Biomassa-upstream stuurgroep

Quick-scans on upstream biomass

YEARBOOK 2006 - 2007

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Yearbook 2006 and 2007

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Preface

Despite recent criticisms, 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 leads to an increased demand for biomass that may eventually surpass the current “food and feed”-oriented biomass production by an order of magnitude. Entirely new economic chains are developing, linking biomass production with final products on a truly global scale.

We are witnessing a built-up of competition between the established applications and the new, non-food applications of biomass with a steep increase in the prices of food as result. The fast development of new large scale applications like biofuels have created large imbalances in supply and demand.

Achieving a sustainable balance is major challenge. Many questions can be raised:

- What is the supply position for biomass ?
- How can we prevent negative impacts on biodiversity ?
- How can biomass be certified as a sustainable raw material ?
- Which crops are suitable for the various food, feed and energy/material applications ? Can there be synergy between the fields ?
- Can we genetically modify crops to better suit the applications ?
- 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 ?

The Biomass Upstream Steering committee (BUS) has made an attempt in the past 4 years to develop insights in a broad spectrum of questions around the theme of supply and trade of biomass. With short studies (“quick-scans”), sometimes extended with a “follow-up”, many aspects have been studied and discussed. This 2^{nd} yearbook is the compilation of these explorative studies over 2006 and 2007.

Through this yearbook we hope tot inform a broader audience about the activities carried out by the BUS with the aim of contributing to the 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.

According to the initial plan, in 2007 the BUS initiative was terminated. The members of the BUS consortium are convinced that the past three years have resulted in a thorough understanding of the biomass upstream world. Of course a lot of questions remained unanswered but as a direct result of the organisation of BUS the most important issues were identified and the most important questions were answered. In last two years of the BUS, it was decided to perform fewer quick scans in order to be able to do more and thorough and research.

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.

1
The competitiveness of Dutch energy wood

By: Leen Kuiper en Jan Oldenburger, Probos
Date: February, 2006

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1. Problem
Dutch energy companies are using large volumes of woody biomass for their energy production. Most of this woody biomass is imported as energy pellets from Sweden, Finland and Canada. In 2003 a total of 400 kton of energy pellets were co-combusted in conventional coal plants, 80% of which (320 kton) were imported. In 2004 the import of pellets increased to a volume of 420 kton. The average price that is paid for these pellets is about 100 euros per ton delivered at the gate. This price is much higher than the price of, for instance a cubic meter of fresh wood from the forests in the Netherlands delivered at the gate of the energy plant. Of course there will be costs involved in making this fresh forestry biomass suitable for co-combustion (e.g. drying, palletizing). However, given the huge difference in price between energy pellets and wood from forestry (approximately 80 euro/ton), the upgrading of fresh forestry biomass could be an interesting option. The more so, because the current upper price level for wood pellets (100 €/ton) is expected to increase in the near future due to increasing demand and limited production capacity on the supply side to satisfy this demand.

2. Questions

1. Why is it difficult to sell Dutch energy wood in comparison with imported energy wood? Is this caused by:
    - Low market price (e.g. energy pellets)
    - Scale
    - Quality
    - Availability
    - Logistics
2. In what way should Dutch energy wood be offered to the market in order to be able to compete with imported woody biomass?
3. Why isn't there a Dutch company that jumps into the market to produce large amounts of energy pellets?

3. Approach
Literature study and expert consultation.

4. Results

4.1 Dutch energy wood and its availability
There are four main sources of energy wood in the Netherlands: (1) wood processing residues, (2) energy pellets (3) used wood (a-quality and b-quality), (4) fresh wood from forestry, landscaping and prunings.

(1) Wood processing residues
The supply-side of wood processing residues and energy pellets consists of "small" family owned companies. The amount of wood from the Dutch wood processors which is traded by these companies is approximately 522,000 odt of residues per year (Probos, 2005). A result of the small-sized privateownership of these companies is that high investments necessary to be able to produce e.g. large amounts of energy pellets cannot be made. Furthermore, these companies are not willing to sell their whole production volume to one energy company only. For instance: Labee Group Moerdijk B.V. produces 70,000 tons of energy pellets per year, but they are not willing to sell more than

30,000 tons to a single Dutch buyer. The rest of their production is sold to foreign companies (especially in Germany) in order to secure their future sales and minimize the risk of sudden changes in the subsidy system in a particular country (Labee, pers.com., 2006).
The traded amount (522,000 odt) of wood processing residues seems large, but most of these wood processing residues already find there way to end users. For this reason, only a limited volume of wood processing residues are available for energy production.

(2) Energy pellets
According to the Witt and Thrän (2005) the total amount of energy pellets produced in the Netherlands in 2004 was 100 kton per year. The market for energy pellets is a global market dominated by a few countries such as Sweden and Canada. The demand for energy pellets is high resulting in an increase in the number op pellet producing countries. During the last 2 years Eastern European countries (e.g. Poland, Estonia and Lithuania) have increase their production capacity. Pettes are being produced mainly from wood processing residues (saw dust, shavings), but the technology is available and even being commercialized on a small scale, e.g. in Germany, to make energy pellets from fresh wood. Unfortunately, the investment costs are high (Holz-Zentralblatt, 2005). The Dutch company Labee Group Moerdijk B.V. is producing energy pellets from forest chips in Germany. The reason why they have developed this activity in Germany and not in the Netherlands is a matter of supply and demand. In Germany the demand for energy pellets is stable and secure for the next 20 years and they have a constant supply of forest chips due to their relation with the largest private forest owner in Germany. The only thing that Labee had to do was to use their experience in pelletizing. Note that the raw material for the pellets produced by Labee in Germany is not 100% fresh wood, but is a mixture of wood processing residues and fresh wood. This reduces the production costs, because the raw material doesn't have to be dried so much.
Mr. Schouwenberg from Essent Energy explained that Essent only uses clean energy pellets (made from saw dust and shavings): about 800 kton per year (2005 data). Essent imports these pellets from Sweden, Canada and Finland. There is no problem yet to obtain large amounts of clean energy pellets and the availability of contaminated energy pellets is even larger. Contaminated pellets are in general made of used wood, but for instance Labee is also using a fraction of fresh branches for the production of these pellets.

(3) Used wood
Dutch companies trading in used wood have exported 970 kton of used wood in 2004 (table 1), 401 kton of which went to foreign energy companies; the remainder went to the board industry in Belgium, Germany and Italy. Most of the exported volume of used wood for energy purposes is exported to Germany (88%) (B-quality wood[1]); the remainder, mainly consisting of C-quality wood,[2] went to Sweden. The reason for these exports is that the price in Germany is higher, but another advantage is that the German utilities will pay a fixed price for a period of 20 years. This guarantees continuity and offers companies the opportunities to anticipate to the increase in demand by increasing their production capacity. The average consumer price that is paid for the green electricity produced from biomass by the German utilities is on average 8,9 cents per kWh. This is three times the European market value of a kWh of electricity.
An other reason for the export of the B-quality used wood for energy purposes to Germany instead of using it in the Netherlands, is that co-firing this type of (contaminated) wood is limited due to environmental legislation which requires higher investment cost for emission reduction. Therefore, the maximum price that can be paid for the fuel is lower. The emission standards in the Netherlands have been developed for energy plants that use fine and clean powder coal. The emission standards for old coal fired and brown coal fired energy plants in Germany are lower due to their age and the type of fuel they use. The emission standards for new power plants in Germany can be compared with those in the Netherlands and for this reason they don't have an advantage in this area.
A further complicating factor is the discussion in the Netherlands whether B-quality wood should be considered a raw material or a waste product. If it is considered waste, an energy plant needs a

[1] B-quality wood: slightly contaminated, e. g. with paints, glues and coats
[2] C-quality wood: hazardous wood waste contaminated with heavy metals, fire retardants and wood preservatives

different permit to be able to co-fire the B-quality wood and it is in most cases difficult to get this kind of a permit.

Table 1: Availability of used wood in The Netherlands (Probos, 2004)

Categories	Total, kton	Use in NL, kton	Exports, kton
A-quality	495	215	280
B-quality	705	50	655
C-quality	50	15	35
Total	**1.250**	**280**	**970**

Table 2: Exports of Dutch used wood (Probos, 2004)

Country exported to	Board industry, kton	Energy companies, kton
Germany	168	353
Belgium	148	0
Sweden	0	48
Italy	250	0
Total	**566**	**401**

(4) Fresh energy wood from forests
The volume (70,000 metric tons) of fresh wood from the forest used for energy purposes is increasing somewhat in the Netherlands, but still it is of minor importance. Most of the fresh woodchips that are used for energy purposes are derived from landscape maintenance and from prunings. The price paid for energy wood chips from the forest is approximately 30 euro per metric ton[3] at the gate of the energy plant. If this is compared to the price for chips from landscaping and prunings (i.e. 17,5 euro per metric ton) it is obvious why the focus is mainly on the procurement of these chips (Ecofys, 2004).

The price is the main driving force for the amount of wood that is extracted from the forest for energy purposes, but other factors are also important. The Dutch forest area is owned by al large number of forest owners owning small pieces of forest land. Consequently, the scale of forest management activities is also limited and efficiency is rather low.
Most of the Dutch fiber wood (round wood and chips) is exported to board producers in Belgium and Germany. Apparently it is economically viable to do so, but transportation costs are quite high. For this reason one would expect it to be possible to use at least part of this fiber wood for energy purposes. The price (app. 40-70 euro/ton) paid for fiber wood at the gate of the board plant evidently is higher than the price which can be paid by the power plant.

A drawback of using fresh wood for co-firing in conventional coal plants is that it should be upgraded first in order to meat the fuel requirements. Different technologies are available (e.g. torrefaction) to upgrade fresh wood. However, this upgrading involves high costs, which is partially due to the high water content of fresh wood. The upgrading of wood processing residues and used wood is much cheaper (if needed al all).Thus, fresh wood from forests cannot compete yet with other sources of woody biomass.

4.2 Unstable and immature market
The market for biomass at the moment is not very transparent and not stable due to the relatively small volumes of biomass that are traded, which makes it difficult to obtain long term, large volume contracts. Consequently, the production and logistics are not optimal. The certainty of frequent, large transports makes it possible to invest in adequate production-, transportation- and handling facilities. Furthermore, the demand for biomass has to be long lasting. This is only possible if

[3] Two cubic meters of coniferous woodchips go into one metric ton

energy companies as well as the government commit themselves to the longtime use of biomass. The current problems with obtaining emission permits and insufficient financial support and security for co-firing biomass create uncertainty. For this reason this commitment is not expressed by the energy companies (Junginger and Faaij, 2005).

5. Conclusions

The competitiveness of Dutch energy wood against imports cannot explained by a single factor; there are many factors involved:

- Long term, stable financial support such as in Germany and clarity about emission permits could result in a more stable market for energy wood in the Netherlands. If these preconditions are met, energy companies are able to offer long term, large volume contracts for the supply of woody biomass (e.g. energy pellets). Dutch pellet producers will be able to invest money to increase their production capacity and they will be in a better financial position to handle different kinds of biomass (e.g. saw dust combined with fresh wood chips)
- Stable production volumes and a continuous supply are the essential elements for a pellet production company to be able to sell large volumes of energy pellets to the market.
- The use of B-quality wood for co-firing in the Netherlands has to compete with the outlet to German energy plants. If the financial support by the Dutch government doesn't change, the use of B-quality wood for co-firing in Dutch energy plants will certainly not increase.
- Furthermore, the board industry in Belgium and Germany is increasing the use of B-quality wood as a "cheap" raw material in order to compete with board producers in countries with low wages.
- As a consequence of a further increase in the competition between different users of biomass, especially for clean wood residues (A-wood and B-wood), the market price will further increase. This may result in a situation in which energy pellets made from fresh wood can compete with these rather "cheap" sources of biomass.

6. Follow up?

A number of questions still remain unanswered:

- What can be done to make fresh wood from the forestry and landscaping (20 euro/ton) more competitive with import (upgrading, increase in scale, security of supply)?
- Which parties should be involved in this process (e.g. Bioenerco: Staatsbosbeheer Dienstverlening (Energiehout b.v.), Van der Wiel, Van Werven and Vagroen (biomassa) B.V.)?
- Which amounts of biomass could than become available?

Consulted experts

- Alex Labee, Labee Group Moerdijk B.V. / Energy pellets Moerdijk B.V.
- Peter-Paul Schouwenberg, Essent Energie
- Cor Siero, Ecopellets BV and Ecochips BV

Literature

- Ecofys, 2004, Prijslijst biomassa brandstoffen
- Junginger, M., A. Faaij, 2005, IEA Bioenergy task 40 – Country report for the Netherlands Universiteit Utrecht, Copernicus Institute, Department of Science, technology and Society, Utrecht
- Koppejan, J., P.D.M. de Boer-Meulman, 2005, De verwachte beschikbaarheid van biomassa in 2010, SenterNovem, Den Haag
- Rinke, G. von, 2005, Waldholz als Alternative bei der Pelletsproduktion, Holz-Zentralblatt, 83, 1106
- Witt, J. von, D. Thrän, 2005, Holzpellets – ein Markt mit Zukunftperspektiven, Holz-Zentralblatt, 93 1279-1280

2

The harvest of forest residues in Europe

By: Leen Kuiper en Jan Oldenburger, Probos
Date: February, 2006

1. 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.

2. 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?

3. Approach

In order to answer the questions above a literature study has been done.

4. Results

4.1 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.

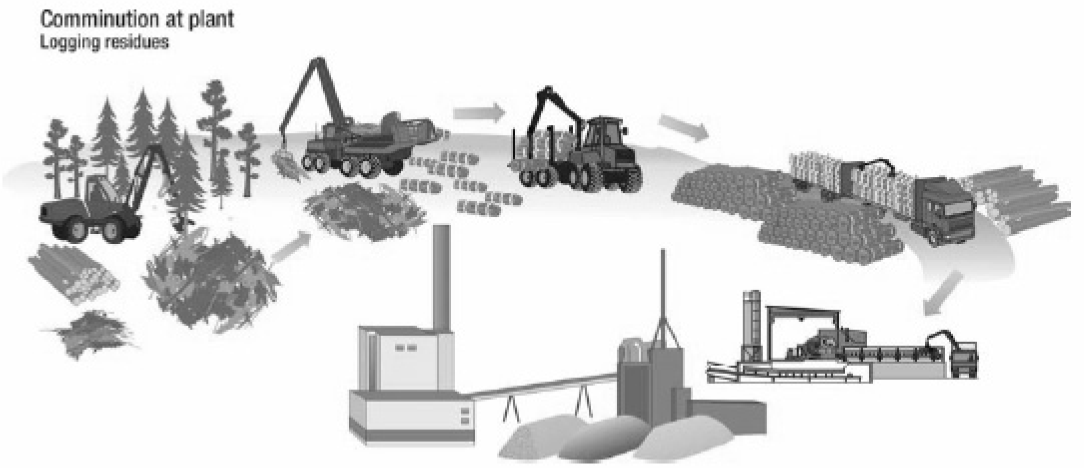
Usually, high costs are involved in the procurement of forest residues from the forest. For this reason a number of technologies have been developed and should be further optimized in order to reduce the costs of harvesting forest residues. Also a number of logistical supply chains have been developed 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)



4.2 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.

<u>Sweden</u>

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
[1] 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 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.

4.3 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.

[1] Conversion factor: 1 PJ equals 0.125 million m^3 fresh wood chips

4.4 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).

4.5 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 (243 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 countries.

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

5. 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.

6. 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 (modeling 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.

Literature

- Alakangas, E., T. Sauranen, T. Vesisenaho, 1999, *Production techniques of logging residue chips in Finland*, VTT Energy, Jyväskylä
- Belle, J.F. van, M. Temmerman, 2001, *Bioenergy and sustainable forest harvesting*, Département Génie rural, Centre de Recherches Agronomiques de Gembloux, Gembloux
- Burgers, J.A., 2002, *Soil and long-term site productivity values*. In: Richardson, J., R. Björheden, P.Hakkila, A.T. Lowe, C.T. Smith, 2002 Bioenergy from Sustainable Forestry - Guiding Principles and Practice. Kluwer, The Netherlands
- Hakkila, P., 2002, *Operations with reduced environmental impact*. In: Richardson, J., R. Björheden, P.Hakkila, A.T. Lowe, C.T. Smith, 2002 Bioenergy from Sustainable Forestry - Guiding Principles and Practice. Kluwer, The Netherland
- Hakkila, P., 2004, *Developing technology for large-scale production of forest chips, Wood energy technology programme 1999-2003*, Tekens, Helsinki
- Juijn, P., 2005, *Het bos als energieleverancier*, Vakblad Natuur Bos Landschap, 1: 14-15
- Meuleman, B., L. Kuiper, G. J. Nabuurs, 2005, *Effect: EU forest for renewable energy to mitigate climat*, Ecofys, Utrecht
- Sikkema, R., 1998, *Kosten van energiehout uit bestaande bossen*, Stichting Bos en Hout, Wageningen
- Richardson, J., R. Björheden, P.Hakkila, A.T. Lowe, C.T. Smith, 2002 *Bioenergy from Sustainable Forestry - Guiding Principles and Practice*. Kluwer, The Netherlands
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Source: Pentti Hakkila, VTT Processes

3

The economics of biomass for biofuel

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Date: April 14, 2006

1. Introduction and objective

There is a worldwide orientation on the possibilities to produce fuels on the base of biomass. It helps to reduce the CO2-emission, as a renewable source it reduces the depletion of sources and the dependence of political instable systems is less. Many reasons to seriously consider the development of new production chains.

One of the issues to consider is the economics. "At what price is the biomass available?" is one of the key questions. And: "which factors determine the availability of the biomass?". The last question can be translated into another question, namely: "What affects the use of biomass for bio-energy applications?" This paper aims to give a handle to assess cost prices of biomass. Furthermore it gives a quick scan overview of calculated cost prices of the bio fuel, which results in some conclusions. Conclusions about the costs of bio fuels and biomass and conclusions about underlying factors, determining the cost price. These factors
affect the use of biomass for bio-energy applications.

The paper distinguish two types of biomass. First the agricultural crops will be discussed. These crops are used primary for bio fuels: wheat, sugar beets, rape seed, other vegetable oil crops; the biomass used for the first generation technology. Secondly by products will be considered. This group is more interesting, in terms of economics and sustainability: the costs of by products differ from those of crops. Secondly , the factors which affect the use of crops differ. Those differences form the reason to distinguish the two feed stocks from each other in this paper.

2.Crop as a feed stock for bio fuels

2.1. Approach

First of all the economics of biomass will be explained. The paper pays attention to the diversity of methods to calculate costs of biomass. It will emphasize the necessity to choose the most suitable method to calculate production costs of biomass – which is highly depending on the circumstances, involved market actors and term.

Then some studies will be discussed. First studies on the (economics of) agricultural new crops will be considered. The OECD-report "Agricultural market impacts of future growth in the production of biofuels" (2006) aimed to look at the economics of biofuel production; this study is relevant for the questions to be answered. The study is based on available data on production technologies and costs; many assumptions has been made due to a lack of data. In the report the production costs of agricultural based fuels have been calculated for several countries. Those production costs have been compared (a) across countries and (b) to the oil-based fuel prices. The OECD mentions a "rough" estimation of the functional relationship between fuel prices, production costs and biofuel production. Besides the OECD-report which considers the OECD-countries, the research with the help of the Policy Analysis System (POLYSYS) will be discusses. This research is focused on the United States, but results of the studies can be used for other countries also.

During the writing of the paper it became clear the impacts of the expected growth in the biofuel-related demand for agricultural products on commodity markets can not be ignored. The biofuel production has several links with other commodity markets, which effects the farmers income and the viability of the system. Also the US Policy Analysis System (POLYSYS) takes the impact on other market into account. The model estimates the potential impact of bioenergy crops production on traditional crop prices and quantities and the – resulting – (potential) impact on net farm incomes. Therefore this paper considers also the effects of the expected growth in the biofuel market on commodity markets which have a relation to the biofuel-commodities.

2.2 Relevant factors

The cost price of agricultural raw materials can be calculated in various ways, but not all of these automatically qualify as a basis for feasibility studies. The circumstances under which the production takes place, the length of time to which the decision refers and the consequences of further production for the rest of the cropping plan determine to a large extent which method is suitable. Several factors can be distinguished which determine which method for calculation costs price is best suitable.

Table 1: Breakdown of factors that determine methodology selection

Producer	Term	Position in relation to one crop	Consequences for cropping plan and/or farming system	Method for calculating costs price
Processor	Long	Not applicable	Not applicable	Full cost price
Farmer	Long	Yes	Yes	Partical cost price
Farmer	Long	Yes	No/few	Partical cost price
Farmer	Long	No	Yes	Full cost price
Farmer	Long	No	No/few	Full cost price
Farmer	Short	Yes	Yes	Partial cost price
Farmer	Short	Yes	No/few	

Source: Meeusen-van Onna, M.J.G, 1998

Table 1 shows that four groups of factors determine the most suitable method for calculating costs prices. First of all, there is the question of whether the agricultural production is to be undertaken place for profit or not, i.e. that the produce is seen as an internal supply by the processor of the raw materials or by the farmer who generates income through producing biomass. A second factor is the period of time the decision refers to. In het context of long term decisions, the changes in the fixed costs should also be taken into consideration, while for the short-term decisions, this element does not have to be taken into account. A third factor is whether the crop is to be positioned in relation to one single crop or not and a fourth factor is whether the growing of new crops is linked to changes in the farming system.

Horring (1948) gives the following definition of cost price: "On the one hand, the cost price is the relationship between the standardized quantities of the means of production multiplied by their monetary value in the next-best application available locally which no longer qualifies and in the period to which the cost price refers, and on the other hand, the non-monetary yield standardized according to quantify and quality corresponding to these quantities of the means of production, these yields being in a certain stage of production."

This definition refers to "standardized" quantities of means of production and products. "Standardization" of this data means that the quantities are averaged out over a number of years. The second element which Horring touches upon in his definition is the valuation of means of production in the next-best applications that no longer qualify. These alternative applications and the corresponding valuations are an important point of interest in particular in relation to labour and land.

Figure 1 gives the components of a full cost price:

- Direct costs
  - Costs of sowing seed/planting materials
  - Costs of fertilizers;
  - Costs of crop protection agents;
  - Other directly attributable costs
  - Interest on circulating assets;
  - Costs of labour carried out by third parties
- Labour costs
- Costs of implements
- Costs of building
- Costs of land use
- General expenses

Figure 1: composition of the full cost price

In some cases it may be reasoned that the crop should be compared with a single other crop that is to be replaced in order to gain insight into the (micro-economic) advantages and disadvantages of that crop. In that case, the partial cost price is the most obvious approach. Then one has to take into account the direct costs and the profit of the crop to be replaced. When the new crop yield more than the direct costs and the profit of the crop to be replaced then one can assume that the new crop will be produced. Sometimes one has to correct for a difference in demand on labour, buildings and implements.

