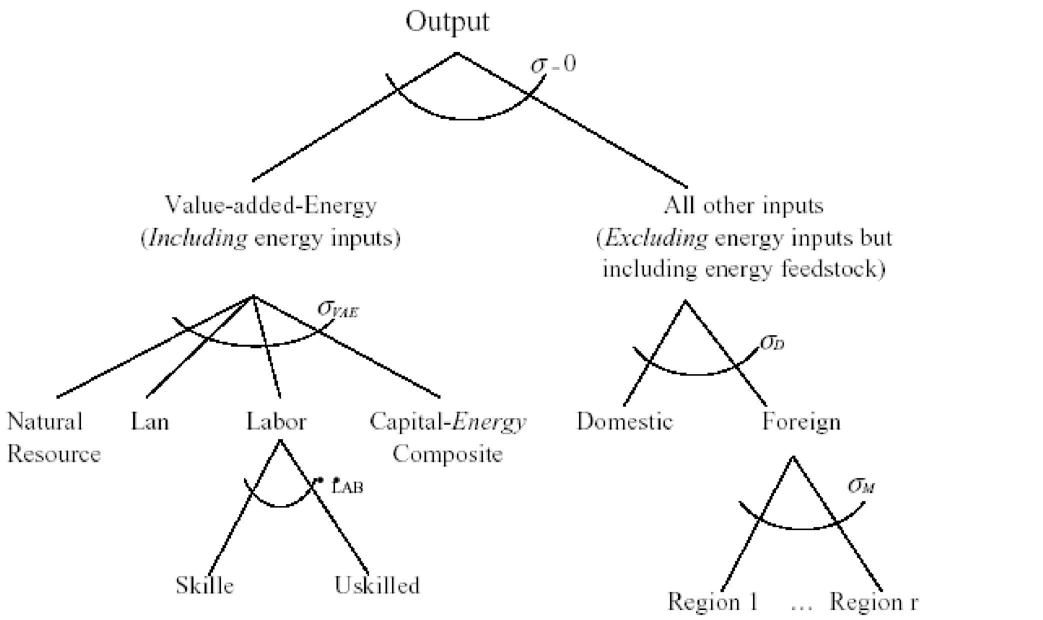
Issues concerning trade-offs between biomass and food security can easily be analyzed within this framework. The demand for food crops is derived from estimated demand functions that include relative prices and income and allow for varying expenditure shares as income grows.

Modelling the demand side for bio-energy

Energy modelling in GTAP already has a tradition, and as mentioned above, we have a consolidated (i.e. consistent) database of conventional energy use. For energy modelling the substitution possibilities in demand amongst alternative energy sources are very important. This can be done in a variety of ways. The GTAP-E model proposes the approach pictured in the figure below, where the various σs here indicate elasticities of substitution. The users of energy decide on their mix of sources on the basis of relative prices, including the domestic/foreign price ratio. If, for example, foreign electricity becomes cheaper relative to domestic electricity, more will be imported. If this cheaper electricity import also leads to falling composite electricity sources, more electricity will be demanded relative to non-electric sources. For bio-energy modelling, the biomass component would have to be folded into this structure.

Figure: Production structure GTAP-E





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HOW TO GET MORE WOOD FROM THE DUTCH FORESTS?