The valuation of labour and capital is a particular point for discussion if the growing is carried out by famers. If the growing is in the hands of the industrial processor, valuation of the resources employed should be made on the basis of the collective labour agreement wage and the market interest rate. If the production is in hands of farmers this is not necessarily the case. Then the value that farmer himself attaches to his labour and capital is relevant. Often, this value is below the level of the going market prices. The following question is raised: "How much lower can the reward for the farmer be?". Of course, in the (extreme) case the farmer does not get anything for his labour and capital, one can assume that there is no long term guarantee of supply. The higher the value for the labour and capital input, the more assurance the farmer has and higher the guarantee of supply.

2.3 Production costs of bio-ethanol

Cost prices differ from region to region and from feed stock to feed stock
Table 2 gives the production costs of bio-ethanol based on agricultural feedstocks.

Table 2: Production costs of bio-ethanol based on wheat, maize, sugar cane and sugar beet, in USD per litre fuel

	Wheat	Maize	Sugar cane	Sugar beet
USA	0.545	0.289		
Canada	0.563	0.335		
EU-15	0.573	0.448		0.560
Poland	0.530	0.337		0.546
Brazil			0.219	

Source, OECD, 2006

The following conclusions can be drawn:

- Production costs of bio-ethanol vary widely:
  - They vary across regions. One can conclude that mainly for bio-ethanol based on maize the production costs vary between 0.289 USD per litre fuel in the USA up till nearly 155 % more in the EU-15.
  - They vary according to the feedstock that has been used. Using sugarcane in Brazil leads to production costs of 0.219 USD per litre fuel, while the used of wheat in the EU-15 leads to production costs of 260% more: 0.573 USD per litre fuel.
- The production costs in the EU are the highest. In the USA bio-ethanol can be produced at a lower price. Also Brazil is able to produce bio-ethanol at relative low costs.
- The differences in production costs are not related to different cost prices of technology; they are based on the differences in costs of
  - feedstock,
  - energy used and
  - prices that are received for the co products from the production process.
- The production costs of ethanol from maize can be produced at lower costs in USA, Canada and Poland.

High impact of costs of feed stock
Another study underlies some of these conclusions. His (2004) has compared some cost prices of bio-ethanol in the same regions as the OECD did.

Table 3: Cost price of bio-ethanol from several regions around the world compared to the price of petroleum motor fuel, in euro per litre and euro per GJ

	Bio-ethanol Europe	Bio-ethanol Brazil	Bio-ethanol USA	Petroleum motor fuel (25 USD/bbl)	Petroleum motor fuel (50USD/bbl)
Price per litre	0.4-0.6	0.23	0.3	0.2	0.4
Price per GJ	19-29	11	14	6	12

Source: His, 2004

Table 3 gives also the costs of production of bio-ethanol in several countries. Again the difference between countries and between feed stock is clear. However, the final cost prices differ from table 1. For bio-ethanol based on USA-corn the cost price is lower, while for bio-ethanol based on EU-feed stocks (wheat as well as sugar beets) the cost price is higher. As the calculated method is not quite clear, it is difficult to explain the causes of the differences. However, both studies give a clear insight that in the USA-case and the case of the EU the feed stock cost are responsible for more than 50 percent of the total costs. In Brazil this share is less: only one-third.

Table 4: Production cost of bio-ethanol based on several feed stocks from several regions in the world, in euro per litre

	Bio-ethanol based on US corn	Bio-ethanol based on EU sugar beet	Bio-ethanol based on EU wheat	Bio-ethanol based on Brazil sugar cane
Feedstock cost	0.20	0.23	0.25	0.06
Operating cost	0.11	0.23	0.20	0.08
Co-product credit	-0.10	0.00	-0.11	0.00
Capital repayment	0.04	0.00	0.09	0.04
Factory gate cost	0.26	0.45	0.42	0.18
Cost per gasoline-eq.litre*	0.38	0.68	0.64	0.27

*adjusted for the lower energy content of bio-ethanol
Source: International Energy Agency (2004)

Table 5 shows again the differences in cost price caused by the feed stock. It shows – like the other studies – the impact of the feed stock and the costs of the biomass.

Table 5: Costs of feed stock for bio-ethanol, in euro per litre

	USD per bushel	Yield (litres/bushel)	Feedstock (USD per litre)	Feedstock (euro per litre)
Bio-ethanol based on US corn (2003)	2.11	10.60	0.20	0.16
Bio-ethanol based on US corn (2002)	2.40	10.60	0.23	0.18
Bio-ethanol based on US sugar cane (2002)	28.77	76.84	0.37	0.30
Bio-ethanol based on India sugar cane (2002)	19.08	74.91	0.25	0.20
Bio-ethanol based on Brazil sugar cane (2002)	6.00	76.84	0.08	0.06

Source: Shapouri, 2003

2.4 Production costs of bio diesel

Cost prices differ from region to region
Table 6 gives the production costs of bio-diesel based on vegetable oils. One can compared those costs with the market prices of the petrol-based bio fuels in order tot assess the viability of bio fuels.

Table 6: Production costs of bio-diesel based on vegetable oil, in USD per litre fuel

USA	0.549
Canada	0.455
EU-15	0.607
Poland	0.725
Brazil	0.568

Source: OECD, 2006

The following conclusions can be drawn:
- The production costs for bio-diesel are the lowest in Canada.
- The production costs for bio-diesel are within or close to the range of production costs for ethanol from wheat and sugarbeets. They are higher than the production costs for ethanol from maize and sugarcane.

His (2004) comes to a lower cost price of bio-diesel: 0.35 to 0.65 euro per litre (10.5 to 20 euro per GJ).

The quick scan literature search learned that only in the Agricultural Simulation Model of the US Agricultural Sector (POLYSYS) the issue of the competing crops is taken into account. This model seeks to estimate the farmgate price needed to make bio-energy crops economically competitive with alternative agriculturual uses for cropland. The model has been used to estimate the economic impacts of increasing the demand for biodiesel fuel and the resulting impacts on the agriculture sector. The model has estimated the potential supply of two new crops that can be used as feedstock for biodiesel: sunflower and canola. The study was focused on the Southeastern states of the US.

Table 7: Impacts on area, crop prices and crop net returns in 2007 in the scenario "USD 2,90 per MBTU"

Crop	Area (base-line) (mill. Acres)	Area (sce-nario) (mill. acres)	Change in area (%)	Change in crop prices (%)
Corn	84.50	83. 20	-1.5	2.3
Sorghum	11.20	11.20	0.0	2.1
Oats	4.70	4.70	0.0	1.1
Barley	7.10	7.10	0.0	1.4
Wheat	76.00	76.10	0.1	0.4
Soybeans	69.50	70.70	1.7	1.0
Cotton	14.00	13.90	-0.7	0.0
Rice	3.20	3.20	0.0	0.0
Sunflower	0.00	0.00		11.9
Canola	0.00	0.10		8.2

Source: De La Torre Ugarte, 2000

Table 7 shows the crop area and price impacts for the "most aggressive" demand scenario in which 1% of the diesel have to be replaced by biodiesel. It's clear that the additional demand requires oilcrops: the area of soybeans is increasing and the area of corn decreases. The demand results in higher prices of vegetable oils. Higher prices for oil and soybeans can be expected. However, due to the fact that the feed market is not increasing which the supply of soy bean meals is growing, the price of soy bean meals declines. This results in only a small increase of the price of soybeans.

2.5 Competitiveness of bio fuel

Competitiveness at 60 USD per barrel

Enclosure 1 gives the marketprices of oil in 2004; when corrected for the differences in energy content one can compare the competitiveness of the biofuels in 2004. However, more interesting is the threshold oilprice at which the biofuels are competitive. Table 3 and table 4 give the threshold oil prices for the bio-ethanol and biodiesel at which they are competitive to the petroleum based fuels.

The following conclusions can be drawn:

- Brazil is the only producer able to produce at lower costs than the marketprice of petrol-based gasoline in 2004 (USD 39 per barrel).
- However – when expressed in USD per litre of gasoline equivalent (taken into account the differences in the energy content) – the production costs of bio-ethanol based on maize is higher than the price of gasoline (without taxes) in 2004 (USD 39 per barrel). It would be competitive at a price of USD 44 per barrel.
- For bio-ethanol based on wheat or sugar beets from EU, Canada and USA the threshold price is higher: up to 60 USD per litre of gasoline equivalent. For the Canadian bio-ethanol from wheat the threshold price is even 140 USD per litre.
- Bio diesel production costs are almost 1,5 to 2 times the oil-based diesel price net of tax in 2004 (USD 39 per barrel). Bio diesel is competitive at a higher threshold price than bio ethanol. The Canadian bio diesel is competitive at a oil price of 60 USD per litre, but the

other bio diesels from EU, USA and Brazil are less competitive. The oil price has to rise to the level of 80-90 USD per litre to be competitive.

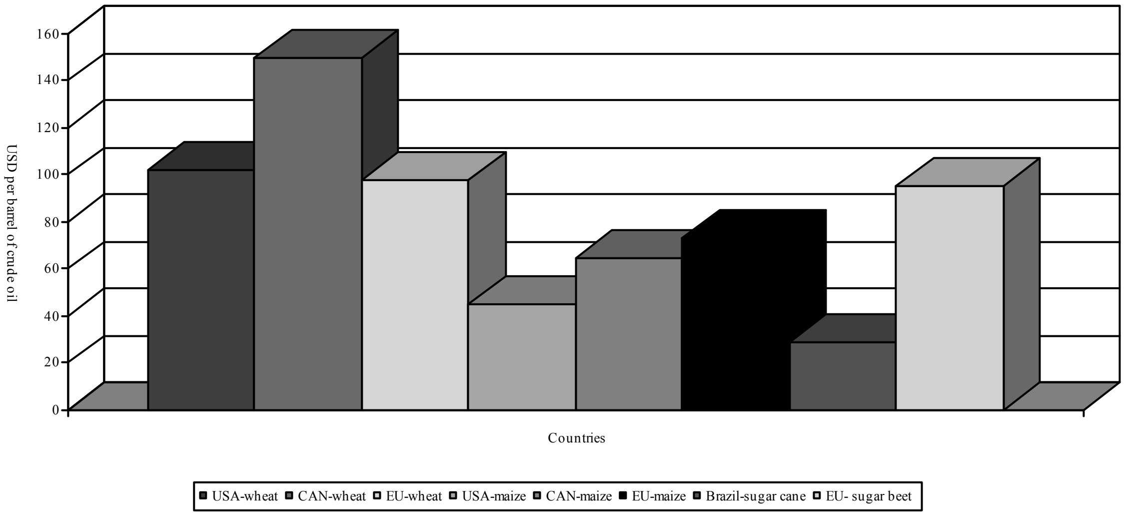

Figure 3: Threshold oil price at which bio-ethanol is competitive, in USD per barrel
Source: OECD, 2006

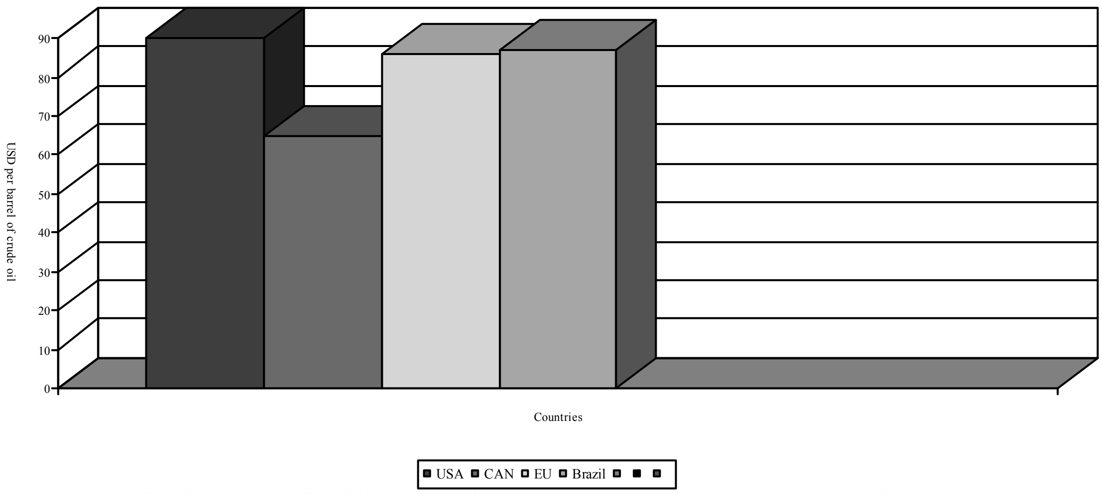

Figure 4: Threshold oilprice at which bio-diesel is competitive, in USD per barrel
Source: OECD, 2006

2.6 Impacts of an expected growth in the biofuel-related demand for agricultural products on commodity markets, which has an effect on the farmers income.

In the OECD-report attention has been paid to the impacts of an expected growth in the biofuel-related demand for agricultural products on commodity markets, which has an effect on the farmers income. Also the POLYSYS – with the focus on the United States pays attention to this issue.

The OECD-study has assessed the impacts on commodity markets by using the OECD partial equilibrium model for temperate zone agricultural commodities. It assumes that prices are developing to a (new) point at which supply and demand are at a (new) equilibrium.

First of all the needed area in the different countries has been assessed. "What area is needed in order to produce 10% biofuels of the total transport fuel consumption?" has been the question. Figure 5 gives an idea of the needed area.

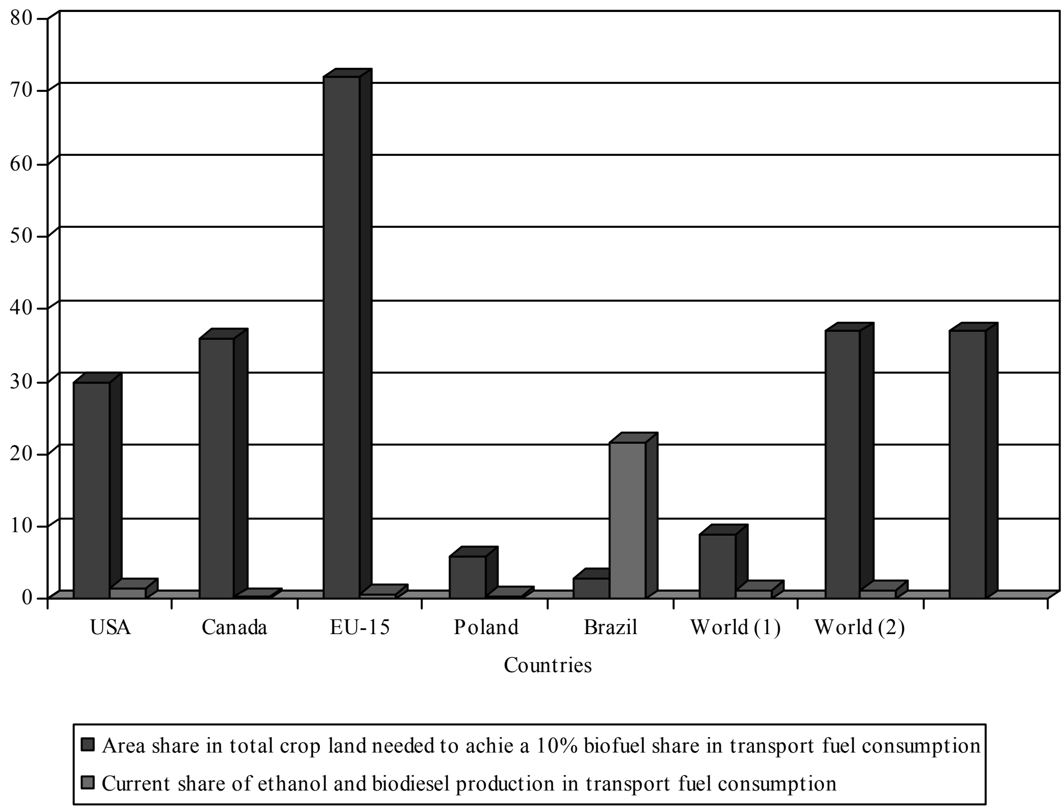

Figure 5: Biofuel shares in transport fuel consumption and land requirements for 10% biofuel shares in major biofuel producing regions
Source: OECD, 2006

One can see that the area requirement is substantial with the current technologies. In the USA and Canada about one third of all land currently harvested for cereals, oilseeds and sugar crops would be needed to produce biofuels equivalent to 10% of their transport fuel consumption. The EU-15 needs more, namely more two-third of the area (72%) currently used for these crops. It's clear that such a development does affect the markets of

- commodities and therefore
- the farmers income and
- the world supply of agricultural products

One has to take into account that these calculations are based on current crop yields and bio fuel production technologies. The necessity to develop technologies which are able to use less prices feedstocks of feedstock mixes is clear, the second generation technologies.
The impacts of the expected growth in the biofuel-related demand for agricultural products on commodity markets have been calculated in the OECD-report. The OECD has formulated three scenario's[2].

[2] Namely (1) Constant biofuels scenario, (2) Policy target scenario and (3) High oil prices scenario

the use of wheat and coarse grains and sugarbeets for ethanol production increases, the use of vegetable oils for biodiesel production increases ↓ increasing imports and decreasing exports ↓ world prices of oilseedmeals, sugarbeets and vegetable oils will rapidly increase world prices of grain will increase less ↓ moderate impacts on meat and dairy markets (except butter due to the rise of vegetable oil prices) ↓ lower growth in ethanol and biodiesel production

Figure 6: Relations between (prices on) the agricultural markets

The *high oil price scenario* assumes higher oil prices, namely USD 60 per barrel. This affects world markets for agricultural products in two ways:

- Higher energy prices will result in higher production costs of agricultural products;
- Higher energy prices will result in more production of biofuels.

The share of energy costs in total production costs is 25 to 43%. When energy prices rise the world prices of agricultural products will be higher. The OECD assumes a rise of world prices from 10% (wheat) to 17% (oilseeds). Furthermore, the world prices of agricultural products will rise due to the fact that the production of biofuels will be more attractive. Mainly for sugar, vegetable oils and oilseed meals this will result in substantial higher world prices. For the other agricultural markets the effects are less, they are relatively small.

The same conclusions have been drawn by Walsh et al. (…) by using the POLYSYS-model, in which the potential impacts of bioenergy production on agricultural markets are being assessed. This has been done mainly for crops which can be used for electricity: switchgrass, willow and poplar. Walsh et al. (??) conclude that a shift of cropland from traditional crops to bioenergy crops results in higher prices for traditional crops. The impact on prices depends on (a) the area shifted to the new bioenergy crops and (b) the elasticitiy of supply and demand for each crop. Walsh et al. calculated fairly large effects: up to 10% in certain scenario's.

The Policy Analysis System (POLYSYS) is able to estimate supply of biomass at different price levels. The model is designed to estimate the area of new crops that will be produced. The land allocation among competing crops in several regions (305 in the US) is based on the maximization of the expected returns. POLYSYS is able to take into account new established prices – due to the new equilibrium in supply and demand. POLYSYS has been used to calculate the area of three new bioenergy crops: switchgrass, poplar and willow.

Table 8: Impacts on area, crop prices and crop net returns in 2007 in the scenario "USD 2,90 per MBTU"

Crop	Area (baseline) (mill. Acres)	Area (scenario) (mill. acres)	Change in area (%)	Change in crop prices (%)	Change in crop net returns (%)
Corn	84.50	83.80	-0.9	1.9	2.4
Sorghum	11.20	10.80	-3.8	7.9	15.2
Oats	4.70	3.85	-18.1	20.5	372.2
Barley	7.10	6.66	-6.2	8.6	10.8
Wheat	76.00	72.10	-5.2	8.5	12.5
Soybeans	69.50	68.20	-1.9	3.6	3.5
Cotton	14.00	13.60	-3.0	1.5	0.0
Rice	3.20	3.15	-1.6	2.4	2.0
Alfalfa	26.60	25.90	-2.7	0.0	
Other hay	32.60	26.70	-17.9	0.0	

Switchgrass	0	14.50			
Poplars	0	0.07			
Willows	0	0.18			

Source: De La Torre Ugarte, 2000

Table 8 shows the effect on crop prices – nearly up to 10%. In response to the large relative acreage loss, the price of products increase

Summarized, the additional demand for agricultural commodities is likely to substantially affect the outlook for their markets. The major producers of biofuels will reduce their exports and increase their imports, resulting in higher world prices.

3. By products as a feed stock for bio fuels

3.1 Approach

A quick scan literature search forms the base for this section. The literature search results in some graphs and tables which show cost prices. Furthermore an analyses of the Dutch situation on by products forms the base for answering the question "which factors affects the use of by products for bio energy applications?". The relevant factors, which affect the use of by products for bio energy will be illustrated by the Dutch case.

3.2 Relevant factors

Why available?

Table 9 gives an overview of the by products in the Netherlands.

*Table 9: By products in the Netherlands, in tonnes per year**

Industry	By product (the typical Dutch word)	Quantity	Comments
Products from the potato-industry	"afgekeurde aardappelen" "aardappelstoomschillen" "snijverlies" "vlokken/snippers"	957.000	Totally
Fats and oils	"oliezadenschroot" "diermeel" "dierlijke vetten" "gebruikte oliën, vetten"	3.725.000 210.000 30.000	Totally schroot, schil-fers industrieel huishoudelijk
Zetmeel en meel	"aardappelpersvezel" "aardappeldiksap" "snippers" "sorteerafval" "aardappeleiwit" "tarweconcentraat" "maïsgluten" "tarwegries"	1.760.000	Totaal
Sugar	"bietenstaartjes" "natte bietenperspulp" "gedroogde bietenpulp"	1.089.000	Totaal

	“bietmelasse”		
Liquid	“graanspoeling”	5.000	
	“bierbostel”	500.000	

* on wet base

Sources: Vis, 2002; Gave, 2003a; Elbersen et al., 2004).

Table 9 gives the an overview of the raw materials which are available in the Netherlands. The first impression is: “a high amount of biomass!”. However, when one looks a little bit closer at the source of the co product the picture is less optimistic for the bio fuel market. One can see that a large amount of the by products is used in the Dutch feed industry. More than 13,5 million tonnes is used as feed. From this amount 8 million tonnes is imported from abroad – as a raw material which can be used in the Dutch feed industry. Only 5 million tonnes is available at the Dutch processing sites. One can ask himself whether the amount of 8 million tonnes will be imported for the bio fuel market. Only when the bio fuel market can offer competitive prices the import will be attractive; otherwise this amount will not be available. This is less the case for the 5 million tonnes, which become available at the Dutch processing sites. When the competitiveness of this industry is – on long term – high this amount will be much more “sure”.

Table 10: The raw materials used in the Dutch feed industry, in 1.000 tonnes

Source of the biomass	Processing	Example	2003	2004
The Netherlands	The Netherlands	Potatos, sugarbeets	1.422	1.520
Import to the Netherlands	The Netherlands	Soybeans, corn, mais	4.078	3.894
Import	Import	Pulp, sojaschroot….	7.884	8.128
Total			13.502	13.668

Source: Productschap Diervoeder

The main driving force for the existence of the by products in the Dutch economy is the demand of (cheap) feed in the pig- and chickensector. The Netherlands are famous because of the ability to use all kinds of by products from all over the world for their feed industry. This ability has formed the base of a high competitive pig and chicken sector. However, one can see a declining demand in this industry. Bolhuis (mondelinge mededeling) expects that the demand will decrease with 1 million ton per year. The large amount of by products is often mentioned as a change for the bio fuel market. However, one can see that a large amount is imported from abroad for the feed industry and the question to be answered is: “will the import take place for a less valuable product as bio energy?”. To summarize: one has to be aware of the driving factors behind the existence of the by product in order to form a realistic picture about the availability of biomass.

Demand of main products, position of the farmers and processing industry

The key driving force of the availability co products is the market of the main product which has to compensate (for a high share) the production costs. The supply of co products is a direct result of the market of the products which form the core business of producing and processing. Therefore: What happens when the market of the main product will decline? What happens when the industry is not competitive any more and the production will move to more competitive countries or regions in the World? Such developments – which have no direct relation to the (bio)energy market – have severe impacts on the availability of the co products. Less demand on processed sugar means: less melasse. The movement of agricultural processing to a low cost country means: less agricultural co products. Therefore: one has to take into account that there is much more dependency on other markets – which have less relation with energy.

Competing uses
The competing markets for the co products have to be considered. In some cases the co products have high value components which can be used in high value outlets (food, farma, feed); fuel is an outlet which can be characterized as “low value”. The owner of the co product will consider the pro’s and contra’s of several outlets and will choose the one which fits the best with his strategy. When the processor wants to focus on products which give the highest yield and he wants to take the risks, the biofuel market is less attractive. However, in the case the processor wants to focus on his core business – production and product development of his main product – the market of bio-fuel might become more interesting.

In the Netherlands, a high share of the co products (80-85 %) is used as feed component. This market is highly competitive and more attractive than the energy market.

Costs of transport and logistics
Co products can be available at low prices at the site of production. However, they have to be transported to the place of processing to bio-energy. This requires often high costs.

Importregime
The question where to process the co products to biofuel is also affected by the importregime. The EU required a higher percentage of tax on product which are processed than on the raw materials. For example: cacaobeans can be imported for 0% and for choclat the EU asks 8-18,7%; the same accounts for soybeans, which can be imported for 4,75% and the import of soybean-oil is taxed by 11,5-12,8%.

3.3 Costs of by products

First figure 7 shows the relation between prices of biomass and sources of biomass. The figures tries to emphasize that by products from mills, forestry and agriculture are relative cheap compared to the energy crops. It’s clear that with a more spread …. Of the biomass the prices are higher. By products from mills are concentrated: they are … at the mill site; however by products from farms …. At several places: in (relative) small quantities at (relative) many places. This results in high costs of transport and logistics.

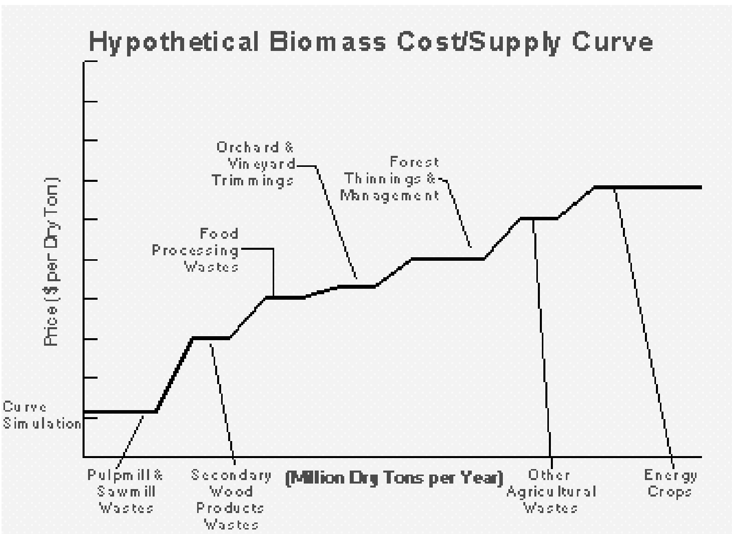

Figure 7: the relative price for by products and energy crops (http://www.woodycrops.org/mechconf/turnbull.html).

Figure 2 also shows that by products are available at relative lower prices.

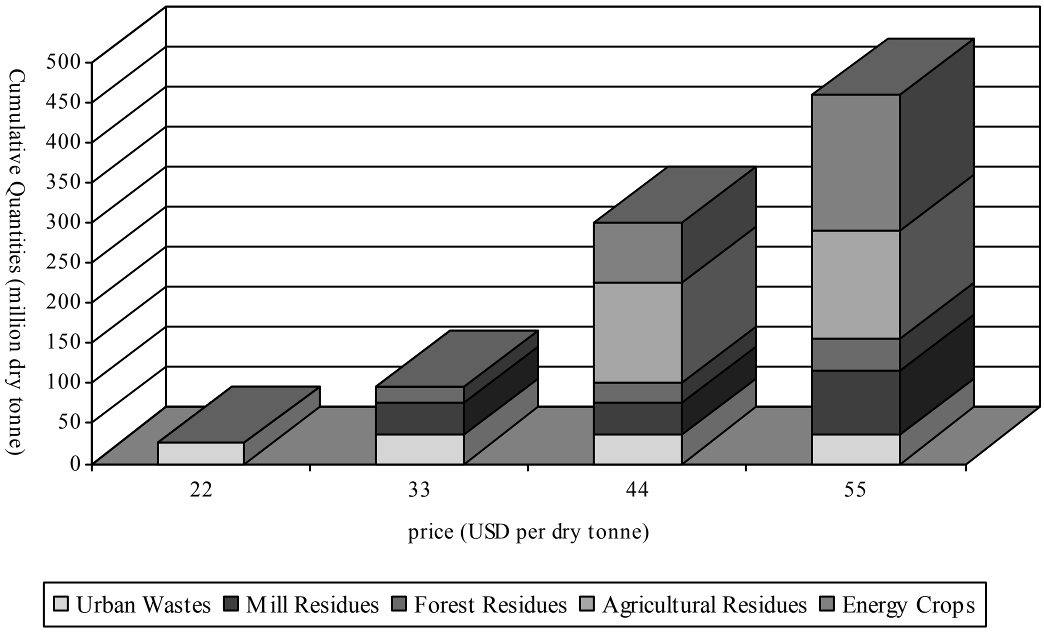

Figure 8: Cumulative quantities of biomass at different prices.
Source: Wright et al., 2000

Table 11 gives the predicted cost price of bio fuels based on second generation processes with the use of "cheap" biomass as a source. One can learn from the previous sections that the costs of feed stock take a high share of the total costs. The challenge – therefore – is: how to reduce those costs? One of the "solutions" is to use less costly feed stock. Therefore it is important to develop the second generation processes, which are able to use all kinds of feed stock. Table 11shows the effect of implementation of the second generation processes with less costly feed stock: the cost price will be nearly 50 percent lower.

Table 11: Predicted cost price of bio fuels based on second generation processes, in euro per litre

	US Cellulosic case 2000	US Cellulosic case 2010
Feedstock cost	0.12-0.13	0.08
Operating cost	0.03	0.01
Co-product credit	-0.02	0.00
Capital repayment	0.11-0.14	0.06
Factory gate cost	0.23-0.29	0.15
Cost per gasoline-equivalent litre*	0.34-0.42	0.22

- adjusted for the lower energy content of bio ethanol

4. Conclusions

Cost prices differ from region to region and from feed stock to feed stock

- Brazil is by far the most cost-effective producer of fuel ethanol – with production costs of about USD 0.22 per litre of ethanol or USD 0.33 litre of gasoline equivalent. USA is following Brazil: USA is able to produce bio-ethanol based on maize for USD 0.289 per litre of ethanol.
- The Canadian biodiesel is (far) the most attractive in terms of cost price.

Production costs of bio diesel are almost 1,5 to 2 times the oil-based diesel price

- Bio diesel production costs are almost 1,5 to 2 times the oil-based diesel price net of tax in 2004 (USD 39 per barrel). Bio diesel is competitive at a higher threshold price than bio ethanol. The Canadian bio diesel is competitive at a oil price of 60 USD per litre, but the other bio diesels from EU, USA and Brazil are less competitive. The oil price has to rise to the level of 80-90 USD per litre to be competitive.

Costs of feedstock have a substantial influence on the cost price
A high percentage of the production costs of biofuels is caused by the costs of the feedstock. More than half of total costst of ethanol production is represented by the value of the feedstock. The same goes up for biodiesel, where three quarters of total production costs is represented by the costs of vegetable oils.

Therefore: bio fuels based on by products have a lower cost price, but …
In general by products are more attractive in terms of economics (cheaper) and in terms of sustainability. However, using by products requires more awareness on risk management. One has to consider the driving forces behind the availability of by products; market developments of the main products have to be considered, the competitiveness of the processing industry have to be taken into account. One has to think about the competitive outlets for the by products and the development in outlets, technology etc. Using by products means: being more influenced by developments outside the bio fuel markets.

Therefore: the development of the second generation technology is important
New technologies – in the longer run – have to be developed in order to use less priced biomass feedstocks.

Influencing factors
Factors that affect the use of biomass for bio-energy applications can be distinguished in three groups: people, planet and profit. The paper has focused on profit, but one can summarized the aspects concerning people and planet.

- Profit:
  - Competing outlets and uses for land and labor
  - Competing outlets for products (by products)
  - Driving forces behind the availability of by products (why are they available?)
  - Technology (second generation is able to use less prices biomass)
  - Logistics and transport (by products!)
- People
  - Income – calculated in a "good" cost price
  - Effects on other agricultural markets and their effects on food security and income
  - Transparency in the agricultural chain
- Planet
  - Use of water, minerals, pesticides, energy
  - Effect on biodiversity, climate, resources

Effect on other markets

The additional demand for agricultural commodities is likely to substantially affect the outlook for other agricultural commodity markets. The major producers of biofuels will reduce their exports and increase their imports, resulting in higher world prices. Also: the production of bio fuels results in more feed. However, is the feed industry demanding this product? And: what does that mean for the cost price of the bio fuels? One has to be aware of the fact that development in market A has influence on the prices of product B, which results in movements on market C and prices of product D. Especially in the case of bio fuels, which requires large amounts of area.

References

De La Torre Ugarte, D.G. and D.E. Ray (2000) “*Biomass and bioenergy applications of the POLYSYS modelling framework*” Biomassa and Bioenergy 18 291-308

His, S. (2004) Panorama 2005: A look at Biofuels Worldwide, IFP-Information

International Energy Agency (2004, Biofuels for Transport, Paris

Lönner, G. and A. Törnqvist, (1990) *Economic Evaluations of Biomass Oriented Systems for Fuel* in Biomass 22 187-194

Meeusen-van Onna, M.J.G. (1998) New methods for feasibility studies on establishemnt of new agricultural production chains, Agricultural Economics Research Institute (LEI-DLO), The Hague

OECD, (2006), Directorate for food, agriculture and fisheries, committee for agriculture, *“Agricultural market impacts of future growth in the production of biofuels”*, AGR/CA/APM(2005)24/FINAL

Shapouri, Conference Agro-Demain reims, France…..

Walsh et al. …………

Wright et al., 2000, Biomass Feedstock Research and Development for Multiple Products in the United States, Bioenergy Feedstock Development Program, 1st World conference and Exhibition on Biomass for Energy and Industry, Sevilla, Spain, June 5-, 2000

(http://www.woodycrops.org/mechconf/turnbull.html).

Annex 1: Market prices of petrol-based gasoline

Table 1.1: Marketprice of petrol-based gasoline, in 2004, in USD per litre fuel

Gasoline	With tax	Without tax	RSC
USA	0,540	0,.384	0.311
Canada	0,680	0.401	0.311
EU-15	1.316	0.406	0.311
Poland	1.200	0.392	0.311
Brazil	0.840	0.394	0.311
Diesel			
USA	0.570	0.373	0.301
Canada	0.680	0.391	0.301
EU-15	1.286	0.396	0.301
Poland	1.090	0.382	0.301
Brazil	0.490	0.384	0.301

Source: OECD, 2006

Conclusion
Cost prices differ from region to region and from feed stock to feed stock

Markets depend on each other - influences
Table 1.1 shows the crop area and price impacts for the "most aggressive" demand scenario in which 1% of the diesel have to be replaced by biodiesel. It's clear that the additional demand requires oilcrops: the area of soybeans is increasing and the area of corn decreases. The demand results in higher prices of vegetable oils. Higher prices for oil and soybeans can be expected. However, due to the fact that the feed market is not increasing which the supply of soy bean meals is growing, the price of soy bean meals declines. This results in only a small increase of the price of soybeans.

The following conclusions can be drawn:

- Brazil is the only producer able to produce at lower costs than the marketprice of petrol-based gasoline in 2004 (USD 39 per barrel).
- However – when expressed in USD per litre of gasoline equivalent (taken into account the differences in the energy content) – the production costs of bio-ethanol based on maize is higher than the price of gasoline (without taxes) in 2004 (USD 39 per barrel). It would be competitive at a price of USD 44 per barrel.
- For bio-ethanol based on wheat or sugar beets from EU, Canada and USA the threshold price is higher: up to 60 USD per litre of gasoline equivalent. For the Canadian bio-ethanol from wheat the threshold price is even 140 USD per litre.

4

Import of Biomass: logistic advantages of overseas pre-treatment

By: Robin Zwart (ECN)
Date: April 13, 2006

Definition of the problem
In the very near future the Netherlands will need huge amounts of biomass, most of which will be imported, for co-combustion in existing coal plants. Furthermore, there will be substantial extra demand for biomass for liquid and gaseous biofuels. Pre-treatment of solid biomass prior to import, and the related costs and efficiency losses, are the key issues that determine the technological and economic potential of the biomass import.

Questions
i. Which pre-treatment technologies need to be included?
ii. Which biomass intermediates or products should be transported?
iii. Which locations will be most suitable to establish pre-treatment plants?
iv. Which scale is the most feasible?
v. What will be the approximate investment costs involved?

1. Introduction

As biomass is envisaged to play a major role in fulfilling national targets concerning the reduction of CO_2-emissions and the introduction of renewable energy sources, ambitious targets have been set. In the EOS-LT program, with respect to co-firing, 25% biomass co-firing (on energy basis) is foreseen for 2020, whereas in 2040 40% biomass co-firing should be realised. In the overall long-term vision of covering 30% of the total energy consumption of the Netherlands by biomass energy in 2040, and covering 20-45% of the feed-stock requirements of the chemical industry with biomass, large-scale import of biomass (either wood or grass-like) will be required.

The Netherlands have a considerable domestic biomass potential, however, this domestic potential may even not be sufficient to reach the short-term targets for 2010 for biofuels (5.75% of demand) and renewable electricity (9% of demand).

2. Large-scale biomass plants

Realising the objective of 30% biomass energy involves approximately 1200 PJ of biomass, which corresponds to 45 GW_{th} of biomass capacity. For comparison, the total installed capacity of all coal-fired power stations in the Netherlands is approximately 10 GW_{th}, whereas the largest size available at this moment for a biomass plant is roughly 100 MW_{th}.

The domestic biomass potential, *i.e.* various waste streams adding up to approximately 100-120 PJ and theoretically another 50 PJ made by "energy farming", might be converted through (de-central) small scale biomass plants (not discussed further in this report). As for the Netherlands, however, most biomass required has to be imported and thus will be available in large quantities at only few places, the (central) biomass plants will generally have to become larger, possibly up to 10 GW_{th}.

These large-scale plants have the advantage of *(i)* economy of scale, *(ii)* higher efficiency, and *(iii)* easier/cheaper to meet emission limits. Furthermore, finding suitable locations for thousands of small-scale plants in a densely populated country is extremely difficult, and large-scale plants better fit to the present situation where most energy is produced at only few places where permits and logistics are suited. This is all very similar to the present situation with coal as fuel.

3. Biomass feedstock, intermediates and final products

Considering the whole route of conversion of overseas biomass to bioproduct (being either electricity, fuels or chemicals) in the Netherlands, numerous processing steps at different locations along the route can be defined. If the large-scale biomass plant is located in the Netherlands, the required biomass can be imported as original feedstock (*e.g.* wood logs or chips) or as biomass intermediate (*e.g.* pellets, pyrolysis slurry, torrefied wood, TOP pellets). Depending on the final product, the final biomass conversion facility might also be located overseas. In that case, the Netherlands would import the product (*e.g.* methanol, diesel, chemicals, SNG, LNG) rather than the biomass feedstock/intermediate.

An overview of an overall system for products from imported biomass is presented in figure 1. The biomass is collected at a number of production locations and transported to collection facilities, from where it will be transported to and stored at a central port. From the central port, the biomass is transported (*i.e.* by ship or train) to a large-scale biomass conversion facility, in this specific case located at the port of destination.

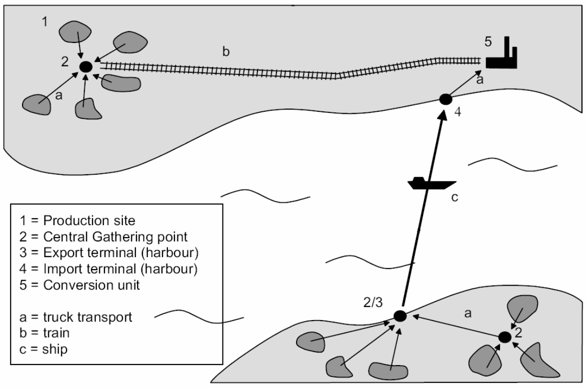

Figure 1 *Overview of an overall system for products from imported biomass* [1]

The biomass conversion facility might also be located at the central gathering point or the export terminal. As all biomass, however, has to be transported by land to this facility and land transport is relatively expensive the distances between production site and central gathering point, as well as between central gathering point and export terminal should be kept small (< 100 km). As a result, the maximum scale of the conversion facility is restricted by the biomass supply (*e.g.* roughly 150 MW_{th} for the central gathering point and 1 GW_{th} for the export terminal) and, hence, the facility might, depending on the scale-up potential of that facility, become relatively more expensive than a 10 GW_{th} conversion facility at the port of destination [2, 3].

Biomass pre-treatment plants, however, are often limited in scale and therefore constructed modular. As a result, biomass can be pre-treated in the export terminal or even in the central gathering point without being burdened by the economy-of-scale effect. As for transport of biomass over longer distances, biomass should preferably be converted into a form that is suitable for bulk handling, the pre-treatment plant should be located preferably near the production location of the biomass, hence at the central gathering point (< 150 MW_{th} scale). The biomass conversion facility, in order to benefit from the economy-of-scale, should at least be located at the export terminal (± 1 GW_{th} scale), but preferably at the port of destination (up to 10 GW_{th} scale) [4].

4. Fischer-Tropsch diesel production as reference case for transportation fuels

The logistic advantages of overseas pre-treatment on import of biomass can be illustrated by the assessment of Fischer-Tropsch diesel production routes. In these Biomass-to-Liquids (BtL) routes biomass is converted into syngas, subsequently fuel is produced via Fischer-Tropsch (FT) synthesis. Entrained-flow (EF) gasification is identified as the optimum process for large scale production of syngas from (a variety of) solid biomass streams (e.g. woody biomass and straw and herbaceous material). As the assessment will illuminate, pre-treatment of solid biomass, and the related costs and efficiency losses, are key issues that determine the technological and economic potential [4].

4.1 System definition

Integrated systems from biomass overseas to FT-products on an 8 GW syngas scale are assessed, a scale at which the actual FT synthesis and product upgrading are economically feasible. The biomass production is assumed in the Baltic States and the Rotterdam harbour is taken as final location. The harvested biomass is naturally dried in the forest before transport to a pre-treatment plant. The first step of the pre-treatment is size reduction and further active drying after which the actual pre-treatment takes place. The product (pre-treated biomass) is then transported to the BtL plant, where it is compressed to the required pressure for gasification, fed to the gasifier, converted into syngas, synthesised to FT-crude, and upgraded to FT-product (*i.e.* diesel).

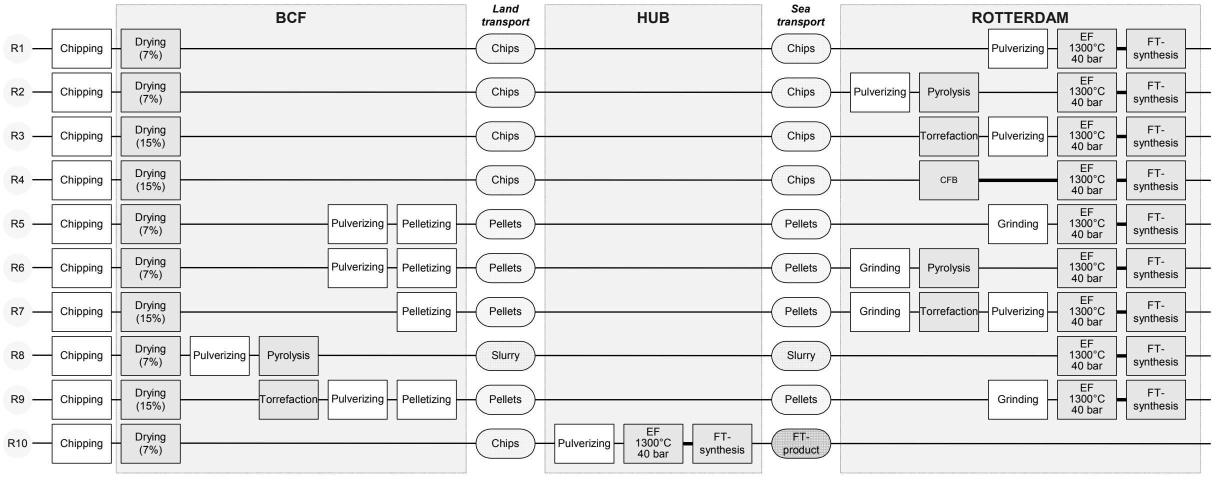

Figure 2 *Overview of the considered Biomass-to-Liquids (BtL) production routes* [4]

The evaluated BtL production routes, as presented in figure 2, comprise the whole chain of biomass collection, transport, syngas production, gas cleaning, FT-synthesis and product upgrading. The biomass is collected in a number of production locations and transported to 80 biomass collection facilities (BCF), from where the (pre-treated) biomass is transported to and stored at 8 central ports (HUB). In order to assess advantages of pre-treatment on transport and storage, several pre-treatment technologies are considered in the BCF. From the central ports, the (pre-treated) biomass is shipped to the location of one syngas production facility. At this facility with intermediate storage capacity, the biomass is (additionally) pre-treated and subsequently gasified. Pre-treatment of biomass in BtL systems may be required to enable feeding into the gasifier, as well as desired for transport costs reduction or improved gasifier operation.

The gasification and synthesis plant is chosen to be located in a Western European port, *e.g.* Rotterdam, based on *(i)* the port infrastructure being appropriate and *(ii)* the port being an existing HUB in production and distribution of transportation fuels. Short term implementation of a BtL route might strongly benefit from a good chemical and petrochemical infrastructure nearby. However, a reference route is considered as well, in which gasification and synthesis are located in the HUB.