Jan Oldenburger and Leen Kuiper, August 2005. Follow-up BUS-report, Probos

1. Introduction

The Dutch forests have a large biomass potential, however it seems that hardly any wood becomes available for biomass purposes. Why is that? Are the forest owners not willing to sell their wood for biomass utilization or are other factors involved which cause the low harvest rate of (private) forest owners? A previous BUS quick-scan[127] indicated that forest managers have no problem selling their wood for biomass utilization if they get the same price as for other uses. The willingness of forest owners and forest managers to increase their harvest levels mainly depends on the role of wood production in the management of their forest and on the type of forest owner. Private forest owners seem to be more willing to increase their harvest level (i.e. if extra financial incentives are provided) than public forest owners, such as municipalities, ministry of defense, state forest service. Hence, the most effective strategy to enhance biomass yields from Dutch woodlands is to focus on private forest owners, especially those who own a rather small forest area (less than 250 ha). The private forest owners have about 32% of the forest area in the Netherlands under their management, i.e. 114,000 ha. The largest part (83%) of this area consists of forest areas of less than 250 ha that are privately owned. Within this group of small forest owners approximately 62,000 ha consists of privately owned forest areas of less than 5 ha. This latter group of very small forest owners is very difficult to reach, because they do not have to register their possession at the Bosschap; this in contrast to forest owners that own a forest area of more than 5 ha.
Many private forest owners are harvesting less wood than the sustainability of their forests would allow. The above mentioned quick-scan indicated that a better exchange of information (forestry extension) and financial incentives for making forest management plans would help changing their attitude.
However, some important questions still remain unanswered:

- How many private forest owners and municipalities, owning more than 5 ha and less than 250 ha of woodland, currently registered at the Bosschap, do harvest wood?
- Which factors, according to the forest owners, are limiting their harvest activities?
- Would a financial incentive result in an increase in the wood volume that is harvested by private forest owners?
- Which share of the private forest owners and municipalities, owning more than 5 ha and less than 250 ha of woodland, currently registered at the Bosschap base their management activities on the results of an assessment of the annual increment of their forest?

2. Method

In order to answer these questions a follow-up has been performed in which a questionnaire (Annex 1) has been send to <u>all</u> private forest owners and municipalities in The Netherlands that own a forest area of more than 5 ha and less than 250 ha, which were registered at the Bosschap in 2005. The questionnaire has focused on this group of private forest owners. During the analysis of the results the respondents have been divided into four different subgroups based on the forest area they own (i.e. 5-25, 26-50, 51-100, and 101-250 ha).

[127] Report on BUS-ticket A4, November 2004, Jan Oldenburger and Leen Kuiper

A further distinction was made between respondents belonging to the group of private forest owners and the group of municipalities. In this way, reliable and representative information about the harvest behavior of the 'most promising' forest owners could be derived. In addition, the willingness of forest owners to harvest more wood as well as the incentives needed, has been assessed.

3. Results

General

The response rate to the questionnaire was quite high: 28%. 412 of a total of 1471 forest owners, which have been addressed, have responded to the questionnaire. The first analyses of the questionnaires resulted in 388 questionnaires that could be used for further analyses. These 388 were divided into 339 private forest owners and 49 municipalities. The response group was divided into four subgroups based on their forest area (see table 1). To check the representativeness of the response group with respect to the total population of forest owners in The Netherlands, the share of the different subgroups within the response group were compared with the share of these subgroups in the total population. This comparison made it clear that the results from the response group can be used to draw conclusions on the total population of forest owners owning a forest area of more than 5 ha and less than 250 ha in the Netherlands. The 1241 private forest owners from this group together own a forest area of 33,000 ha.

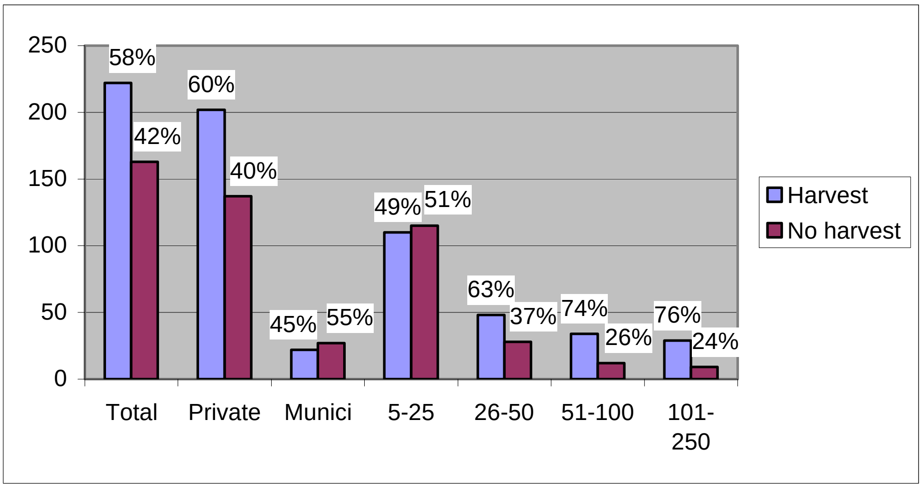
Table 1. The composition of the population of addressed forest owners and of the response group