4.2 Biomass feeding considerations

When conventional feeding systems are to be applied, biomass needs to be pre-treated to become similar to coal or converted into a pumpable liquid. In order to mill biomass to <u>*particles*</u> with the required size (*i.e.* ~100 μm) the electricity consumption is approximately 7% of the energy value of the biomass. Furthermore, milled wood still cannot be fed with conventional systems, due to the fibrous nature of the biomass. It does not fluidise and fluffs are formed that plug the piping. Therefore, milling of biomass to a size of 100 μm is not considered a feasible option. Alternatively, *char* might be used, obtained from (slow) pyrolysis. The char, however, contains only 40-60% of the energy of the biomass. The remainder is contained in the (tar rich) pyrolysis gas, which has to be used on site and is not available for BtL production if the FT process is located elsewhere. Therefore, char is considered not a feasible general option due to the low overall chain efficiency. *Torrefaction* is a mild thermal treatment in which the biomass looses its resilient and fibrous properties. It becomes dry, brittle, and can be easily milled. The energy efficiency of the torrefaction step is up to 95%. The remainder is torrefaction gas mainly containing H_2O, CO_2, and small amounts of light (oxygenated) hydrocarbons. This combustible gas can be used to provide heat for the torrefaction process. Torrefaction is considered as a suitable pre-treatment option.

Options based on liquid feeding involve pyrolysis. By (fast) pyrolysis a liquid, *bio-oil*, is produced containing up to 70% of the energy of the biomass. The remainder of the energy is for ~15% in the pyrolysis gas and ~15% in the char. The gas can be used to generate the electricity for the plant and about half of the char is required to produce the heat for the pyrolysis process. The other half is surplus. However, in most cases it is burned inside the process as well resulting in additional waste heat. Overall the efficiency is low and, therefore, bio-oil is considered not a feasible option. *Bio-slurry* is produced in a (fast) pyrolysis process similar to bio-oil production, with the exception that all produced char and oil are isolated as a slurry. This process is developed by Forschungs Zentrum Karlsruhe (FZK) in Germany. The energy efficiency of this FZK process is approximately 85-90%, the pyrolysis gas is used to provide the heat for the process. With this higher efficiency bio-slurry is considered a feasible candidate option.

Alternatively to converting biomass into liquids or coal-like material, new feeding systems for biomass can be developed. In a *low-temperature gasifier* the biomass is converted into product gas and a small amount of char. The gas with entrained char is fed into the EF gasifier. Advantages are that no extensive biomass pre-treatment is required, as circulating fluidised bed (CFB) gasifiers can handle relatively large fuel particles. The efficiency is nearly 100%. The easiest solution of feeding biomass to the entrained-flow gasifier is direct piston screw *feeding of 1 mm particles*. Electricity consumption for milling is only in the order of 1-2% and there are no conversion losses. The challenge, however, is to ensure stable feeding and dosing to the gasifier burner to establish a stable flame.

4.3 Biomass transport considerations

For transport of biomass over longer distances, biomass should preferably be converted into a form that is suitable for bulk handling. Therefore, the pre-treatment plant should be located preferably near the biomass production location. Biomass forms that are suitable for cost-effective transport over longer distances (considering the biomass feeding issues described before), and allow transshipment with bulk handling processes, are: chips, pellets, bio-slurry and torrefaction pellets (TOP).

When chipping wood the biomass is also dried to 7-15% moisture prior to the process to reduce the electricity consumption. *Wood chips* are readily transported and transshipped by bulk handling processes, however due to the relatively low bulk density (~350 kg/m³) and the risk of rotting, costs of transport, transshipment, and storage are relatively high. The production of *pellets* leads to an increase of the bulk density of the biomass (~450-650 kg/m³). Pellets are suitable for bulk handling as well. Alternatively, biomass materials can be converted into a bio-slurry or into torrefied material. The *bio-slurry* has the advantage of a very high bulk density (~1200 kg/m³) and it can be transported and handled as a liquid (comparable to heavy oil). However, HSE (health, safety, and environmental) aspects of bio-slurry are not yet clear.

In case of torrefaction, the biomass can be transported as *torrefied wood* chips, which are suitable for bulk handling. However, the torrefied branches, leaves, needles and straw contain too many fines. Pelletisation is therefore preferred to produce the so-called “TOP pellets”. Additional advantage of pelletisation is the increase in both material and energy density (~850 kg/m³). This also happens in normal pellets, however, due to the resilient nature of fresh biomass the increase in density is much smaller. Further advantages of torrefied biomass with respect to handling and further processing are the hydrophobic nature of the material and the lower electricity demand during pulverisation. Increasing the energy density is even more advantageous than increasing the mass density as from certain densities a higher mass density has no logistic advantages anymore (i.e. the mass becomes the limiting factor in ship transport instead of the volume).

4.4 BtL production routes

The ten assessed BtL production routes as presented in figure 2 can be divided into three groups, *i.e.* routes *(i)* based on sole chips transport (R1 to R4), *(ii)* in which biomass is pelletized conventionally before transport (R5 to R7), and *(iii)* with some kind of thermochemical conversion performed before transport (R8 to R10). When transporting biomass as chips to the syngas facility in Rotterdam four concepts are evaluated; 1 mm powder feeding (R1) to the EF gasifier and bio-slurry production (R2), torrefaction (R3) or CFB gasification (R4) before EF gasification.

Conventional pellets have to be ground in Rotterdam to be fed either straight into the EF gasifier (R5), or to be pyrolysed (R6) or torrefied (R7) in order to simplify the feeding system of the EF gasifier. The torrefaction process still contains a pelletisation step, as temporary storage of the torrefied wood at Rotterdam is desired. TOP pellets are fed to the EF gasifier by lock hoppers, intermediate disintegration to 100 μm particles, and a pneumatic feeding system, whereas bio-slurry uses a pump, and 1 mm particles a piston compressor for pressurisation and screw feeding system. In routes R8 and R9 the pyrolysis and torrefaction are performed in the BCF in order to benefit from logistic advantages. CFB gasification within the BCF as a pre-treatment step is not considered, as this would require syngas transport from the BCF to Rotterdam.

The final route R10 is based on EF gasification and FT-synthesis in the HUB. As the FT-synthesis generates more than one product this requires additional storage facilities at the HUB for transport of all these products to take place at an economically attractive scale, i.e. with large-scale overseas transport. In order to benefit from the economy of scale this would imply that only one HUB should be considered instead of eight. However, from (road) transport of the biomass point of view, one HUB is less interesting. This route therefore is evaluated on the basis of both one and of eight HUBs. The routes R1 to R9 all are based on the existence of eight HUBs (and eighty BCFs).

4.5 Assumptions

The assessment of the BtL routes is based on the general assumption that biomass, *i.e.* chipped wood logs with a moisture content of 35%, in all routes is delivered at the BCF at a fixed price of 4.0 €/GJ or 45 €/ton. The efficiencies of the different routes, in combination with the different economy of these processing steps and logistic costs, determine the final production costs of the FT product. With the efficiencies of the individual processing steps as presented in table 1 the overall efficiencies from biomass with 35% moisture content to FT diesel become as presented in table 2. The highest efficiencies are obtained when 1mm particles can be fed to the EF gasifier (57.8%), the lowest when the biomass is converted to bio-slurry before being gasified in the EF gasifier (53.5%).

Table 1 LHV efficiencies of process steps

Drying	
To 7% moisture	106.5
To 15% moisture	105.1
Pre-treatment	
Chipping, pelletising, pulverising, grinding	100
Pyrolysis	90
Torrefaction	95
CFB gasification	99

EF gasification	
1 mm particles	72.8
Bio-slurry	74.9
TOP pellets (disintegrated)	73.6
CFB gas	71.1
FT-synthesis yields	
C_{1-4}	4.5
C_{5-10}	6.2
C_{11+}	68.4

Table 2 LHV efficiencies of total process

Feeding system EF	Individual processing steps	Overall
1mm particles feeding	1.065 x 0.728 x (0.062+0.684)	57.8%
Bio-slurry	1.065 x 0.90 x 0.749 x (0.062+0.684)	53.5%
TOP pellets	1.051 x 0.95 x 0.736 x (0.062+0.684)	54.8%
CFB gas	1.051 x 0.99 x 0.711 x (0.062+0.684)	55.2%

Efficiencies of chipping, pelletising, pulverizing, and grinding are set to be equal to 100%, although in reality some small losses might be expected. Energy demands of drying and transport are accounted for as utility costs and not included in the overall LHV efficiencies. Only C_{5+} is considered to be upgraded to FT diesel.

The investment costs for the different routes are presented in table 3. The lowest investment costs are obtained when 1mm particles or the gas from the CFB gasifier are fed to the EF gasifier situated in Rotterdam (3.2 billion €), the highest when the biomass is thermally converted into bio-slurry or TOP pellets in the Baltic States (>5.4 billion €) when the biomass is converted to bio-slurry before being gasified in the EF gasifier (53.5%).

Table 2 Investment costs in billion €

Route	Description	BCF	HUB	Rotterdam	Overall
R1	Chips transported to Rotterdam and EF gasified as 1mm chips	0.2	0.0	3.1	3.3
R2	Chips transported to Rotterdam and pyrolysed before EF gasification	0.2	0.0	4.3	4.5
R3	Chips transported to Rotterdam and torrefied before EF gasification	0.1	0.0	4.2	4.3
R4	Chips transported to Rotterdam and CFB gasified before EF gasification	0.1	0.0	3.1	3.3
R5	Pellets transported to Rotterdam and EF gasified as 1mm chips	1.8	0.0	2.8	4.6
R6	Pellets transported to Rotterdam and pyrolysed before EF gasification	1.9	0.0	4.1	6.0
R7	Pellets transported to Rotterdam and torrefied before EF gasification	1.3	0.0	4.2	5.5
R8	Bio-slurry transported to Rotterdam and EF gasified	2.8	0.0	2.3	5.1
R9	TOP pellets transported to Rotterdam and EF gasified	1.9	0.0	2.7	4.6
R10[a]	Chips transported to HUB and EF gasified as 1mm chips in 1 EF plant	0.2	3.1	0.0	3.3
R10[b]	Chips transported to HUB and EF gasified as 1mm chips in 8 EF plants	0.2	4.1	0.0	4.3

4.6 Production costs

In figure 3 the cost breakdown as well as the overall fuel costs in Rotterdam are shown. The resulting total production costs of the FT-product at Rotterdam vary between 12.4 and 19.0 €/GJ. When looking at the cost breakdown of the FT-product, the influence of pre-treatment (*i.e.* densification) of the biomass on the final production costs of the FT-product is clearly demonstrated. In the cost breakdown the production costs are divided into biomass costs, transshipment (*i.e.* loading and unloading), transportation and storage costs (*i.e.* the logistics), capital costs, operation and maintenance costs, and utility, by- and rest product costs.

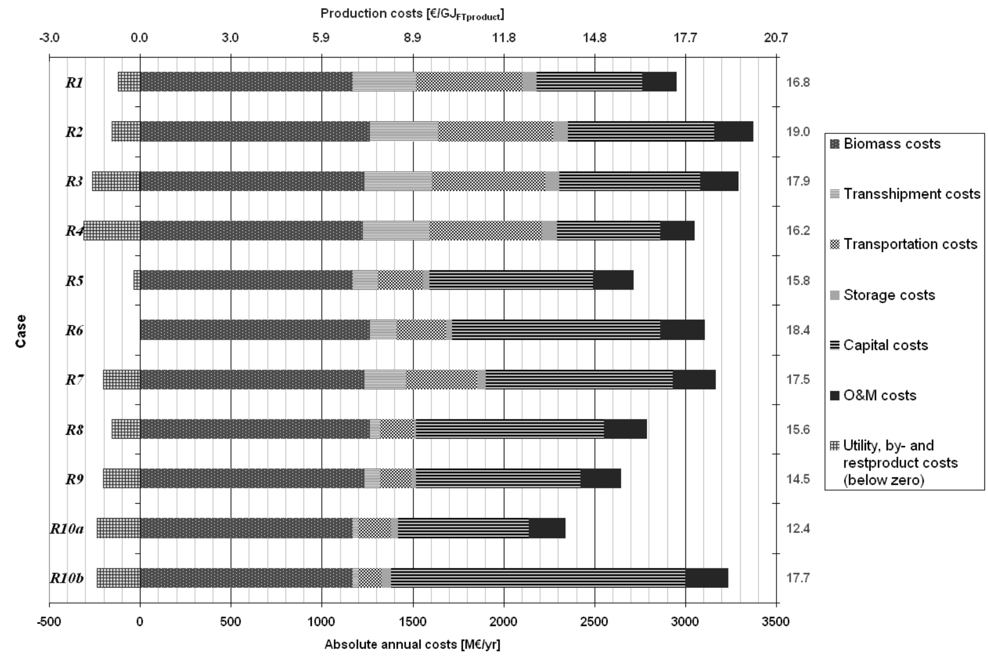

Figure 3 *Cost breakdown of the production costs of FT-product*

The lowest production costs for FT-product (12.4 €/GJ) are achieved by placing the synthesis plant in one HUB and not in Rotterdam (R10), however, from transportation point of view (*i.e.* the amount of trucks required to the centralized plant) one HUB is not realistic. Therefore this case is evaluated on the basis of eight HUBs as well, demonstrating clearly the (dis)advantage of economy of scale as the production costs increase drastically to 17.7 €/GJ.

Second to fourth best routes are based on pre-treatment by torrefaction (R9), pyrolysis (R8) or pelletisation (R5) in the BCF. When compared with the same conversion technologies applied in Rotterdam (R6 and R7) the advantage of pre-treatment at the front-end of the BtL production route is clearly demonstrated. This effect can also be observed when comparing the routes based on chips transport with similar routes based on conventional pellets transport (R1 versus R5, R2 versus R6 and R3 versus R7), however (conventional) pelletising is less interesting than more advanced pre-treatment (*i.e.* pyrolysis and torrefaction) overseas.

The low-temperature CFB gasification concept was evaluated on the basis of chips transport (R4). This route is the most interesting one of the routes with pre-treatment in Rotterdam (R1 to R4). However, CFB gasification as a feeding system for EF gasification will not be able to compete with overseas torrefaction and/or pyrolysis. The advantages of densification before transport outweigh the advantage of the CFB feeding. CFB gasification can still be considered as feeding system in case of an overseas synthesis plant, however, based on logistic problems overseas (as discussed before) one overseas plant is not realistic and the advantage of CFB gasification will be compensated by the need for multiple overseas plants, and, hence, the disadvantage of economy of scale.

The cost breakdown reflects that the actual biomass costs, *i.e.* initially 4.0 €/$GJ_{biomass}$ at the BCF or, taking into account overall production efficiencies, even up to 7.0 €/$GJ_{FT\ product}$, account for a significant part of the overall production costs, however, on an annual basis the actual biomass costs do not differ significantly for the evaluated BtL routes, hence the differences in production efficiency of the different BtL routes has a limited influence on the feasibility of the specific routes.
It also shows that in case of chip transport the logistic costs might run up to approximately one-third of the total production costs, hence providing some financial margin for pre-treatment (*i.e.* densification) steps in the front-end of the BtL production route. The additional investments related to these pre-treatment steps are less than the associated logistic cost reduction.

4.7 Conclusions for the BtL assessment

The main conclusions of the assessment of ten Biomass-to-Liquids (BtL) production routes, with regards to possible logistic advantages of overseas pre-treatment are (i) pre-treatment (*i.e.* densification) of the biomass at the front-end of the BtL route significantly increases the economic feasibility of the BtL production route, (ii) advanced overseas pre-treatment by means of torrefaction is more attractive then pyrolysis or conventional pelletisation and (iii) a large scale central overseas synthesis plant (8 GW_{th}) would be the most attractive route for BtL production, demonstrating that import of the final product instead of the biomass (intermediate) might be interesting as well. Local logistic aspects, however, require construction of several "small scale" synthesis plants (1GW_{th}) causing significant disadvantages due to economy of scale.

5. The distinction between transportation fuels and electricity, gaseous fuels, and chemicals

Although there are a lot of similarities between the BtL routes and biomass-to-electricity (BtE), biomass-to-gaseous fuels (BtG) and biomass-to-chemicals (BtC) some differences along the routes might cause some of the conclusions drawn from the BtL assessment to be invalid for the BtE, BtG and BtC route. Therefore the main distinctions between transportation fuels and electricity, gaseous fuels, and chemicals are discussed in this paragraph, as well as the effect of these distinctions on the conclusions drawn with regards to possible logistic advantages of overseas pre-treatment.

5.1 Electricity

The main difference between the BtL route and the BtE route is that import of electricity has to be excluded. Hence, in case of large scale implementation of BtE all BtE routes are solely based on import of biomass (intermediates). The intermediates that might be considered are basically the same as in the BtL routes, hence wood chips, pellets, bio-slurry, and TOP pellets, although biomass will not always need to be pre-treated to be similar to coal or converted into a pumpable liquid

(§4.1). As, however, densification of the biomass is more important than the loss of efficiency (as concluded in §4.6) it seems to be legitimate to conclude that overseas pre-treatment either by torrefaction or (for BtL routes) slightly less interesting pyrolysis or pelletisation will also significantly increase the economic feasibility of the BtE production route.

5.2 Gaseous fuels & chemicals

In contrast to electricity, gaseous fuels and chemicals can be imported from overseas, hence BtG and BtC routes should not only consider import of biomass (intermediates), but also the import of the final products gaseous fuels (*e.g.* as compressed natural gas CNG or liquefied natural gas LNG) and chemicals. The difference with BtL routes might be that whereas BtL plants aim at large scale implementation in order for the synthesis and product upgrading to be economically feasible, BtG and BtC plants might already be economically attractive at smaller scales. As a result, the implementation of a smaller scale BtG or BtC plant in the HUB might become attractive, whereas for BtL this was not realistic (as mentioned in §4.6). Hence, not only the overseas pre-treatment, but also overseas production of the final product, might significantly increase the economic feasibility of the BtG and BtC production route.

Onshore transport of (synthetic) natural gas by pipeline, for example, is still economical and convenient, especially taking into account the existing natural gas grid. Major obstacle, however, is the realisation of required huge investments in this gas infrastructure over the next 20 years [5]. For offshore transport of natural gas, pipelines become challenging as the water depth and the transport distance increase, hence LNG or CNG become effective means of transporting (synthetic) natural gas (from overseas biomass) [6].

Cooling natural gas at atmospheric pressure until it condenses at minus 160°C into liquid form produces liquefied Natural Gas (LNG), reducing its volume tremendously to just $^{1}/_{600}{}^{th}$ of its gaseous volume. This reduction of volume was the main reason for developing natural gas liquefaction processes as it addresses the need to transport large quantities of natural gas across oceans and to other continents in special cryogenic tankers or stored in heavily-insulated tanks [7, 8]. Compressed Natural Gas (CNG), *i.e.* natural gas compressed at pressures ranging from 100 to 180 bar, provides an effective way for shorter-distance transport of gas, *i.e.* for distances up to 4000 kilometres, especially in case of offshore reserves not linked to existing gas grids. At distances above 4000 kilometres the cost of delivering gas as CNG becomes essentially the same as the LNG and market demands play the deciding role [6]. A typical LNG import would require a gas demand of 5 GW_{th}. When substituting a significant amount of the Dutch annual natural gas consumption according to national renewable targets, the 5 GW_{th} scale will easily be reached.

In case of LNG, the costs of field development, liquefaction and regasification are independent of the distance to be travelled, whereas the costs of tankers are both volumetric size and travelling distance related. With just 30% of the costs being travelling distance related [8] it’s obvious that LNG is something especially interesting when long distances have to be overcome, as is illustrated in figure 4. The costs of pipelining natural gas benefit substantially from economies of scale (*i.e.* large diameter pipelines are not that more expensive to lay), but do increase significantly with increasing transport distances. Considering that biomass is most likely to be obtained over long distances (*e.g.* the Baltic States, Latin America, Africa or British Columbia), LNG produced overseas from biomass might end up being economically more attractive than transporting the biomass (intermediates) and convert it into SNG in Europe.

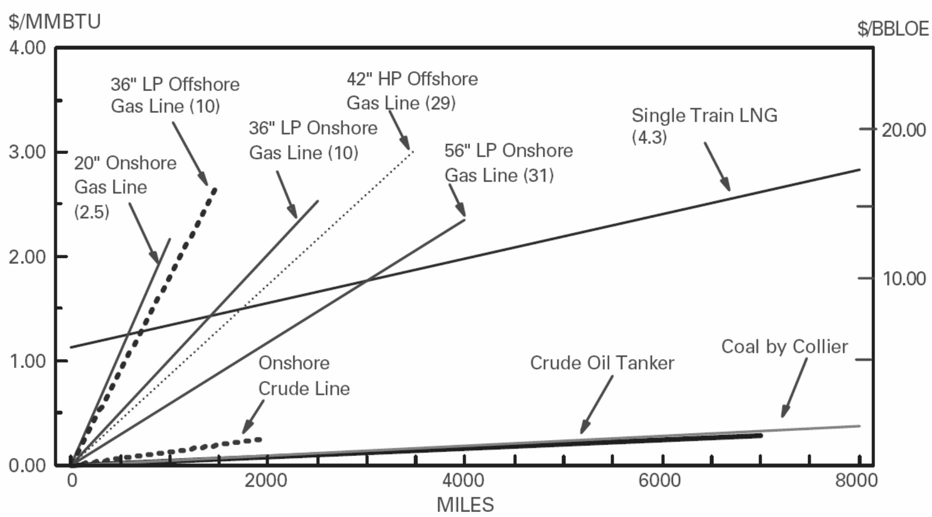

Figure 4 *Illustrative costs of gas, oil and coal transportation* [8]

An estimate of the costs (including liquefaction and regasification) might be obtained from the single train LNG equation, which would result in 1.5 $/MMBTU SNG (approximately 1.2 €/GJ SNG) when transporting the gas over a distance of 2500 kilometres (approximately 1550 miles). This distance is also used within the evaluation of FT diesel production routes, where costs of biomass (intermediate) transport where calculated for, among others, wood chips, slurry, and TOP pellets. Transport costs amounted to 0.7 €/GJ for slurry and TOP pellets and 2.3 €/GJ for wood chips. Taking into account an efficiency of SNG production of 70%, the actual transportation costs would become ~3.3 €/GJ SNG for wood chips and ~ 1.0 €/GJ SNG for bio-slurry or TOP pellets. These costs do not yet include costs of pyrolysis or torrefaction, when accounting for these costs as well the costs for having the biomass transported over a distance of 2500 km to a Western European port, *e.g.* from the Baltic States, will definitely be higher than the 1.2 €/GJ required for transporting liquefied SNG. In case of biomass being over even longer distances (*e.g.* Latin America, British Columbia), the advantage of LNG transport will probably have even a bigger impact. A more detailed evaluation will, however, have to be performed to confirm this preliminary conclusion.

6. Conclusions and recommendations

1. In order to fulfil national targets concerning the reduction of CO_2-emissions and the introduction of renewable energy sources, most biomass required has to be imported and thus will be available in large quantities at only a few central large-scale biomass plants.