Total population	**Total**	**5-25 ha**	**26-50 ha**	**51-100 ha**	**100-250 ha**
Number of forest owners in total population	1471	988	208	162	113
Number of private owners	1241	897	168	116	60
Number of municipalities	230	91	40	46	53
Response group	**Total**	**5-25 ha**	**26-50 ha**	**51-100 ha**	**100-250 ha**
Number of forest owners in total questionnaire	388	225	76	46	38
Number of private owners in questionnaire	339	207	68	41	23
Number of municipalities in questionnaire	49	18	9	5	17

Harvest yes or no?

In general the number of forest owners that do harvest wood from their forest is larger than the number that don't: 58% of the respondents do harvest wood (Figure 1). There is a noticeable difference in harvest behavior between private forest owners and municipalities. Furthermore, the results indicate that forest owners with larger possessions are more inclined to harvest wood than forest owners that possess small forest areas.

Figure 1: Harvest or no harvest by the different categories of respondents



Limiting factors for wood harvest

The forest owners were asked to mention the most important factors which limit wood harvesting in their forests (three factors maximum) (see figure 2). Not surprisingly, 20% of the forest owners mention the low wood price as the most limiting factor for their harvest activities. Especially private forest owners that harvest wood stress this point. Ranked second, with a share of 17%, is the fact that wood production is no objective in forest management. This factor is mentioned most by municipalities and private forest owners, who own a small (5-25 ha) forest area.

If the limiting factors mentioned by forest owners that harvest wood and owners that don't are compared, slight differences are visible (figure 3). The low wood price is mentioned most by the forest owners, who do harvest wood. Only 26% of forest owners that don't harvest wood mention the low wood price as a limiting factor. The main limiting factors for the forest owners that don't harvest wood are the young age of the forests and the fact that wood production isn't an objective in their forest management.