2. The domestic biomass potential might be converted through (decentralised) small scale biomass plants. As for the Netherlands, however, most biomass required has to be imported and thus will be available in large quantities at only few places, the (central) biomass plants will generally have to become larger, possibly up to 10 GW_{th}.

3. Pre-treatment (i.e. densification) of the biomass at the front-end of the Biomass-to-Product (BtP) route significantly increases the economic feasibility of the BtP production route.

4. In order to reduce logistic costs biomass should be pre-treated in the biomass collection facility (BCF) before being transported by land to a central port (HUB) and by ship to Western Europe.

5. The size of the BCF is determined by the typical scales of pre-treatment processes as well as limitations in surface area (*i.e.* travelling distance) of the biomass production site. As most

pre-treatment processes have limited scales and are constructed modular, the BCF will have a typical biomass throughput up to 150 MW_{th}.

6. In case of Fischer-Tropsch diesel production advanced overseas pre-treatment by means of torrefaction is more attractive than pyrolysis or conventional pelletisation. It is expected that in case of biomass-to-electricity (BtE), biomass-to-chemicals (BtC) or biomass-to-gaseous fuels (BtG) torrefaction will also be the most attractive pre-treatment option.

7. Due to economy-of-scale aspects overseas Fischer-Tropsch diesel production in the HUB is less interesting. For BtE routes overseas electricity production makes no sense, whereas for BtC and BtG routes importing the final product might be considered as an alternative for importing the biomass (intermediate).

8. The size of the HUB is determined by the desired transport distance between BCF and HUB as well as typical scales of (non-modular) biomass conversion processes. When supplying a HUB from 8 BCFs the transport distance between BCF and HUB is limited (below 100 km) whereas the biomass throughput of approximately 1 GW_{th} might enable economically feasible conversion of biomass in to the final product in the HUB as well.

9. With the biomass throughput of the HUB being approximately 1 GW_{th} production of chemicals and/or gaseous fuels in the HUB, unlike FT synthesis, might be economically attractive. For Synthetic Natural Gas (SNG) from biomass transporting the gas as LNG or CNG to Western Europe might already have some major logistic advantages taking into consideration that biomass has to be imported from the Baltic States. Biomass import from further away (*e.g.* British Columbia, Latin America) will probably just enlarge this advantage.

10. In case chemicals and or gaseous fuels are desired in Western Europe, a more detailed evaluation will have to be performed to confirm the preliminary conclusion that importing the final product instead of the biomass (intermediate) might have significant logistic advantages.

References

[1] C. Hamelinck: *Outlook for advanced biofuels.* PhD thesis, University of Utrecht, 2004

[2] H.P. Calis, J.P. Haan, H. Boerrigter, A. Van der Drift, G. Peppink, R. Van den Broek, A. Faaij and R.H. Venderbosch: *Preliminary techno-economic analysis of large-scale synthesis gas manufacturing from imported biomass*. Presented at the Pyrolysis and gasification of biomass and waste meeting, 30 September - 1 October 2002

[3] H.P. Calis, J.P. Haan, H. Boerrigter, A. Van der Drift, G. Peppink, R. Van den Broek, A. Faaij and R.H. Venderbosch: *Technical and economic feasibility of large scale synthesis gas production in the Netherlands from imported biomass feedstock – a Strategic Decision Analysis study.* Concept SDE report, 2002

[4] R.W.R. Zwart, A. Van der Drift and H. Boerrigter: *Integrated Fischer-Tropsch diesel production systems*. To be published in Energy & Fuels, ECN, 2006

[5] P. Cayrade: *Investments in gas pipelines and LNG infrastructure - Which impact on security of supply*. Beicip-Franlab, 2003

[6] A. Deshpande and M.J. Economides: *CNG: an alternative transport for natural gas instead of LNG*. University of Houston, 2003

[7] *Cabrillo port: a new source for clean, reliable energy….* BHP Billiton, 2004

[8] J.T. Jensen: *The development of a global LNG market*. Oxford Institute for Energy Studies, 2004

5

The effect of the increasing timber prices on the availability of biomass

By: Mark Vonk Probos
Date: December 2006

Definition and problem:

Timber prices are rocketing over the past year. According to timber merchants, during each new transaction timber prices have risen again. So-called non-commercial thinning is no longer non-commercial and pre-commercial thinning (thinning before 30 years) is executed increasingly. Timber from pre-commercial thinning is especially suitable as biomass.

What is the short and long term influence of these high prices on the availability of biomass?

Questions

1. What causes the extreme increment of the timber prices?
2. Does the demand for biomass influence this process?
3. What is the effect on the development of the timber prices on the availability of biomass?
4. What is the long-term effect of the timber prices on the availability of biomass?

Authors: Mark Vonk

Method.

For this quick scan available statistics, recent publications and sources on the Internet were referred and several actors on the timber market were interviewed.

Referred sources.
During the recent months, from August until November 2006 several publications were written and published in the various media.

- Forse prijsstijgingen op de rondhoutmarkt (big price increment on the round wood market): Bosberichten oktober 2006
- Marktrapport NL delegatie: Internationale soft wood conference 2006-11-06
- Forest products annual market review 2005-2006: Geneva timber and forest study paper 21, UN-ECE
- Press release VVNH nr. 0610924
- www.globalwood.org/market1
- www.ustr.gov
- Various Holz Zentral papers of the last weeks.

Interviews

Due to the fact that no fresh statistics were available during the quick scan (the most recent statistics are published at the end of 2005), a survey was performed. During the survey, representative companies from the timber trading branch and consulting agencies from the Netherlands, Belgium, Sweden, Germany and Canada were consulted on the issue.

Dutch state forest service.
The service is specialised in forest exploitation, trade and processing of forest products from the estates managed by the Dutch state forest service.

"The effect of the latest developments on the timber market is for sure that pre-commercial thinning are reaching a break even point. Especially timber from small management units that produce OSB assortments. The demand for biomass as fuel has increased in general but the demand for pellets as part of the biomass for fuel has increased substantially more than other products like fresh chips etc. The demand for chips in the panel industry has increased substantially and also the quality requirements have been altered over the past view months. More "green" parts are allowed in the chips. This can be explained as a reaction on the shortage of fresh chips.

The service confirms that the level of timber harvest is depending on a budged driven system. As soon as the annual budget is closed, more timber is not harvested although the prises are good and the forest management of the forest is not influenced negatively. The service estimates that the shortage of timber on the market is not very large and argues that the price increments is rather a corrective compensation than a hick up of the market. The prises of standing round wood have not changed over the past ten years only the costs for processing have increased and compensated in the round wood prise. The timber market is changing into a bidders market. Until now the buyers were ruling the market and were regulating the demand and supply mechanism but with a shortage, the bidders are regulating this mechanism. This requires a complete different market approach of the forest managers"

Norske Skog Parenco
Norske skog Parenco is one of the largest players on the Dutch round wood and forest exploitation market.
"The demand for fresh biomass for fuel is mainly coming from the neighbouring countries but the demand for by products from the processing industry is almost doubled in the Netherlands. Fresh chips are hardly exported to the energy industry abroad. The company recognises that the balance in the market is very fragile and easily disrupted with the slightest increment of demand. This effect is enforced by the fact that forest managers hardly respond to the growing demand. The supply demand mechanism is not working properly. An other effect that is disrupting the supply and demand mechanism is the fact that the supply of round wood has been influenced substantially by a series of storms over the past decades and is compensated during the last harvesting season."

A.J. v/d Krol
A.J. v/d Krol is a medium large round wood trading company in the Netherlands.
"Most information on developments on the market is collected from the media. The company is not active on the biomass markets and has no factual information about streams of biomass. By analysing the information, the company expects that within five years the market for OSB and biomass for fuel will be divided more or less equally. In the past half year the company has had great difficulty to buy timber for the right prise in order to be able to meet contractual obligations. Eventually the company was able to persuade a forest manager to sell, by offering a "crazy" amount of money. According to the company, the argument for not selling was, that the harvest was not planned in the management plans. This confirms that forest managers are not market oriented and work strictly and rather inflexible along the lines of the management plans. The company is not selling any OSB timber on the energy market yet but recognises the fact that more and more competing trading companies, specialised in harvesting timber only for the biomass branch, are entering the round wood market."

Weijtmans
This company is specialised in the harvest of trees from outside the forests (Lanes, green strips along roads and high ways, Gardens, Parks etc.) and one of the largest players on this market.
"The company policy is to gain as much as possible value from a tree that is felled. So not all material is chipped but the trees are carefully graded and cut into assortments for the designated proces-

sors. In the past the company has supplied biomass to the power plant of Cuijk but due to a lack of trust in the company as a result of a couple of incidents (deliveries were refused), all biomass is supplied to German biomass clients (with satisfying results). The company is convinced that the MEP regulation for power companies is influencing the market negatively as they can demand the highest qualities for competing prizes."

<u>Gooskens hout Moerdijk</u>
This company is specialized in the trading, storage and distribution of soft woods from Scandinavia, the Baltic States and Russia. The company import directly from the mills.
"The demand and supply mechanism is affected by the economic forecast of last year. The predicted growth appeared to be much larger than expected. As timber contracts are made at the end of the year and mainly based on the economic predictions, the volumes of the purchase contracts were too low. The existing stocks were sold out much earlier than expected which resulted in an earlier and higher demand. Also the demand of timber as an alternative for oil based and steel products has increased as well over the last six to eight months. The effect of the increasing global market is becoming more evident. The company recognises this, as less timber is available from the other side of the Ural. The flow of material from the Eastern Europe and Russia is more and more diverted to the far east with the effect that sources more close to the western markets are forced to produce to the maximum capacity. The increment of the demand has grown substantially faster in the building sector than in other sectors like the packaging industries.

<u>Stora Enso Skog</u>
This company is one of the largest trading companies in Scandinavia, supplying the processing Industry (pulp, paper and timber processing) and is part of the multinational Stora Enso group.

"In the last six to eight months the demand for timber in the timber processing departments has become bigger than the demand in the pulp and paper departments. This indicates an important increase of the marked for sawn timber and panel products. The exports to the US has decreased were the exports to the European market has increased. The company is also importing round wood from the Baltic States and Russia but this is getting more and more difficult. This due to the fact that the local processing capacity has been extended over the last few years and the export of round and sawn timber from the Baltic States and Russia to the Far East has increased rapidly. Timber from the Scandinavian sources and specifically Finland has decreased substantially as a result of the changed tax regulations. Forest owners are more hesitated to harvest as the tax system has changed as per 2006 where before tax rates were based on an estimated net income from the forest, the new system calculates the tax from the actual income/production."
<u>Norbord Genk</u>
This company is based in Belgium and one of the leading producers of OSB, MDF and chipboard panels in Europe.
"The OSB stock is sold out and the supply period is ten weeks. Chipboard is sold only in large quantities with a supply period of two weeks. All OSB is supplied to the building sector at the moment. As a result of the changed VAT rate from 16% to 19% in Germany, the German trading branch is stockpiling building material and purchasing as much as possible before the end of 2006. The prise of panels is affected by other raw material more than the timber prise as other raw material for the panel industry are oil based or linked otherwise to the oil market. The production capacity of the timber processing branch and the forest exploitation branch has increased gradually over the last few years but as the sectors are entering the max capacity because of the growing demand, a shortage on the supply side drives the prises of round timber up. This effect is evident during the timber auctions in Belgium were only the big ("read rich") companies are able to buy. Luckily private forest owners respond to the market situation and put their timber on the market. Despite the fact that the company is one of the bigger players on the market and able to buy from local forests, the company had to decide to import timber from Scotland in order to fulfil the demand. Concerning the input of recycled timber as raw material for the panel industry, the market is shifting towards the energy sector. According to the company this can be explained by the fact that recy-

cling companies have improved their refinery techniques and are able to sell high quality recycle material that can be used as fuel as well."

EPF European Pallet Federation

This organisation represents the European pallet industry.

"The situation on the oil market has a direct effect on the prises on the timber market. Especially in Belgium, more and more timber is used as fuel on industrial scale i.e. green houses, bio energy etc. as the use of natural gas is not subsidised as it is in the Netherlands. But also on the scale of households, the consumption of wood as fuel has increased.

Dekker Hout Den Haag

This company is specialized in the trading, storage, processing and distribution of soft woods from, Scandinavia, the Baltic states and Russia and hardwoods from tropical regions like south east Asia and south America . The company import directly from the mills.

"The so-called China effect is not the reason for the explosive increase of the timber prise as the markets in the far east have been growing more or less steadily over the past ten years. The shock on the market of timber from Malaysia is a direct effect of changing policy on illegal timber from Indonesia. The government of Indonesia has, under pressure of the international community, put more effort in tackling the problem with illegal harvested timber. This, in combination with a growing demand in Europe and low stock has an immediate effect on the prise of timber. The current situation is stable. The development of the timber prise is more or less normal but can be disrupted easily in case alternatives for timber are becoming economically competitive. Developments can already been seen on the market of frames and windows were plastic and aluminium frames are gaining a more important place on the market.

Platform Hout Nederland

This organisation operates as platform and representative for several branches in the timber industry in the Netherlands.

"The representative from the platform has no up to date information about market trends and refers to the statistics that have been up dated last December 2005. Following the trends of these statistics, the recent peak in the development of the timber markets cannot been explained.

NRC

Trading company, specialised in the trade of round wood biomass.

"The current development of the timber prises is a direct effect of the hampering supplies from the forest. During the harvest season no new contracts are made in order to respond to the growing demand. Concerning the developments on the market of biomass, especially in Germany the market has developed substantially and an increasing flow of biomass (i.e pellets) towards South Germany, Austria and Italy is supplied from the German timber processing industry. The company is getting an increasing demand for supplies of biomass and is exploring overseas sources. (South and North America) These sources are already supplying SCA and other big companies.

SFI Swedish forest industries federation

This organisation represents the Swedish timber and forest industry.

"The representative of the organisation is market annalist and states that the current developments on the timber market is the effect of a wide range of factors that affect the balance in the mechanism of supply and demand. Most important factors are: The growing demand for timber on the European market, growing exports of timber to Asia and Africa from the Baltic states and Russia, the EU import policies and taxes on timber and timber product from outside the EU, The decrease of production in Austria and Finland."

Biomassa stroomlijn

This company is specialised in the trade of recycled timber and biomass from outside the forest.

"The export of recycled timber to Germany and Belgium has increased substantially over the past six to eight months. Most recycled timber is sold to the panel industries. In Belgium the greenhouse industry is changing from gas to biomass as fuel as a result of the gas prize. In response to the information from the Belgium panel industry, the company doe not confirm the competition of the panel industry with the power plants as a result of the improved refine techniques. The company states that the panel industry has a lack of raw material due decision to shift entirely to the processing of recycled timber. With the growing demand of building material the panel branch has an instant shortage of raw inputs and shifting to fresh chips is rather difficult."

Fritz Schainhorst
This company is based in Germany and specialized in the trade of round wood.
"As a result of the expanded processing capacity in Germany the demand for round timber has increased rapidly. Also the demand for firewood has increased more than in recent years."

Bockelman-Holz
This company is also based in Germany and is specialized in the trade of round wood.
"The representative of the company states that the demand for fire wood has increased strongly compared to last year, but is growing in the same pace as other timber and timber products. Reason is the increased processing capacity in Germany."

Holzhandlung Sachse.
This company is also based in Germany and is specialized in the trade of round wood.
"The representative states that the development of the timber market is strongly influenced by the new VAT rates. The company is not able to indicate whether the demand for firewood has increased as firewood is traded in a wide range of units (m³, bag etc) and the company has only sales data in Euro's

Avison Management Services
This company is based in British Columbia Canada and operates as forest management consultancy agency.
"The total amount of timber exported to the US is 50% of the total exports of Canada. The importance of the US market is evident. Since 2005 the ho9usebuilding market in the US has decreased about 30% and the expectations are not very positive. As a result of the mountain pine beetle pest, the annual harvest has been increased up to 4,6 million cubic meter from the Vanderhoof forest district whereas normally only 1,9 million cubic meter is harvested. This has an immediate effect on the timber prise.

Findings

The extreme price developments as seen over the past six to eight months is not the result of one or two reasons but is the result of a combination of several factors. Factors that have been developing over a longer period, for example the economic growth in the far East but also factors that have occurred relatively suddenly, for example the VAT rates in Germany. During this quick scan the market principle that prize development is depending on order and demand is used to analyse the development on the market. Below factors influencing demand and supply more than normal are summarized.

Factors that have been influencing the demand:
- The purchase of sawn timber in the first half year in 2006 was not optimal as the forecast of the economic growth was underestimated. Stocks were sold out more quickly than expected which forced the trading sector to buy more early than expected.
- The demand of timber from the region has increased as the flow of timber from Eastern Europe are shifting to the far East.
- The VAT rates in Germany are altered as from the beginning of 2007. The trading sector is stockpiling building material rapidly.
- The economic growth of in Europe is strong with the direct effect on the demand.
- The MEP regulations for the energy sector has a positive effect on the demand. Power producers have become a serious competitor on the market of fresh wood chips.

Factors that have been influencing the supply:

- Supply from Eastern European countries and Russia is decreasing. The processing capacity is extended locally this opened possibilities of export to the far East and made the eastern region less dependent on the western regions.
- Forest mangers are despite the urge and better offers from the timber trading sector not able or not willing to respond to the situation on the market.
- Timber harvest in Finland has decreased as a result of the changed tax system. Forest owners are hesitating to harvest.
- The efforts of the international community to stop the flow of illegally harvested timber is taking effect. The current developments on the Malaysian timber market is the direct effect of the decreasing exports from Indonesia.
- In the past decades, the supply from European forest has been artificially high as a result of a series of storms. The compensation has started in the last harvesting season (2005-2006).

Expected developments.

The developments in North America will probably cause a surplus on the timber market. The economic developments and the housing market in the US is decreasing. In Canada and especially BC timber harvest has grown three times in regions affected by the mountain pine beetle. This development can release the market in the rest of the world temporarily with a positive effect on the prize.

The overall supply of timber on a global scale will gradually change and stabilize but will not increase in the same pace as the demand. Unexplored sources like Bolvia and Peru already show that exploitation is very expensive and probably economically invalid on the long term. Illegally harvested timber will be banned. Harvesting rates will be decreased as a result of the introduction of responsible management systems.

The demand will grow worldwide. Markets in Latin America, Africa and South East Asia are developing and will also in future.

Conclusion.

Considering the developments on the timber market and the economic developments on global scale, all signs point in the direction that timber is becoming a scarce commodity. The timber market shows similarities with the oil market where relative small incidents have big effects. For example the miscalculations of the trading sector and the VAT change in Germany cause an extreme peek in the demand with an unpredictable effect on the balance between demand and supply.

The total demand is growing and the total supply from the global sources will not grow equally and are spread over more actors on the global market.

The availability of (woody) biomass will probably follow the developments of the timber market in general as substantial amount of biomass are derivates (wood pellets) from the processing sector.

With increasing cost for transport and the competition on the global market, the European market will be increasingly depending on (own) local sources. This opens up possibilities for forestation and biomass plantations in the near future.

6

Biomassateelt en waterberging

By: Martijn Boosten and Annemieke Winterink Probos
Date: May, 8, 2007

Summary

Inleiding

Gezien de verplichtingen (vanuit Kyoto en de Europese Unie) die Nederland heeft voor vermindering van de CO_2-uitstoot en de opdracht om in 2020 20% van de energiebehoefte uit duurzame bronnen te halen, is het noodzakelijk de hoeveelheid biomassa voor energieopwekking te vergroten. Naast de bestaande bronnen voor biomassa, zoals bossen en akkers, vormen de uiterwaarden langs rivieren een belangrijke en nog bijna onbenutte bron voor biomassa.
In het waterbeleid dat de Nederlandse overheid op dit moment voert wordt veelvuldig ingegaan op het belang om meer ruimte te geven aan water. Het beleid is op dit moment in uitgevoering waarbij veel ruimte vrijgemaakt (gaat) worden om waterberging en ruimte voor de rivier te combinatie met natuurontwikkeling. Daarnaast moeten buitendijkse belemmeringen, zoals bouwwerken maar ook bossen en andere houtige opstanden zo veel mogelijk worden verwijderd om de doorstroming te bevorderen.

Tijdens deze Quick-Scan is geïnventariseerd wat de mogelijkheden zijn voor biomassateelt in de uiterwaarden in het kader van meervoudig ruimtegebruik en wat de mogelijkheden zijn om het hout dat vrijkomt bij onderhoud en beheer van (natuur in) de uiterwaarden in te zetten als biomassa.

Nederlandse uiterwaarden: eigendom en beheer

Ruw geschat heeft Nederland ongeveer 50000 ha uiterwaarden langs de grote rivieren (H. Hupkes, staatsbosbeheer, pers.med.) Van de 50.000 ha uiterwaarden heeft rijkswaterstaat ongeveer 47.000 ha in beheer. Dit beheer wordt (gedeeltelijk) uitbesteed aan verschillende beheerders; staatsbosbeheer, natuurmonumenten, provinciale landschappen of particulieren. Daarnaast hebben delfstofwinners, de dienst landelijk gebied, gemeenten en private beheerders terreinen in eigendom of beheer (Peters *et al.,* 2006).

Verschillende beheerders betekent ook verschillend beheer, uiterwaarden worden gebruikt voor landbouw, begrazing en natuurontwikkeling. Deze verschillende functies hebben invloed op de opstanden in de uiterwaarden. De terreineigenaar (het rijk) is formeel gezien verantwoordelijk voor het garanderen van een goede doorstroming van de rivier. Hierbij moeten hydraulische knelpunten voorkomen worden. Rijkswaterstaat is hiervoor de uitvoerende instantie en controleert of obstakels in het rivierbed die ontstaan zijn, zoals bijvoorbeeld spontane begroeiing, verwijderd moeten worden of worden toegestaan op grond van een afgegeven vergunning. Indien obstakels of begroeiing zoals houtige opstanden niet in de vergunning zijn opgenomen moeten deze verwijderd worden (Peters *et al.,* 2006), of deze belemmeringen moeten elders gecompenseerd worden. Gezien het ruimtegebrek langs de Nederlandse rivieren lijkt het vinden van compensatiegebieden om kap van (spontane) vegetatie tegen te gaan niet haalbaar.

Wet en regelgeving

In het rivieren gebied zijn meerdere wetten, beleidsplannen en nota's van kracht. Hieronder volgt kort een overzicht van de meest prominente wetten en hoe deze zich verhouden tot het verwijderen van houten opstanden in de uiterwaarden en de mogelijkheid voor biomassateelt.
Wet beheer Rijkswaterstaatswerken (WbR). Deze wet is van toepassing op het gehele rivierbed tussen de buitenkruinlijnen van de waterdijken en regelt een veilig en doelmatig gebruik van de waterstaatswerken die in het beheer zijn van het rijk. Alle grote rivieren in Nederland vallen onder deze wet. Artikel 2 uit de WbR vermeldt dat "een vergunning is vereist voor iedere handeling die naar het oordeel van de rivierbeheerder met één of meerdere voorschriften moet worden begrenst of aangestuurd"(Peters *et al.,* 2006) Voor het plaatsen of verwijderen van objecten, het aanbrengen van begroeiing of de (spontane) ontwikkeling van vegetatie is een vergunning nodig. Het aanbrengen van wijzigingen in het winter- of zomerbed van de rivier kan veranderingen in de stromingspatronen van het rivierwater met zich meebrengen. Bijvoorbeeld; als het terreinbeheer van de uiterwaarden minder intensief wordt zal dit als gevolg hebben dat er, indien er geen begrazing plaats vind, meer begroeiing ontwikkeld wat resulteert in meer opstuwing van het water. Rijkswaterstaat hanteert als richtlijn dat indien er veranderingen plaats vinden en deze leiden tot een waterstand stijging van 1mm op de as van de rivier dan moeten er compenserende maatregelen plaats vinden. (Peters *et al.,* 2006) De WbR laat weinig ruimte voor het aanplanten/ onderhouden van wilgen plantages de uiterwaarden.

Planologische Kernbeslissing (deel 4) ruimte voor de Rivier (2006) (PKB 4). In waterbeleid 21ste eeuw wordt aangegeven dat er in de retentiegebieden die slechts van tijd tot tijd onder water staan eventueel mogelijkheden zijn voor andere gebruiksdoeleinden. Deze mogelijkheden zijn sterk afhankelijk van het type gebruik en de frequentie van de overstroming. Gezien deze uitspraak zou een wilgenplantage voor biomassateelt in deze retentiegebieden tot de mogelijkheden behoren. Echter in de PKB deel 4 welke in december 2006 is vastgesteld, staat "retentie wordt voor de korte termijn niet als maatregel ingezet. Het wordt beschouwd als sluitstuk"

Er wordt ook ingegaan op het feit dat er in vergelijk met 1997 sprake is van een beheersachterstand in het rivierengebeid (Rijn en Maas). In PKB 4 staat dat naar schatting enkele honderden hectares spontane forse vegetatie verspreid over verschillende gebieden in de uiterwaarden en oeverzone staan. Daarnaast ontstaat er door extensivering van het gebruik en beheer een groter areaal aan "ruw grasland" wat invloed heeft op het doorstromende karakter van de rivier en zijn waterstanden. "Om dit opstuwende effect teniet te doen moet deze vegetatie met prioriteit worden gecompenseerd of verwijderd".(Anoniem, 2006b) Helaas is niet helder wat de samenstelling is van de "forse vegetatie" die spontaan in de uiterwaarden tot ontwikkeling is gekomen. Het vermoeden bestaat dat het hier gaat om houtige vegetatie met onder anderen Wilgen (*Salix*) en populieren (*Populus*) van verschillende leeftijden. Het is interessant te weten hoeveel van de te verwijderen vegetatie gebruikt kan worden als biomassa. Daar is op dit moment weinig inzicht in. Staatsbosbeheer heeft ruwweg geschat 277 hectare bos staan in de uiterwaarden die ze beheren (*H. Hupkes (staatsbosbeheer) pers.med.*). Daarnaast geeft de PKB ook aan dat nieuwe projecten in de uiterwaarden extra inspanning vragen van zowel de rivierbeheerder als de terreinbeheerder. Een nieuw inrichtingsproject zal beoordeeld worden op zijn ontwikkelingen in de loop van de tijd voordat tot realisatie overgegaan kan worden. Gezien de ontwikkeling van het verwijderen van de ruwe vegetatie zal het ontwikkelingen van biomassaplantages zeer waarschijnlijk geen optie zijn in het kader van deze PKB. Aan de andere kant zijn er wel degelijk kansen voor het inzetten van vrij gekomen vegetatie uit de uiterwaarden als biomassa.

Waterbeleid 21ste eeuw (Anoniem, 2000) meldt dat er extra ruimte gecreëerd moet worden voor de rivier door dijken landinwaarts te verleggen, uiterwaarden te verlagen en obstakels in het winterbed te verwijderen. Dit impliceert net als in de voorgaande twee alinea's dat er weinig ruimte is voor houtige opstanden in de uiterwaarden. Toch wordt er ook aangedrongen op het zoeken naar mogelijkheden waarbij waterbeleid gekoppeld kan worden aan natuur, landbouw, recreatie en/of drinkwatervoorziening. Dit in oogschouw nemend zou een biomassaplantage tot de mogelijkheden kunnen behoren.

Beleidslijn grote rivieren. Binnen deze beleidslijn wordt onderscheid gemaakt tussen bergend of een stroomvoerend regime in het rivierbed. Daarnaast zijn de activiteiten in twee verschillende categorieën ingedeeld, riviergebonden en niet riviergebonden.
Onder het bergende regime zijn alle activiteiten toegestaan mits ze voldoen aan de gestelde rivierkundige randvoorwaarden, dit houdt in dat "er geen sprake is van een feitelijke belemmering van toekomstige vergroting van de afvoer- of bergingscapaciteit en de optredende waterstandsverhoging of de afname van de bergingscapaciteit zo gering mogelijk is" (Anoniem, 2006a).
In het stroomvoerende regime zijn de riviergebonden activiteiten toegestaan. In deze beleidslijn wordt de realisatie van natuur onder riviergebonden activiteiten gerekend. Ook deze activiteiten moeten voldoen aan de gestelde rivierkundige voorwaarden. Niet riviergebonden activiteiten zijn niet toegestaan in het stroomvoerende regime, tenzij er sprake is van een groot openbaar belang of een zwaarwegend bedrijfseconomisch belang voor bestaande grondgebonden agrarische bedrijven en activiteiten die niet buiten het rivierbed gerealiseerd kunnen worden.
Kijkend naar het opzetten van biomassateelt plantages zal deze activiteit zeer waarschijnlijk vallen onder niet riviergebonden activiteiten. In het bergende regime zou deze activiteit plaats mogen vinden, echter gezien het karakter van de wilgen groei en het gegeven dat deze vorm van begroeiing de maximale hydraulische ruwheid bevat is de kans dat de plantage aan de gestelde rivierkundige voorwaarden voldoet minimaal. De hydraulische ruwheid ook wel stromingsweerstand genoemd, is de weerstand dat het rivierwater ondervind van objecten in het rivierbed.

Wilgenteelt

Biologisch gezien zijn de mogelijkheden voor wilgenplantages in de uiterwaarden erg positief. In het verleden kwamen op de natste delen van de uiterwaarden uitgestrekte, aangeplante wilgenhakhoutbossen voor. Wilgen kunnen erg goed tegen frequente overstromingen. Vreugdenhil (*et al.*, 2006) heeft onderzoek gedaan naar de invloed van overstromingsfrequenties op verschillende boomsoorten, hierbij bleek dat met name boomsoorten van het geslacht wilg (*Salix* spp.) goed in staat zijn zich aan te passen aan overstromingen. Zaailingen waren in staat 12 weken van totale onderdompeling te overleven. Deze eigenschappen zorgen ervoor dat de wilgen zeer geschikt zijn om aangeplant te worden in uiterwaarden en retentiegebieden die, meer of minder frequent, onderwater komen te staan. Spontane opslag van wilg vindt veelvuldig plaats in de uiterwaarden. Dit wordt ook benoemd in PKB deel 4 waar men het heeft over achterstallig onderhoud.

Aan de beheertechnische kant kleven er echter nogal wat bezwaren aan wilgenplantages in de uiterwaarden. Zo werden wilgen vroeger in de uiterwaarden van steenfabrieken om opslibbing te bevorderen, deze eigenschap is in strijd met het huidige waterbeleid (Wolf *et al.,* 2001). In de studie 'Boeren met water' die onder andere is uitgevoerd door het Centrum voor Landbouw en Milieu (CLM) in 2001 worden mogelijkheden voor meervoudig ruimtegebruik beschreven. Hierbij wordt het verbouwen van houtige energiegewassen onder natte omstandigheden als mogelijk toekomstgericht bedrijfstype beschreven. Voor agrariërs met gronden aan rivierbeddingen kan het telen van energiegewassen zoals wilg een mogelijke nieuwe bedrijfsvoering zijn. Echter gezien de hierboven geschetste beleidskaders zal wilgenteelt in uiterwaarden en retentiegebieden naar verwachting niet of nauwelijks van de grond komen.

Het aanplanten van wilgen levert tegenstrijdige gevoelens op bij beheerders van de uiterwaarden zoals bijvoorbeeld staatsbosbeheer. Uit gesprekken met een aantal medewerkers van staatsbosbeheer blijkt dat biomassaproductie uit houtige opstanden die uit de uiterwaarden, op last van Rijkswaterstaat, verwijderd moeten worden, positief ontvangen wordt. Het aanplanten van biomassaplantages daarentegen niet. Deze eerste signalen vanuit het beheerders veld zijn zeer zinvol, biomassaproductie vanuit natuurontwikkeling en/of onderhoud lijkt een groter draagvlak te hebben dan biomassateelt.

Biomassa als nevenactiviteit van natuurbeheer.
Als onderdeel van de ecologische hoofdstructuur moet langs de bedijkte rivieren 13.500 hectare en langs de onbedijkte maas 1170 hectare nieuwe natuur komen. De Ministeries van LNV en V&W

hebben afgesproken dat voor de nieuw ontwikkelen natuur ongeveer 8000 hectare voor 2015 ingericht moet worden als natuurontwikkelingsgebieden. Dit gebeurt onder anderen onder de noemer van de Nadere Uitwerking voor het Rivieren Gebied (NURG) (Anoniem, 2006b). In deze gebieden worden maatregelen getroffen, zoals afgraven, om meer ruimte te maken voor waterberging. Hiermee krijgen deze gebieden een dubbele functie; natuur en waterberging (Milieu en Natuur Planbureau, 2007).

In het kader van het boek 'Cyclisch beheer in uiterwaarden' dat in 2006 is uitgebracht door het Centrum voor Water en Samenleving en de toenemende interesse voor biomassaproductie zijn met name deze nieuw te ontwikkelen natuurgebieden interessant. Cyclisch beheer van uiterwaarden houdt in het kort in dat door successie en verjonging af te wisselen een dynamisch evenwicht ontstaat waarbij de afvoercapaciteit van de rivier stabiel blijft (Peters *et al.*, 2006) Met name het terugzetten van natuurgebieden in successiestadia waarbij (delen) van de vegetatie tijdens het beheer gekapt worden, biedt mogelijkheden voor biomassaproductie uit vegetatie. Als de 8000 hectare nieuw te ontwikkelen natuur ingericht zouden worden onder cyclisch beheer dan is er een grote potentie om biomassa te vergaren uit het hout dat vrijkomt vanuit het beheer. Uiterwaarden moeten immers beheerd worden. Het inzetten van de verwijderde vegetatie als biomassa is slechts een extra stap om eventueel extra inkomsten te genereren.

Tijdens de ontwikkeling van (ooibos)vegetatie in het cyclische beheer kunnen ruwweg 5 verschillende fasen onderscheiden worden. De vestigingsfase (0-3 jaar), De staken fase (3-10 jaar), Doorgroeifase (10-20 jaar), Volwassenfase (20-50jaar) en de degeneratiefase (>50 jaar). De hydraulische weerstand van de vegetatie maakt ook een ontwikkeling door.
Met name het pionierswilgenbos bezit de hoogste vegetatiedichtheid en hydraulische ruwheid terwijl de hydraulische ruwheid van een ouder bos veel lager is. (Peters, 2002).

Proefberekening

In het kader van deze quick scan is een proefberekening uitgevoerd om te bepalen hoeveel biomassa er vrij kan komen uit de nieuw te ontwikkelen natuur langs de uiterwaarden.

Bij de proefberekening is uitgegaan van de 8000 ha natuurontwikkeling langs de uiterwaarden. Hierbij is aangenomen dat deze natuurgebieden beheerd worden door middel van cyclisch beheer. In de uiterwaarden zullen zich verschillende successiestadia ontwikkelen. In deze voorspelling nemen we aan dat ongeveer 25% van het oppervlak van de nieuwe natuur zich tot ooibossen zal ontwikkelen, in dit geval wilgenooibossen. De overige 75% zal bestaan uit water, gras, ruig struweel en dergelijke.
Gemiddeld is de geschatte jaaropbrengst van een wilgenplantage 11.45 (t ds/ha.jaar) (dit is een gemiddelde genomen uit 9.7 t ds/ha.jaar (Gigler *et al.*, 1999) en 13.2 t ds/ha.jaar (Zeijst *et al.*, 1994).
In totaal zal er dus in 2015, 2000 ha wilgenooibos zijn. Ervan uitgaande dat hiervan de helft oogstbaar is, zal er dus (1000 * 11.45 t ds/ha.jaar =) 11 450 t ds jaar kunnen worden geoogst.

Op dit moment wordt er in Nederland gemiddeld 110.000 t ds biomassa per jaar geproduceerd uit houtige opstanden (met name bossen). De 11450 t ds biomassa uit de uiterwaarden zou dus 10% bij kunnen dragen aan de huidige biomassa productie vanuit houtige opstanden.

Er moeten bij deze proefberekening wel enige kantekeningen geplaatst worden. We gaan er hierbij vanuit dat al het ooibos dat zich ontwikkelt (de 25%) zich in het volwassen stadium bevind. Onder de noemer van cyclisch beheer ontwikkelen zich verschillende successie stadia dus zal de 25% een overschatting kunnen zijn. Daarnaast gaan we er vanuit dat 100% van de oogst daadwerkelijk omgezet gaat worden tot biomassa, dit is niet geheel reëel aangezien er altijd wel verlies optreedt.

Conclusie

Gezien het wettelijke kader waarbinnen het beheer van de rivierbeddingen en uiterwaarden zich bevindt, lijkt het aanleggen van biomassaplantages zeer onwaarschijnlijk. Wilgenplantages vormen na het kappen een dichte begroeiing. Deze vorm van vegetatie heeft hydraulisch gezien een maximale ruwheid. Gezien alle wettelijke bepalingen waarin opgenomen is dat activiteiten in het rivierbed geen belemmering mogen vormen voor het waterbergende capaciteit en het watervoerend vermogen van de rivieren, sluit dit biomassateelt in uiterwaarden volledig uit. Eventuele mogelijkheden zouden zich bevinden in het opzetten van plantages in het kader van meervoudig ruimte gebruik in retentiegebieden. Echter op dit moment ligt de focus van het Nederlandse waterbeleid voornamelijk op oplossingen buitendijks, zodat binnendijkse retentiegebieden op korte termijn geen prioriteit hebben.

Aan de andere kant lijkt de kans voor het inzetten van het hout dat vrijkomt bij het beheren/onderhouden van de uiterwaarden voor biomassa zeer reëel. PKB deel 4 beschrijft dat er enkele honderden hectares aan ruwe vegetatie opgeruimd moet worden om het opstuwende effect van deze vegetatie teniet te doen. Daarnaast moet er voor 2015 8000 hectare nieuwe natuur ontwikkeld worden langs de uiterwaarden. Door deze natuur te beheren volgens het concept van cyclische beheer is er de mogelijkheid biomassa te produceren als nevenactiviteit naast natuurbeheer. Daarbij wordt de afvoer capaciteit van de rivieren gewaarborgd. Als gekeken wordt naar de proefberekening die in het kader van deze quick scan is gemaakt, kan er een redelijke hoeveelheid biomassa geproduceerd worden door het combineren van biomassaproductie en natuurbeheer.

Aanbevelingen

Om een inschatting te kunnen maken of het financieel rendabel is om houtige opstanden die vrijkomen uit uiterwaarden vanuit beheer in te zetten voor biomassaproductie, zijn de hoeveelheden en de frequentie waarmee de houtige opstanden vrijkomen van belang.

Het uitvoeren van een casestudy zou aan te bevelen zijn om meer inzicht te krijgen in de mogelijkheden voor het combineren van natuurbeheer en biomassaproductie. Het is van belang na te gaan welke maatregelen er getroffen moeten worden om te zorgen dat er genoeg overruimte gecreëerd wordt voor de te ontwikkelen natuur. Het is belangrijk dat de successie niet meteen leidt tot een overschrijding van de maatgevende hoogwaterstand waardoor te vroeg moet worden ingegrepen in het cyclische proces. Er is geen standaard te geven over het tijdsbestek waar binnen maatregelen plaats gaan vinden en dus in welke hoeveelheden de eventuele biomassa vrijkomt vanuit het beheer. Via een modellen studie zou gekeken kunnen worden wat de invloed is van bepaalde vegetaties op het stroomvoerende regime van de rivieren. Hieruit zou dan afgeleid kunnen worden in welke cycli het kappen van de vegetatie moet plaatsvinden om water opstuwing door de vegetatie te minimaliseren.

Gezien de proefberekening zou biomassa vanuit uiterwaarden beheer een redelijk onderdeel kunnen uitmaken van de biomassaproductie in Nederland. Echter er zou verder door berekend moeten worden wat de daadwerkelijk opbrengst is.

Literatuurlijst

Anoniem, 1996. *Wet beheer rijkswatersta*atswerken. Ministerie van Verkeer en Waterstaat.

Anoniem 2000. *Waterbeleid voor de 21ste eeuw. Geef water de ruimte en aandacht die het verdient.*

Anoniem, 2006a *Beleidslijn grote rivieren*, Ministerie van Verkeer en Waterstaat.

Anoniem, 2006b. *Planologische Kernbeslissing deel 4, Ruimte voor de rivier*. Projectorganisatie Ruimte voor de Rivier.

Anoniem, 2006c. *Nota ruimte "Ruimte voor ontwikkeling"*. Ministerie van VROM.

Gigler, J.K. 2000. Drying of willow biomass in supply chains. Wageningen, Wageningen Universiteit.
Peters, B., m.m.v. G. Geerling en T. Smits, 2002. *Successie van natuurlijke uiterwaardlandschappen*. Werkdocument in het kader van het onderzoek "Cyclische
verjonging van uiterwaarden" op basis van empirische kennis. Bureau Drift, Berg en Dal & Radboud Universiteit Nijmegen

Peters,B.W.E., E. Kater,en G.W Geerling, 2006. *Cyclisch beheer in uiterwaarden: natuur en veiligheid in de praktijk.* Centrum voor Water en Samenleving, Radboud Universiteit, Nijmegen.

Vreugdenhil. S.J., K. Kramer en T Pelsma, 2006. *Effects of flooding duration, -frequency and -depth on the presence of saplings of six woody species in north-west Europe.* Forest Ecology and Management 236 (2006) 47–55.

Wolf, R.J.A.M., A.H.F. Stortelder en R.W. de Waal. 2001. Ooibossen. Stichting Uitgeverij van de koninklijke Nederlandse Natuurhistorische Vereniging,Utrecht.

Wolters, H.A., M. Platteeuw en M.M. Schoor. 2001. *Richtlijnen voor inrichting en beheer van uiterwaarden. Ecologie en veiligheid gecombineerd*. RIZA.

Zeijts, H. van, E.B. Oosterveld en E.A. Timmerman. 1994. *Kan de landbouw schone energie leveren?* Utrecht, CLM.

Internetsites

http://www.mnp.nl/mnc/i-nl-1351.html (geraadpleegd op 23 april 2007)
http://www.clm.nl/projecten/boerenmetw.html (geraadpleegd op 23 april 2007)

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7

Biomassa en Boswet

By: Mark Vonk
Date: April 2007

Inleiding.

Het houdt de gemoederen binnen de bosbouwsector al enige tijd bezig. De nota van de minister van LNV met begeleidende brief aan de tweede kamer over zijn voornemen om het voortbestaan van de boswet te overwegen het in het kader van de administratieve lastenverlichting van het overheidsapparaat. Grond voor dit voornemen is volgens de minister dat er geen juridische en Europese verplichtingen voor handhaving van de wet bestaan en dat er voldoende andere vervangende wetten en regels zijn.

Er is sinds het verschijnen van de brief van de minister veel gezegd, vergaderd, besproken en geschreven over de mogelijke effecten en de juridische houdbaarheid van de boswet. Dit alles leverde in de sector alleen maar meer vraagtekens op. Met name de vraag over het waarom van het afschaffen van een wet die uitblinkt in eenvoud, effectiviteit en handhaafbaarheid klinkt vaker door.

De werkelijke consequenties van het opdoeken van de oude maar vertrouwde boswet zijn echter door niemand onderzocht. Stichting Probos heeft gemeend hier een voortrekkersrol te moeten vervullen en heeft samen met de handhavers boswet en de AVIH een aantal zaken op een rij gezet om meer helderheid te krijgen in deze zaak. Doel van het onderzoek is de argumentatie voor het opheffen van de boswet aan de praktijk te toetsen en de effectiviteit van de vervangende wetten en regels te beschouwen vanuit het perspectief van de huidige situatie zonder de bestaande boswet.

In het kader van dit onderzoek is ten eerste is gekeken naar de effectiviteit van de boswet en het uitvoerend orgaan. Ten tweede zijn de gevolgen van het verdwijnen van de boswet voor bestaande wetten en regels en is de effectiviteit van de overblijvende en vervangende wetten en regels beoordeeld en ten derde zijn de theoretische consequenties van het zonder meer opdoeken van de boswet zoals voorgesteld door de minister, ten aanzien van het bosareaal en landschappelijke beplantingen in Nederland beoordeeld.

Hierbij is centraal gesteld dat met het opheffen van de boswet niet de bescherming van het bosareaal ter discussie wordt gesteld maar alleen de lastenverlichting van het overheidsapparaat tot doel heeft.

Probleemstelling

De minister heeft naar de tweede kamer het voornemen geuit om de herplantplicht van de boswet op te heffen. Deze plicht zegt kortweg: wat eens bos is, zal altijd bos blijven. Men is immers verplicht om er voor te zorgen dat er na de kap wee een nieuw bos op zal komen. De minister schrijft dat er bekeken zal worden of ander instrumenten voldoende andere waarborging zijn voor de instandhouding van het bosareaal. De deskundigen denken van niet. Deze mensen denken dat er een aanzienlijke kans is dat er bos zal verdwijnen. Natuurbeschermingsorganisaties zullen bijvoorbeeld bos kappen ten gunste van andere natuurtypen en met name de kleine particulieren zullen eindelijk hun kans schoon zien om van het bos af te komen. Doormiddel van interviews met allerlei deskundigen (handhavers boswet etc) zal getracht worden beter inzicht te krijgen in de te verwachten effecten. Op basis van deze informatie wordt vervolgens bekeken welke effecten dit kan hebben op de beschikbaarheid van de houtige biomassa op korte (kappen van het verdwijnende bos) en lange (kleiner bosareaal) termijn.

Onderzoeksvragen.
- Wat zijn de alternatieve waarborgen voor de instandhouding van het bosareaal?
- Wat is de geschatte effectiviteit van deze waarborgen als het gaat om handhaving?
- Hoeveel bos zal naar schatting verdwijnen door het wegvallen van de herplantplicht?
- Welke effecten heeft dit op korte en lang termijn voor de levering van houtige biomassa?

Methode.

Literatuur onderzoek:
Workshop: Boswet weg bosweg……..
Participatie: AVIH secretariaat

Resultaten.