Figure 2: Limiting factors for wood harvest mentioned by the response group

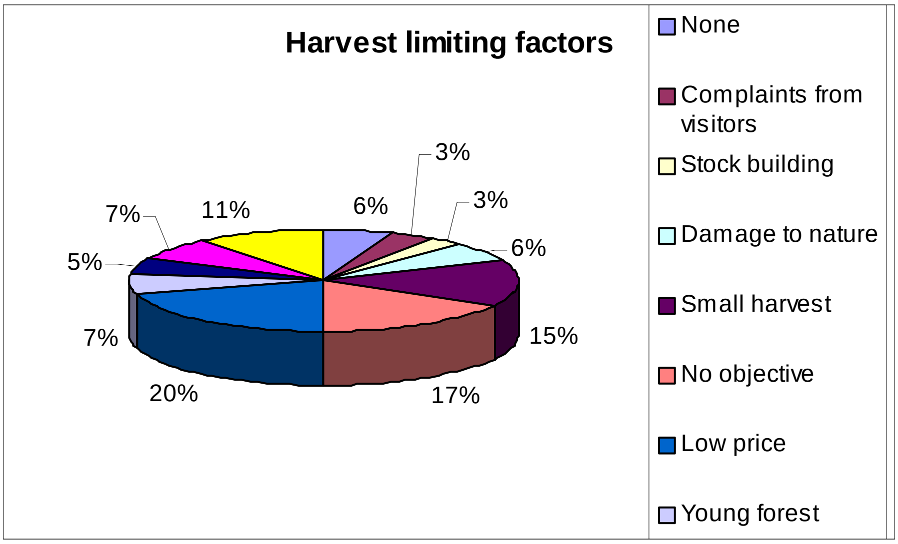
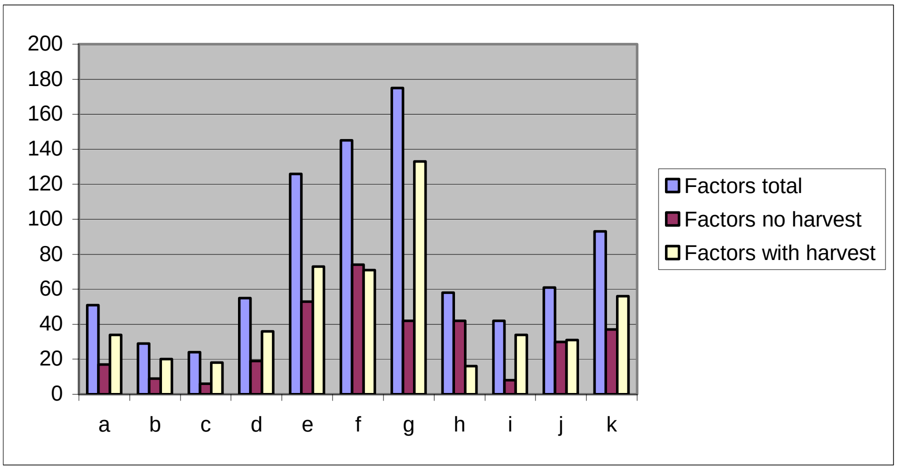


Figure 3: Limiting factors in total and mentioned by forest owners that do and don't harvest wood



a. None, b. Complaints from visitors, c. Stock building, d. Damage to nature, e. Small harvest, f. No objective, g. Low price, h. Young forest, i. Damage to roads, j. To much work, k. Other.

Financial incentives

The forest owners were asked if a financial incentive of 10 euro per cubic meter standing timber would result in higher harvest levels. The question focused on the private forest owners because earlier results indicated that this category of forest owners is more eager to react on a financial incentive than e.g. municipalities.

The results show that this financial incentive would work for 24% of private forest owners that have responded to the questionnaire (i.e. 83 out of 339). 72% of these private forest owners were already harvesting wood. This kind of financial incentive will have the largest effect on private forest owners that own a forest area of less than 100 hectares and which are already actively engaged in wood harvesting (see table 2). On average 30% of the private forest owners that are already engaged in wood harvesting, would increase their harvest level because of the proposed financial incentive.

Table 2: The number of private forest owners owning an area between 5 and 250 ha that already harvest wood and would react positively on a financial incentive of 10 euro per m^3 standing timber

	Number of owners that harverst view	Positive reaction	Share
	106	26	25%
26-50	44	17	39%
51-100	32	13	41%
101-250	20	4	20%
Total	202	60	30%

The low wood price is mentioned by 48% of the private forest owners as the most limiting factor for their harvest activities. It is, however, striking that 54% of these private forest owners indicated that they would not increase their harvest if they would get a financial incentive of 10 euro per m^3. This is partly due to the fact that some of these owners have indicated that they already harvest the maximum amount of wood from their forest. For the other owners limiting factors other than the low wood price are apparently more important in determining their harvest volume. The two main other factors are the fact that wood production is no objective in forest management and the small harvest volume.