1. Documentenonderzoek en interviews naar de bestaande wet en regelgeving die de boswet zouden kunnen vervangen en het mogelijke effect daarvan.
2. Workshop waarin samen met de handhavers boswet naar antwoorden is gezocht over de effectiviteit van de boswet en de vervangende regels en wetten in de praktijk.
3. Theoretische analyse van de gevolgen van het verdwijnen van de boswet voor het bosareaal in Nederland.
4. Participatie met de AVIH, waarin de AVIH het effect onderzocht van de ontheffingsregelingen die LNV met Staatsbosbeheer, Rijkswaterstaat, Dienst der Domeinen en Defensie heeft getroffen.

1. Documentenonderzoek

Welke wetten en regels kunnen de boswet vervangen en wat is de effectiviteit daarvan.
Natuurbeschermingswet (NB wet)
Flora en Fauna wet (FF wet)

Wet op de ruimtelijke ordening (WRO)
Gemeentelijke kapverordeningen
Algemeen rijksbeleid
Het beheer zoals dat plaatsvindt door NGO's en het rijk

- Nb-wet 1998

Onder de gewijzigde Natuurbeschermingswet 1998 worden de Vogel- en Habitatrichtlijngebieden aangewezen, gezamenlijk Natura 2000-gebieden genoemd. De Natuurbeschermingswet vormt het wettelijke kader en geeft de richtlijnen aan. In de praktijk blijkt dat alle gebieden die beschermd worden door de Natuurbeschermingswet 1998 ook in de EHS vallen. Beheer van deze gebieden is opgehangen aan de zogenaamde natuurdoeltypen.

Natuurdoelen die zijn vastgelegd binnen de EHS zijn afgeleid van de natuurdoeltypenkaart
---"De natuurdoelenkaart is in feite een samenvatting van de doelen die met name door allerlei instanties voor natuur gesteld zijn, namelijk van provincies (incl. Particuliere beheerders en Waterleidingmaatschappijen in de duinen), Staatsbosbeheer, Defensie en Rijkswaterstaat. Het is dan ook niet beperkt tot de netto-EHS zoals die door de provincies wordt begrensd, maar het bevat 'alle' bestaande en geplande natuur in Nederland, zowel binnen de EHS als daarbuiten, voor zover belangrijk gevonden door genoemde organisaties"
[1].---

[1] Bron achtergrondrapportage bij natuurbalans 2003 werkdocument 2003/24 Alterra

In een brief van het Bosschap aan de vaste kamercommissie wordt gesteld dat het voorkomt dat in het kader van de vogel en habitat richtlijn bos is aangemeld als “niet-bos” (heide, stuifzand of open water in veengebieden) terwijl de actuele vegetatie voldoet aan de definitie van bos volgens de boswet.

Dit is ook geconstateerd door de onderzoekers van de vijfde bosstatistiek.(8,2% van de steekproef-punten bleek in niet-bos te liggen waar het volgens de gegevens uit de bossenkaart 2001 wel had moeten liggen)

Natura 2000 gebieden wordt voldoende areaal bescherming geboden als het gaat om de bescherming van voorkomende rode lijst soorten en beschermde habitats.
Dit betekend dat bosareaal pas dan beschermd is als bewezen en vastgelegd dat daarmee de aanwezige rode lijst soort beschermd is.

Habitat typen die in aanmerking komen voor bescherming met het Natura 2000 doel zijn:
- Duinbossen droog. Verbetering verspreiding, Behoud maar lokale uitbreiding.
- Duinbossen vochtig. Behoud verspreiding, behoud maar lokale uitbreiding.
- Duinbossen binnenduinrand. Behoud verspreiding, behoud oppervlakte.
- Veldbies-beukenbossen, Behoud verspreiding, uitbreiding oppervlakte.
- Beuken-eikebossen met hulst, Behoud verspreiding, uitbreiding oppervlakte.
- Eiken-haagbeukenbossen subtype A. Behoud verspreiding uitbreiding oppervlakte
- Eiken haagbeukenbossen type B. Behoud verspreiding en behoud oppervlakte
- Oude eikenbossen. Behoud verspreiding en behoud oppervlakte.
- Hoogveenbossen. Behoud verspreiding en uitbreiding oppervlakte.
- Vochtige alluviale bossen. Subtype A. Behoud verspreiding en uitbreiding oppervlak.
- Vochtige alluviale bossen. Subtype B. Uitbreiding verspreiding en uitbreiding oppervlak.
- Vochtige alluviale bossen. Subtype C. Behoud verspreiding en uitbreiding oppervlak.
- Droge hardhout ooibossen. Uitbreiding verspreiding en uitbreiding oppervlak.

- FF-wet;

In de flora en fauna wet is niet bepaald dat bos bos moet blijven tenzij het is gedefinieerd en door gedeputeerde staten aangewezen als beschermde leefomgeving. Dit zijn gebieden, anders dan natuurmonumenten en/of staatsnatuurmonumenten, welke een leefomgeving zijn voor een beschermde inheemse plantensoort of een beschermde inheemse diersoort.

- Gemeentelijke bevoegdheden.

De gemeentelijke bevoegdheden beperken zich tot de bestemmingsplannen in het kader van de wet op de ruimtelijke ordening. Bossen en landschappelijke elementen zijn alleen voldoende beschermd als ze zijn beschreven in de bestemmingsplannen zijnde bos met speciale landschappelijke en of natuurwaarde. Voor de bescherming van de individuele boom heeft de Vereniging van Nederlandse Gemeenten (VNG) hebben een model Algemene Plaatselijke Verordening (APV). Veel gemeenten maken gebruik van deze modeltekst of een aangepaste versie daarvan.

In de meeste gevallen als het gaat om bescherming van bos en landschappelijke beplantingen, vormt de boswet de basis voor het wettelijke kader voor de bestemmingsplannen en de APV’s. en wordt in deze documenten verwezen naar de boswet.

Er is op het gebied van verlening en handhaving van kapvergunningen een trend waar te nemen dat gemeentes het vergunningenstelsel juist uitdunnen en er geen kapvergunningen worden vereist voor de kap van bomen.

- Algemeen rijksbeleid:

In de “Visie op de houtoogst”, een gezamenlijk product van het ministerie van LNV en het platform hout wordt gesteld dat er geen specifiek bos en houtbeleid is. Het Nederlandse bosbeleid is vastgelegd in de nota “Natuur voor mensen, mensen voor natuur” deze nota gaat niet in op areaalbescherming en geldt bovendien alleen voor de gebieden die binnen de EHS vallen.

- Het beheer zoals dat plaatsvindt door NGO’s en het rijk.

Het beheer is volledig afgestemd op de ontwikkelingen van het overheidsbeleid en kan niet worden gezien als argument voor de bescherming van het bosareaal. In theorie is dankzij het bestaan van de boswet zijn bijvoorbeeld RWS en SBB nu verplicht conform de boswet te werken en ontbossing moet worden gecompenseerd. In de praktijk blijkt dit anders te werken. Grote beheerders zoals Natuurmonumenten werken nu dankzij de boswet in specifieke gevallen met het wandelend bos concept hierbij is men verplicht het oppervlakte bos te handhaven binnen een beheerseenheid maar is de locatie niet strikt vastgelegd. Dit zijn op dit moment de enige waarborgen voor in stand houding van het bosareaal. Het valt nog te bezien of de genoemde beheerders zonder deze verplichtingen het bestaande bosareaal zullen handhaven.

2. <u>Workshop.</u>

De centraal gestelde vragen tijdens deze workshop waren:

A. Wat zijn de alternatieve waarborgen voor de instandhouding van het bosareaal?
B. Wat is de geschatte effectiviteit van deze waarborgen als het gaat om handhaving?
C. Hoeveel bos zal naar schatting verdwijnen door het wegvallen van de herplantplicht?

Ad. A.
In de praktijk bieden alleen de wet op de ruimtelijke ordening (WRO) bescherming en de Natuurbeschermingswet (NB wet) voldoende mogelijkheden om het bosareaal te beschermen. Voor de NB wet gebieden geldt dit echter maar voor een klein deel van het werkelijk bos. Het zijn alleen die bossen die zijn aangewezen als; in stand te houden bos.

De Flora en Fauna wet (FF wet) is gericht op individuele soorten en biedt geen bescherming.

Gemeentelijke kap-/bomenverordeningen, zijn het instrument bij de uitvoering van de WRO. De inhoud en de uitvoering van de verordeningen kunnen per gemeente verschillen. Herplant is vaak geen verplichting binnen dit systeem en de uitvoering erg afhankelijk van willekeur. Er bestaat een model verordening die is opgesteld door de VNG. De handhaving van de kapverordening is een zwak punt. In de meeste gevallen is de plaatselijke kapverordening opgehangen aan de boswet . Dit houdt in dat bij afschaffing van de boswet ook alle plaatselijke verordeningen moeten worden aangepast.

Ad. B. De WRO in combinatie met de lokale verordeningen bieden een theoretische/passieve bescherming. In de praktijk blijkt meer dan eens dat de gemeente wikt en ook beschikt. Doordat gemeentes met twee petten moet werken en de politiek gevoelige onderwerpen zoals uitbreiding van de infrastructuur, woonwijken en industrie moeten worden afgewogen tegen bos en natuur, leggen de laatste het vaak af en is er in veel gevallen ook geen of in onvoldoende mate sprake van compensatie. Geld is daarbij vaak het argument om compensatie niet uit te voeren. In de WRO is compensatie niet geregeld en is gebaseerd op conservering en niet op ontwikkeling. De WRO is in die zin niet technisch van aard. Ontbrekende zaken zijn eisen ten aanzien van herplant en beheer. Een koppeling tussen de WRO en de aanlegvergunningen, beschreven in de bestemmingsplannen kunnen voldoende bescherming bieden. Dit vind echter op zeer kleine schaal plaats.

De NB wet bied alleen bescherming op expliciet beschreven bossen, gemotiveerd vanuit ecologische gronden. Toezicht en handhaving vindt plaats middels een vergunningenstelsel.

Ad. C. Bossen die in de praktijk gevaar lopen op termijn te verdwijnen zijn landschapselementen die geregistreerd zijn bij bosbouwondernemingen, Bosjes en singels buiten bosverband, Bossen die omwille van soortenbeleid worden opgeruimd, bossen voor landbouwgrond, bos voor andere bestemmingen zoals infrastructuur, wonen en industrie, Bos voor andere natuur.

Naast het werkelijk verdwijnen van bos in absolute zin verdwijnt er ook bos en landschappelijke beplanting in kwalitatieve zin. Dit omwille van bijvoorbeeld ruilverkaveling, infrastructurele werken etc.

Wat er, uitgedrukt in oppervlaktes, aan bos gaat verdwijnen zonder boswet is voor de deelnemers moeilijk in te schatten maar op basis van lokale ervaringen met de handhaving komt het huidige gemiddeld neer op enkele honderden tot duizend hectare per jaar per provincie. Daarnaast wordt nu ongeveer een even groot deel door de boswet beschermd en voor verdwijning behoed. In een situatie zonder boswet verdwijnt naar schatting een gemiddelde van 1000 hectare per jaar per provincie.

Stand van zaken bet betrekking tot de boswet is dat de wet op details verbeterd kan worden. Het is een sectorale wet en eenzijdig georiënteerd op het economisch belang van de bossen. Daarnaast is het toegesneden op kaalkapsystemen en past het niet in de beheersfilosofie van vandaag. Ook is de relatie tussen de WRO en de boswet onduidelijk en kan de boswet conflicteren met de NB wet.

Echter blijven een aantal sterke punten van de wet overeind. De wet is eenvoudig, een effectief tegen lage kosten. Er is een breed draagvlak bij de bevolking als de boseigenaren. Handhaving levert een beperkte last voor de burgers door een korte procedure tijd. Beheerders worden aangezet tot een actieve zorgplicht en de wet beschermd ook bossen en landschapelementen buiten de EHS.

Algemene conclusie die tijdens de workshop naar voren kwam is, dat in theorie de wetten en regels die naast de boswet bescherming bieden aan het bosareaal voldoende zouden moeten zijn. De nadruk ligt hierbij op de theorie. De deelnemers zien in de uitvoering de bottleneck omdat veel andere regels juist zijn opgehangen aan de boswet en bij afschaffing van de laatste alle bestaande regels moeten worden aangepast. Het levert inderdaad een wet minder op maar ten compensatie van de lacunes veel meer extra regels. Wel erkennen de deelnemers dat de boswet aan revisie toe is

3. Theoretische analyse.

Geconcludeerd kan worden dat alleen de vogel- en habitatrichtlijn gebieden een relatieve areaalbescherming waarborgen aangezien de leefomgeving voor de erkende en beschermde waarden in die gebieden niet mag worden aangetast. Voor bos mag worden aangenomen dat bestaand bos in die gevallen dus bos moet blijven.

Uit de verschillende statistieken kunnen vervolgens de volgende gegevens worden gehaald.

Methode:
Totaal bosareaal is gebaseerd op informatie uit de kerngegevens bos en hout 2005.
Alle andere oppervlaktes zijn afgeleid uit de verdelingen zoals weergegeven in de vijfde bosstatistiek in het hoofdstuk bescherming, waarbij is aangenomen dat alle Natura 2000 bos binnen de EHS valt.

Bosoppervlak in NL

Totaal (Ha)	Bos binnen de EHS[2]	Bos buiten de EHS
360.000[3]	300.960 Ha	59.040 Ha

[2] Bron Vijfde NL bosstatistiek concept Juni 2006
[3] Bron: Kerngegevens bos en hout november 2005. Oppervlakte bos dat voldoet aan de FAO criteria.

Verdeling binnen de EHS [4]

Totaal EHS	Natura 2000	Geen Natura 2000
300.960 Ha	121.680 Ha	179.380 Ha

Bos dat binnen de voorgestelde kaders geen of onvoldoende areaalbescherming heeft.

Bos buiten de EHS	59.040 Ha
Bos binnen de EHS zonder Natura 2000 toekenning	179.380 Ha
Totaal	**238.320 Ha**
Uitgedrukt in % van het totaal bosareaal in NL	66,2%

Er kan worden gesteld dat deze 238.320 Ha zonder de boswet onvoldoende is beschermd tegen functieverandering (van bos naar niet-bos).

4. Participatie AVIH onderzoek.

Het AVIH onderzoek heeft zich met namen gericht op de effecten van de ontheffingsregelingen die door LNV zijn overeengekomen met respectievelijk; Staatsbosbeheer, Rijkswaterstaat, Dienst der Domeinen en Defensie. Deze instanties zijn ontheven van de meldingsplicht voor uitvoering. Deze zaak is in het kader van ons onderzoek erg belangrijk omdat het een goed beeld geeft van de praktijk waar beheerders geen rekening hoeven te houden met de boswet. Ontheffing van de boswet veroorzaakt ook een ander effect dat binnen de boswet gewaarborgd is, namelijk de voorwaarde dat herbebossing ‘bosbouw kundig verantwoord’ moet zijn. Zodra beheerders ook in dit kader geen verplichtingen worden opgelegd of controle plaats vindt, zal het aandeel kwaliteitshout in het Nederlandse bos drastisch afnemen, met alle gevolgen voor de sector.

De conclusie van de AVIH is op zijn minst zorgwekkend te noemen. Het blijkt namelijk dat er voordat de gegevens openbaar werden gemaakt een beroep op de openbaarheid van bestuur moest worden gedaan. De verstrekte gegevens bleken vervolgens niet compleet of volledig te ontbreken er werd een verschil van ongeveer 25% tussen gemelde kap en gecompenseerde oppervlak gevonden. Verder meld de AVIH dat er geen controle door de AID plaats vindt om een en ander te controleren en te verifiëren.

Ook blijkt uit andere bronnen dat lang niet alle gevelde oppervlaktes worden gecompenseerd.

Naast deze zaak haalt de AVIH ook een aantal voorbeelden aan om de werking van de boswet en het handhavingmechanisme te illustreren. Een tweetal kapmeldingen worden, geheel volgens voorschrift, gedaan bij de provincie doorgespeeld aan de gemeentes die op hun beurt allerlei niet van toepassing zijnde procedures opstarten. Met tot gevolg dat de eigenaars vast komen te zitten in diverse procedures en een rekening krijgt van tussen de 400 tot 500 Euro aan legeskosten. Dit terwijl de boswet herplant vereist en de gedragscode regelt dat er zorgvuldig wordt gewerkt conform de eisen van artikel 75 van de FF wet.

De AVIH geeft in haar conclusie aan dat de boswet en het controle systeem daaromheende bescherming van bos en al haar bijkomende waarden het best waarborgd en het meest effectief is. De vereniging pleit voor een verandering van de wet op de ruimtelijke ordening, door alle bos uit de wet te halen en onder te brengen bij de boswet. Ook pleit de vereniging voor het gelijke monniken gelijke kappen beleid ten aanzien van bosbeherende overheden. Zeker als dit wordt afgezet tegen de ondermaatse rapportage en het ontbreken van controle en verificatie en de verantwoordelijkheid die de Nederlandse overheid heeft ten aanzien van ons eigen bosbeheer. Nederland maakt zich op diplomatiek niveau wel zorgen om wet en regelgeving en de handhaving op het gebied van bosbeheer elders op de wereld maar laat aan het thuisfront aantoonbaar steken vallen.

[4] Er van uitgaande dat alle Natura 2000 bos binnen de EHS valt.

Conclusies.

- Het voornemen van de minister op de boswet op te doeken zal allen leiden tot een beperkte lastenverlichting van het overheidsapparaat. Het hoofddoel van de boswet, namelijk wat eens bos is moet bos blijven wordt hierbij niet formeel ter discussie gesteld.

- De notitie verschijnt in een periode waar de politieke interesse voor de bos- en houtsector aan het verminderen is en de lastenverlichting van het overheidsapparaat bovenaan op de agenda staat. Zie ook de beleidsvisie op de houtoogst. Maar tegelijk ook in een tijd waar de politiek zich druk maakt om het veranderende klimaat, gebruik van verantwoorde en duurzame energiebronnen, het verminderen van de CO2 uitstoot en het verminderen van onze afhankelijkheid van energiebronnen elders. Vreemd als je daarbij bedenkt dat de politiek daarbij ogenschijnlijk erg makkelijk omspringt met het behoud van een van onze belangrijkste CO2 vastleggers en bron van biomassa, namelijk ons Nederlandse bos en landschappelijke beplantingen.

- Uit de analyse van de NBW gebieden blijkt dat er waarschijnlijk meer bos is (was) in Nederland dan aanvankelijk officieel geregistreerd. In de bosstatistiek is een verschil van 8% ontdekt van meetpunten die in bos zouden moeten liggen maar dat in werkelijkheid niet deden. Een nulmeting (eventueel terug in de tijd bijvoorbeeld 1998 zou op z'n plaats zijn om; A. een mogelijke areaalverschuiving te verifiëren en B. om de arealen op de doeltypen kaart en de oorspronkelijke arealen te vergelijken)

- Bestaande wetten en regels kunnen alleen in theorie voldoende waarborgen bieden voor het behoud van het bosareaal. De praktijk laat echter een volledig ander beeld zien. Gezien de ervaringen en de huidige ontwikkelingen zal het opheffen van de boswet juist het averechtse effect opleveren dan de bedoeling is. Namelijk geen of ontoereikende areaalbescherming door: Inefficiënt of volledig ontbreken van toezicht , verschillen in interpretatie, een toename van de druk op het overheidsapparaat door een uitgebreid vergunningenstelsel.

- Afschaffing van de boswet zal direct effect hebben op het Nederlandse bosareaal buiten maar ook binnen de EHS. Met name landschappelijke beplantingen en kleine bosjes in particulier bezit in lopen direct gevaar. Maar ook bossen waar geen expliciete bescherming (door aanwezigheid van rode lijst of beschermde habitats) voor geldt zijn onvoldoende beschermd. Het verdwijnen van bos wordt voornamelijk ingegeven door het grote waardeverschil tussen bosgrond en landbouwgrond en door het gangbare omvormingsbeleid (het is ecologisch gezien makkelijker scoren met grasland dan met bos). Daarnaast zullen bossen en landschappelijke beplantingen die verdwijnen door bestemmingswijzigingen niet gecompenseerd worden.

- Zou de inschatting van de handhavers kloppen dan zou in ongeveer 20 jaar tijd het onvoldoende beschermde areaal bos (66% van het huidige areaal) zijn verdwenen.

Alhoewel de boswet oud is en wellicht aan revisie toe, lijkt het met enige aanpassingen een prima kapstok te zijn voor de natuurwetgeving in Nederland. De wet heeft zich al geruime tijd bewezen en is mits goed toegepast en de procedures juist uitgevoerd zeer effectief en eenvoudig.

- Wat de brief van de minister in ieder geval heeft veroorzaakt is dat de belanghebbenden aan het denken zijn gezet en er veel duidelijk is geworden. Er zijn hierdoor een aantal unieke kansen op verbetering boven komen drijven. Het is tijd voor een eenduidige brede wetgeving waarin alle bosdoelen worden gediend met oog voor de ontwikkelingen van deze tijd. De boswet kan als instrument en de ervaring van de sector en handhavers prima dienen als raamwerk waar de nieuwe of aangepaste wetgeving omheen gebouwd wordt.

Literatuur en andere documenten:

Alterra, Achtergrondrapportage bij natuurbalans 2003 werkdocument 2003/24 NB wet,
Bomenstichting, Bomen en wet, 2001
LNV, Project herbeoordeling LNV-vergunningen met bijlage TRCJZ/2006/1412,
LNV, nota "Natuur voor mensen, mensen voor natuur" Nota natuur, bos en landschap, 2000.
LNV Natura 2000 doelendocument,
LNV, rief van de minister aan de tweede kamer,
LNV, Nota Boswet commissie Rotteveel,
LNV, Evaluatie natuurwetgeving plan van aanpak,
LNV, Programmatisch handhaven natuurwetgeving plan van aanpak.
VROM Inspectie. De uitvoering van het compensatiebeginsel. 2006
Probos, Bosstatistieken,

Andere info uit correspondentie en gesprekken.
Bas Visser van B.M. Visser en partners, Cees Boon van de AVIH, Leon Jansen van de Provincie Limburg, Ineke Brusse en Annemarie Jorritsma van het Bosschap, Jaap Roording van LNV. Bosschap,

Achtergrond bij de gebruikte gegevens:

In een brief van het bosschap aan de vaste kamercommissie wordt gesteld dat het voorkomt dat in het kader van de vogel en habitat richtlijn bos is aangemeld als “niet-bos” (heide, stuifzand of open water in veengebieden) terwijl de actuele vegetatie voldoet aan de definitie van bos volgens de boswet.
(Zie ook de aantekening over het tot stand komen van de doeltypenkaart uit het rapport van Alterra 2003/24)

Dit is ook geconstateerd door de onderzoekers van de vijfde bosstatistiek.(8,2% van de steekproef-punten bleek in niet-bos te liggen waar het volgens de gegevens uit de bossenkaart 2001 wel had moeten liggen)

Hieruit blijkt dat er waarschijnlijk meer bos is in Nederland dan officieel geregistreerd en kunnen beheerders hun gang gaan met omvorming. Een nulmeting (eventueel terug in de tijd bijvoorbeeld 1998 zou op z’n plaats zijn om; A. een mogelijke areaalverschuiving te verifiëren en B. om de arealen op de doeltypen kaart en de oorspronkelijke arealen te vergelijken)

Definitie bos volgens het CBS

- Terrein zodanig begroeid met bomen, dat de kruinen een min of meer gesloten geheel vormen dan wel zullen gaan vormen;
- Kapvlakte;
- Brandgang;
- Bospad;
- Boomkwekerij;
- Houtopslagplaats;
- Verspreide bebouwing, voor zover die in het bos ligt;
- Populierenweide.