Management plan/annual increment assessed
The forest owners were asked if their annual increment has been assessed during the last ten years. This was done in order to see if there is a relation between having a regular assessment of the annual increment and harvesting wood or the decision whether it is sustainable to harvest more wood from the forest.
48% of in total 221 wood harvesting forest owners have indicated that it would be sustainable to harvest more wood from their forest, 51% indicated that they can not harvest more wood in their forest; and 1 % didn't know. Surprisingly, these assumptions made by the forest owners are rarely based on an assessment of the annual increment during the last 10 years. Only 14% of the forest owners that indicate that they could sustainably harvest more wood have done an annual increment assessment during the last ten years. This percentage is higher (24%) for the forest owners that indicate that it is not sustainable to harvest more wood.
Table 3 shows that only 18% of the forest owners that responded to the questionnaire have done an annual increment assessment during the last 10 years. 64% of these owners do harvest wood and 36% don't. The majority of the forest owners with a forest area smaller than 50 hectares haven't got a management plan nor a recent assessment of the annual increment in their forest. Only 15% of forest owners with holdings smaller than 50 ha have their annual increment assessed during the last 10 years. The share of forest owners that can base their harvest activities on the results of an assessment of the annual increment in their forest is higher (24%) for the 3rd (51-100) and 39% for the 4th subgroup (101-250) of forest owners, but is still quite low.
If the results are extrapolated to the total number of forest owners owning a forest area between 5 and 250 ha, approximately 1207 (i.e. 82%) of the total number of 1471 forest owners, which have been addressed do not base their management activities on a recent assessment of the annual increment in their forest. Of these 1207 forest owners 672 are engaged in wood harvesting (i.e. 55%).

Table 3: The number of annual increment assessments that were made by the forest owners that responded to the questionnaire

	Number of owners	**Annual increment assessed**	**Share**
5-25	225	34	15%
26-50	76	10	13%
51-100	46	11	24%
101-250	38	15	39%
Total	385	70	18%

4. Discussion

There are a number of possibilities to increase the amount of wood that is harvested by forest owners owning a forest area between 5 and 250 ha. It is, however, difficult to determine which strategy could best be followed. The results of this questionnaire could be of some assistance:

Offering a financial incentive
This assessment of the harvesting attitude indicates that a high financial incentive is the most determining factor to substantially increase wood harvest levels of private forest owners in the Netherlands. In the questionnaire an incentive of 10 euro per m^3 standing timber was suggested, which is about equal to the current market price for standing (pulp) timber. From the category of forest owners that are not involved in wood harvesting, only 85 owners would consider to start (or resume) harvesting wood from their forest because of the proposed incentive. However, the proposed financial incentive would increase the harvest level of 30% of private forest owners that are already harvesting wood. The group of forest owners that would increase their harvest level if the financial incentive is offered

to them manages about 8,600 ha. Assuming a 20% increase in utilization rate from 60 to 80% of the annual increment, the effect of this proposed (and rather generous) financial incentive will be an increased harvesting volume of 14,000 m^3/annum.

Stimulating harvest activities

The results of the questionnaire show that presently there is a large number of forest owners that do not harvest wood from their forest: within the response group 40% of the private forest owners and 50% of the municipalities do not harvest wood. Extrapolation of the results to the total population of forest owners in the Netherlands suggests that 533 private forest owners and 130 municipalities do not harvest wood from their forest (table 4). As expected, most of the forest owners that don't harvest wood can be found in the first subgroup of small holders, who own 5-25 ha of woodland. Stimulating the private forest owners from this subgroup to harvest (more) wood could result in an increase of the area in which wood is harvested with approximately 5,900 ha, in which an additional volume of about 33,000 m^3 of wood can be harvested each year (given an average forest area of 11.8 ha per owner an annual increment of 8 m^3/ha/y and a harvesting rate of 70%). However, it will be quite difficult to reach these forest owners and to overcome problems associated with small harvest volumes and the scattered location of the forests areas.

These problems could partially be overcome by offering a full service contract, by which a contractor takes over the wood harvesting and selling activities from the forest owner. The contractor can offer the harvested wood to the market collectively, thereby negotiating a better price. In this way a larger volume of industrial round wood will enter the market, part of which can become available for bio-energy purposes.
This full service concept can also be offered to the owners from subgroup 2. It will probably not be viable to offer a full service contract to the owners from subgroups 3 and 4, because the forest area owned by these forest owners will already provide a relatively large amount of wood and thus they are already in a position to negotiate a good price for their wood.

Making a management plan, including an assessment of the annual increment

Although it cannot be concluded from this questionnaire that stimulating the forest owners to develop a management plan for their forest will always result in significantly higher harvest levels, stimulating forest owners to do so may be an effective way to increase the harvest level from the forest owners with a forest area of more than 5 ha and less than 250 ha. An assessment of the annual increment in their forest will help them to determine what amount of wood can be sustainably harvested. If this stimulation measure is aimed at the 3rd and 4th subgroup which owns a forest area of more than 50 ha, the total forest area under a management plan in the Netherlands would grow substantially. As a consequence the harvest level will probably increase in this forest area. It would involve 103 owners from subgroup 3 (88 private forest owners and 15 municipalities) and 53 owners from subgroup 4 (37 private forest owners and 16 municipalities) with a total area of approximately 15.000 ha. Assuming that better information on their actual harvesting activities may lead on average to a 10% increase in utilization rate, the effect will be an increased harvest volume of about 12,000 m^3/a.

Table 4: The number of forest owners owning a forest area of more than 5 ha and less than 250 ha that do not harvest wood

	Private owners	Municipalities	Total
5-25	440	61	501
26-50	59	22	81
51-100	26	28	54
101-250	8	19	27
Total	533	130	663

5. Conclusions

1. Although the group of private forest owners who possess very small woodlands less than 5 ha in size has a substantial forest area under their management (i.e. totaling 62,000 ha), they will be very hard to reach, because they are not registered at the Bosschap. Hence their potential contribution to the supply of more woody biomass from the Dutch forest will be negligible.
2. Stimulating the category of small private forest owners (5-25 ha) to harvest more wood from their forest will have the largest effect on the amount of wood that becomes available from private forest owners owning a forest area between 5 and 250 ha. It may result in 33,000 m^3 of wood harvested additionally each year. Some of the problems encountered by the forest owners from this subgroup may be overcome by offering them a full service contract.
3. The rather high financial incentive of 10 euro/m^3 needed to bring about a change in attitude may result in an additional 14,000 m^3/a.
4. Another (effective) measure to increase the harvest level is by offering private forest owners the opportunity to make and implement a management plan for their forests [128]. This will result in an increased harvest volume of about 12,000 m^3/a.
5. All three stimulation measures combined may result in an additional volume of 59,000 m^3/a.

[128] Combining the full service concept with a management plan may be a good way to stimulate and finance management plans. It is important that the company, which is writing the management plan is independent of the company, which is harvesting and selling the wood. The forest owner too should be involved in this process to assure a certain level of independence.

Annex 1
Wood harvest questionnaire

Name ownership/organization (if applicable): ………………………………
Contact person: ………………………………
Place: ………………………………

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1. What is the size of your forest area? : ……….. ha

2. Do you harvest wood from your forest? ☐ yes
   ☐ No (continue with question 5)

3. How many m^3 of wood do you harvest each year? : ……….. m^3

4. Would it be sound to harvest more wood from your forest?
   ☐ Yes
   ☐ No, I already harvest the maximum amount

5. Has your annual increment been assessed in the last ten years? ☐ Yes
   ☐ No

6. What are according to you the factors that hinder the harvest activities in your forest most (3 hindering factors maximum)?

- ☐ None
- ☐ Wood harvesting isn't an objective
- ☐ Complaints from visitors or neighbors
- ☐ Low wood price
- ☐ I'm increasing my stock
- ☐ My forest is to young to harvest
- ☐ Damage to nature
- ☐ Damage to roads and paths
- ☐ The harvest size is to small
- ☐ Too much work
- ☐ Other e.g.

…………………………………………………………………………………..

7. Would you harvest more wood if you would get 10 euro more per m^3 standing timber?

- ☐ No
- ☐ Yes, how much m^3 more? :…………… m^3

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