Niet tot bos worden gerekend:
- Beboste delen van parken;
- Niet in het bos gelegen boomkwekerijen;
- Woongebieden (met stratenpatroon) en terreinen voor verblijfsrecreatie die in bos gelegen zijn;
- In het bos gelegen campings.

<u>Definitie bos volgens de vijfde bosstatistiek 2006:</u>

- Bos met een duidelijke productiefunctie
- Bos met een duidelijke behoudcomponent. Male-, boom- en strubbenbos. Het scherm- en het landgoed/parkbos.
- Bos met een component natuurontwikkeling. Struweel <8m. spontaan, tijdelijk of onbeheerd bos.
- Bos met een bijzonder terrein type. Laan, houtwal, singel, hakhout, griend/energie, recreatiebos, landschappelijke beplanting.
- Geen bos. Bos op de bossenkaart aangegeven als bos maar bij veldbezoek: agrarisch gebied, bewoning, dagrecreatie, industrie, militair. terrein. Natuur terrein, park, begraafplaats, sportterrein, stortplaats, verblijfsrecreatie, water, wegen.

8

SWOT-analysis of the Dutch forest exploitation sector

By: Leen Kuiper, Probos
Date: September 18, 2006

PART 1 OVERVIEW OF THE DUTCH FOREST EXPLOITATION SECTOR

1.1 AVIH

The "Algemene Vereniging Inlands Hout (AVIH)[1] is a branche-organization in The Netherlands of entrepreneurs active in the field of forest management, wood harvesting, round wood trade and round wood processing (saw mills, paper industries, biomass) as well as in consulting services on forest management. The AVIH was founded in 1951 and has 80 participating members. Some of the AVIH-members are actively involved in the field of forest exploitation and timber trade in neighboring countries (Germany and Belgium) as well. The AVIH is participating in the European Network of Forest Entrepreneurs. Since 2000 the AVIH has been member of FSC (Forest Stewardship Council) and, as such, actively supports sustainable forest management and the FSC chain-of-custody.

1.2 Economy of the Dutch forestry and wood processing sector

The Dutch "Economisch Instituut voor het Midden- en Kleinbedrijf (EIM)" has calculated that the harvesting and processing of Dutch round wood (logs) generates an annual turnover of about 300 million euro (excluding VAT). In 2004 a total of 325 companies, registered at the "Bosschap", were involved in forest exploitation and timber harvesting (table 1), with an annual turnover of 47 million euro directly resulting from work in Dutch woodlands.

Table 1
Overview of registered companies involved in forest exploitation in The Netherlands (data updated through December 2004)

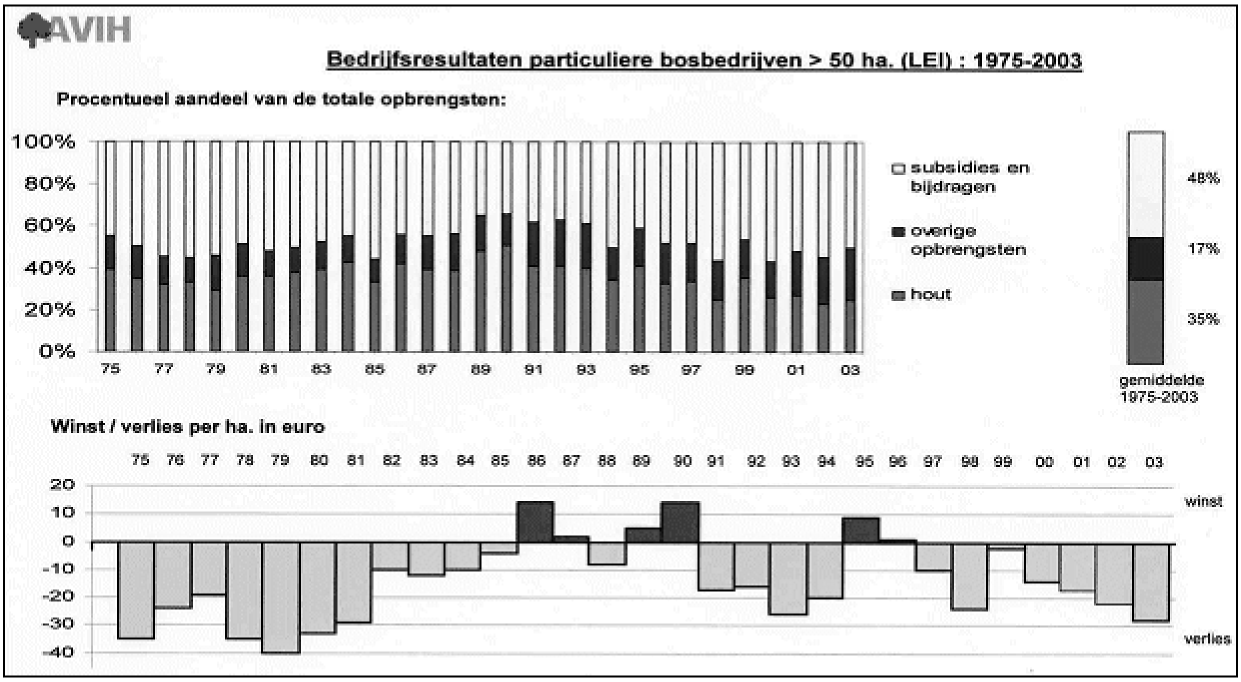
Annual return category (euros/a)	Number of companies	Total returns form work in the Dutch woodlands (euros)
Less than 11,350	70	119,300
11,350 – 45,380	88	2,567, 600
45,380 – 113, 445	72	5,403,400
113, 445 – 226, 890	39	6,260,950
226, 890 – 453,780	32	10,530,300
Over 453,780	24	22,521,700
Total	**325**	**47, 404,000**

For the sustainable management of Dutch woodlands wood production and the harvesting of round wood provides an important source of income. Subsidies too contribute significantly to the economy of forest enterprises, but it is uncertain how long these subsidies will continue to be provided by the government. The forest owner can decide by himself on the level of wood harvesting in terms of quality, quality and wood species which he is willing to provide to the market. Since 1950 the Dutch Agricultural Economic Institute (LEI) is monitoring the economic performance of forest companies with more than 50 hectares of woodlands: unfortunately their performance is mostly

[1] Most of the information in Part 1 is derived from http://www.avih.nl/

negative (Figure 2): over the past 30 years only during 6 years the economic returns have been profitable.

Figure 1
Economic returns from forest companies larger than 50 ha, monitored since 1975.



1.3 Round wood traders

Timber traders involved in forest exploitation take a specific position in the Dutch round wood market: these companies buy standing timber from forest owners and carry out the harvesting, transportation and delivery to the wood processing industries. This implies that the round wood supply chain from woodlands to the industry is in one hand. Consequently, organization of the supply chain is very effective and communication lines are short. The timber traders work closely together with forestry contractors, transportation companies and the wood working industries. In this respect, the timber traders fulfill an important function by signing supply contracts with the wood processing industry and buying contracts with the forest owners. The forest exploitation traders often have their own forest exploitation units and timber transportation capacity. If not sufficiently they hire sub-contractors to do the chain saw work, the skidding and forwarding of the logs to forest roads and the logistics by lorries in combination with railroad transports and sometimes by river barges. About 50 AVIH members are involved in timber harvesting and trading as their main activity, which are responsible for 75 percent of the total Dutch wood harvesting.

Round wood traders deliver various wood assortments to the wood working industries. Firstly, they buy standing timber form forest owners: trees, which are earmarked by the forest managers to be felled. Secondly, the round wood traders carry out all harvesting operations, including the cutting of logs into the desired assortments and the transportation of the round wood assortments to end-users. Round wood traders buy several wood lots from different forest owners (sometimes even from forest owners abroad) to be able to supply a continuous stream of assortments specified to the requirements of the industry. In most cases the round wood traders have their own personnel to carry out the harvesting and they have sufficient lorries for transports. However, frequently the traders hire specialized sub-contractors to carry out specific activities. Especially in the Dutch situation, characterized by many small forest owners, who often lack the requited skills and are unable to supply sufficient volumes of wood to be harvested, the round wood traders play an important role in bringing supply and demand together and in achieving an economy of scale.

1.4 Logistics and transportation

The market for Dutch wood is confined to The Netherlands. On the contrary: timber is being traded wide across the countries' boundaries. International supply and demand highly influence the market position of Dutch industrial round wood. Round wood from the Dutch woodlands is almost exclusively transported by lorries. However, transport over water and by rail do play a role at timber imports. But because most Dutch round wood processing industries are not located near waterways or railways, additional road transport by lorries often is required. In the Netherlands over 200 lorries are being used for round wood transports owned by about 50 entrepreneurs. They use modern equipment, including specialized lorries for short sized assortment and for long-sized logs. Most round wood is being transported as short sized assortments. A recent development with the lorries for short sized round wood assortments is that they no longer have their own loading and unloading crane mounted to the lorry. This saves some weight and thus more round wood can be transported. In which case the round wood assortments are being loaded at the forest roads by a forwarder and unloaded by a crane installed at the processing plants.

In the Dutch round wood supply chain the costs for transportation may amount to 20% to 40% of the timber value at the gate of the processing plant. This stresses the need for a high loading rate and is also the reason that short wood lorries are increasingly being used to transport consumer ready wood products from the panel and saw mill industry as a return freight. Unfortunately, the different EU member states do not have uniform and consistent regulations on the maximum allowable lorry weight: in The Netherlands 50 tons lorries are allowed; in Belgium 44 tons and in Sweden and Finland 60 tons.

1.5 Round wood market

The Dutch round wood market is characterized by many different wood species, many suppliers, a supply of small wood lots from often small woodland areas and a wood processing industry which is mostly small-scaled. Round wood imports play an important role on this market. The wood processing industry requires assortments of a certain quality, diameter and length. The Dutch forest owners offer their round wood as standing timber in the forests. Round wood traders combine and join together this very heterogeneous round wood supply into the specific requirements of the industry, both in The Netherlands and abroad. Dutch saw mills no longer deliver sawn wood products from stock, but deliver upon specifications "just-in-time". Thus the supply lines between wood lands and end-users are very short.

Wood fibers are the main product on the Dutch wood market, as a raw material for the pulp and paper industry. Pulp fibers are being made from small sized round wood and from the residues of the sawmill industries. The worldwide demand for paper annually increases by about 2 to 3 percent . Consequently, also the demand for wood fibers increases steadily. This impacts not only the price for small sized round wood, but also for the larger sized saw logs. For the economic performance of the saw mill industry not only the price of the swan products is important but equally the price for its rest products (residues): from each saw log about 50% is being sold as sawn wood products and 50% as residues.
Also the panel industry is active on approximately the same wood market. If the timber demand by the building and construction sector or by the furniture industry increases, this immediately affects the round wood prices in the forests. The price level is restricted at the upper level by the price of alternative materials such as concrete, plastics and metals. Inevitably, wood will out price itself if the same products can be made from a cheaper raw material (e.g plastic garden furniture).

The paper and panel industries provide the largest outlet for small sized round wood. These industries operate at an international market and often belong to large international consortia. The round wood they need has standard dimensions, which allow fast processing of relatively large volumes. On the other hand, the Dutch saw mill industry delivers their sawn products mainly to the Dutch market. Saw mill for (broadleaved) hard woods generally are smaller in size than saw mills for soft woods (conifers). Therefore, the specifications of the raw material, sawing techniques, economy and market outlets mat widely differ between these two sectors. Some of the Dutch saw mills may process both hardwoods and soft woods, in which case the round wood is bought with a specific end-use in mind and can hardly be standardized. Saw mills specialized in soft woods buy their round wood in relatively large and standardized volumes, which allow fast processing and a tight delivery schedule.

Obviously, the Dutch round wood processing industry is subject to competition from similar industries abroad. The demand for (the same) round wood is impacted by players on an international market. This means e.g. that some of the Dutch saw logs of oak are actually being transported to China in stead of being processed in The Netherlands; Dutch poplar logs go to Morocco and Dutch beech logs to Denmark.

1.6 Harvesting costs

Round wood can be supplied by the forest owners in different ways:

- As standing timber in the forests
- As cut down long-sized stems, hauled and forwarded to the forest road
- As assortments cut to specified dimensions, being stacked in a pile alongside the forest road

In The Netherlands most round wood is being sold as standing timber. This means that the buyer is responsible for all logging activities, the transportation and supply of the different assortments to the wood working industries, according to their specifications. Harvesting costs may vary according to the harvesting method applied, the type of timber (tree species and volumes) and the specific terrain conditions, such as the presence of dense undergrowth, ditches, hauling distance to the nearest forest road, etc). The harvesting costs of the standing timber method include all costs of felling, pruning, cutting it to smaller sizes by chain saw, skidding and forwarding of the logs and to stacking them into piles. The costs of the long stem method include felling, pruning hauling and stacking.

1.7 Biomass

In the Netherlands power companies provide an additional outlet for small sized timber, logging residues, wood processing residues and used wood to be converted to power and heat in bio-energy plants. Also the co-firing of woody biomass in coal plants in increasing significantly. As a result there is a growing extra demand on the wood market. This may have a positive impact on the market provided that traditional uses are not being out-competed. From an environmental point of view it would be a pity if wood from which many useful products can still be made, would be burned instead. Preferably bio-energy is generated from woody biomass which is not or no longer suited for other end-uses. This implies that forestry biomass which can be used as raw material for the panel and paper industries, should not be used directly as a bio-fuel.

In Scandinavia foresters have some experiences with the harvesting of energy wood. Even in Scandinavia the percentage of fresh wood being harvested uniquely for the purpose of bio-energy is relatively small. Frequently the harvesting is confined to trees suffering from stem-rot or the collection of logging residues on clear cut areas[2]. This has the additional advantage that the clear cut areas can be more easily replanted. If a similar situation would be valid for the Netherlands, this

[2] Of all the energy wood derived from Swedish woodlands 10% comes from regular thinning; 20% is from low quality stems being rejected for other uses and 70% from the collection of logging residues from clear-felling.

would imply a very limited contribution of forestry biomass to the total volumes of biomass required. In The Netherlands clear cutting is no standard practice. Most wood is being harvested in regular thinning.
New developments may include the use multi-stem harvesters, which are currently being tested in Sweden (figure 2). And there are prototypes of baling machines which can bundle tree tops and branches into round bales, which can easier be handled and transported by regular lorries (Figure 3).

Figure 2
Multi-stem harvester with a felling head which can handle a number of small-sized stems

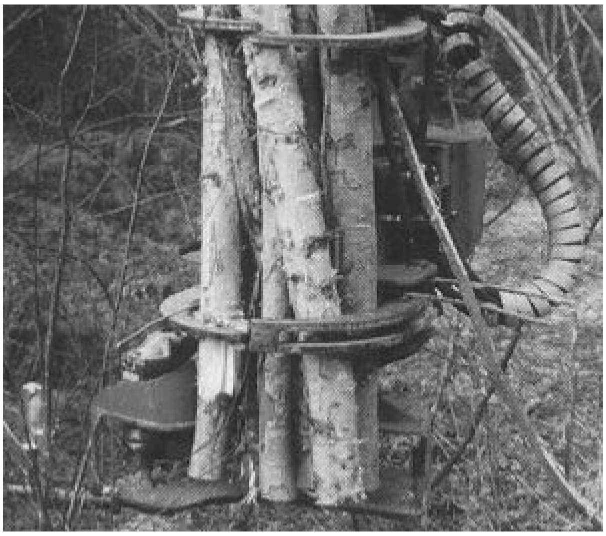
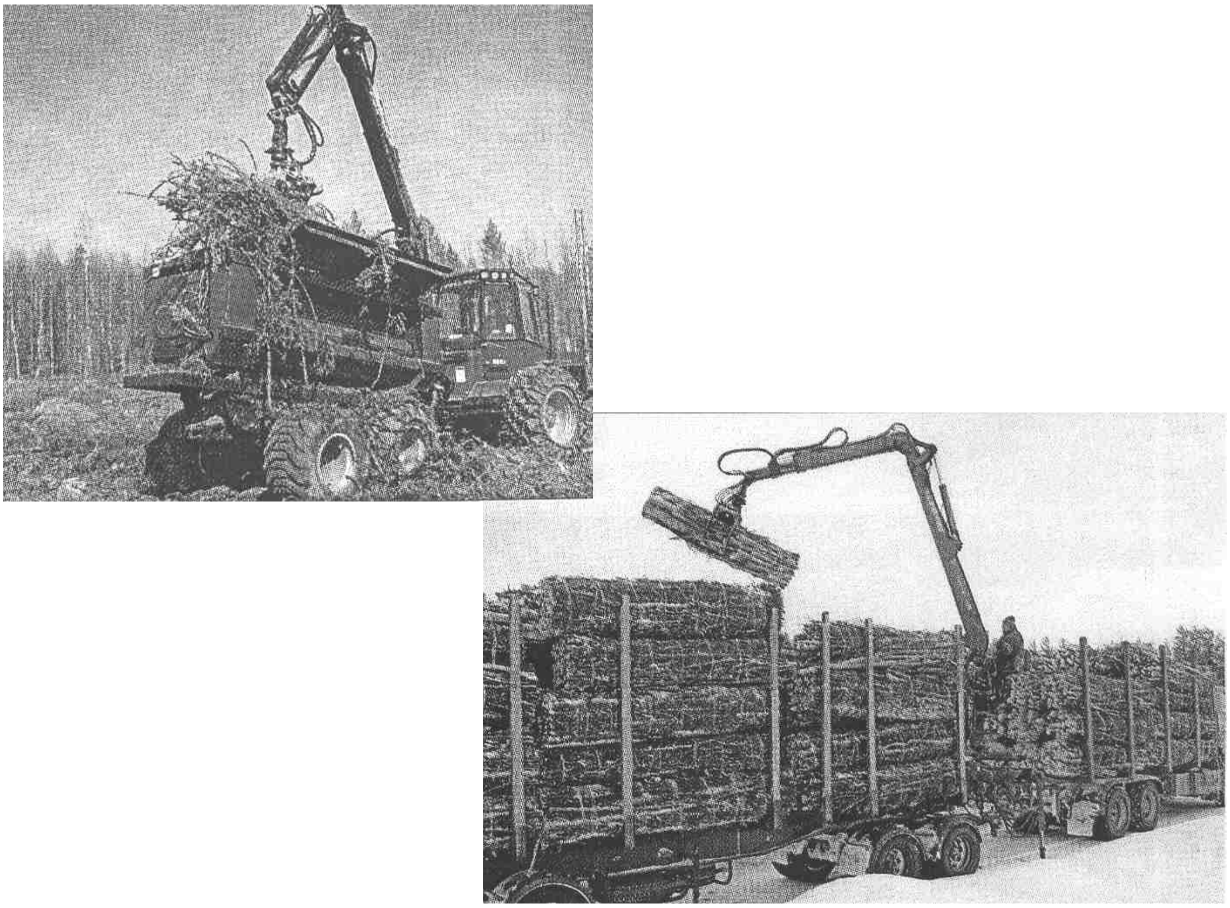


Figure 3
Swedish machines to bundle treetops and branches for easier handling and transportation



1.8 Energy wood from Dutch forests

Several AVIH-members are active in the field of production, harvesting and trade in woody biomass (table 2). Depending on the conversion technology bio-energy power plants demand specific requirements to the biomass supply in terms of moisture contents, allowable sand fraction, sizes of the chips and percentage leaves and bark.

Table 2
AVIH-members, which are actively involved in the production and handling of woody biomass (in alphabetical order).

Companies	
Beeftink en Zn, Fa. A.	Parenco Hout B.V.
Bruins & Kwast Groenaannemers B.V.	Silvertand Houthandel
DEVOBO Forest Service B.V.	Vliet, Houthandel C.L. van
Mensink Loonbedrijf v.o.f.	Weert Rondhout B.V., Van
Meulendijks Rondhout B.V.	Weijtmans, Boomrooierij
Ned. Rondhout Combinatie B.V.	Willemsen Naaldhout B.V.

How much energy wood from the Dutch woodlands will become available on the market, very much depends on the price and on the fuel specifications. The fresher the wood, the lower its combustion value. E.g. wood from summer felling contains more moisture and leaves than wood from winter fellings. The comminuting of fresh round wood and logging residues into wood chips for energy purposes can best be done in a large chipper or tub grinder at a central yard near the energy plant than by using small mobile chippers in the forests. Central chipping certainly has advantages for the logistics and economy of the supply chain. In this respect, the paper and panel industry has preceded the bio-energy sector in harvesting and transporting round wood (logs) from the forest to the conversion site and in doing the necessary pretreatment steps at a central yard.

Apart from forestry biomass as a co-products of the management of Dutch woodlands, a lot of woody biomass is being supplied by trees felled for urban development and to make room for new infrastructures (e.g. roads, railways). In addition to prunings from parks and gardens, used wood from demolition sites and wood processing residues, a limited fraction of fresh wood from forests and landscape plantings is actually being used as bio-fuel. Whether or not this is a feasible alternative to traditional uses, is a matter of business economics.

PART 2 SWOT-ANALYSIS

What are the strengths and weaknesses of the Dutch Forest exploitation sector and which opportunities and threads are being experienced by the companies involved? By means of a SWOT-analysis the actual and future situation can be analyzed on the basis of which better choices can be made. In this follow-up study a SWOT-analysis has been carried out in accordance with the planning methodology developed by Santema et al (1997) [3] in close collaboration with participants from the sector, of which the main results will be presented.

2.1 Methodology

In short the planning methodology of Santema et al. distinguishes four stages, each with a similar structure: based on an commonly agreed point of departure (e.g "Dutch companies involved in forest exploitation are well organized, knowledgeable and business oriented and are very well able to compete with foreign companies") data are being collected, analyzed, possible relationships suggested and new ideas generated. With the help of a choice-instrument the collected data are structured and grouped together and priorities given, which will provide a focus. Each stage in this planning process should lead to a concrete result, which forms the point of departure for the next stage.

In the first stage of a SWOT-analysis the internal strengths and weaknesses as well as the external opportunities and threads are presented in an orderly way. In stage 2 the internal and external factors are being related to each other in a so-called confrontation matrix. From this matrix main points of attention are being derived. In stage 3 for each of the main points of attention several options are being generated and priorities given. In stage 4 concrete activities are being formulated to arrive at the desired results.

<u>Stage 1: SWOT-overview of the internal en external surroundings</u>

Summary internal surroundings

Strengths	Weaknesses
S1	W1
S2	W2
S3	W3

Summary of external surroundings

Opportunities	Threats
O1	T1
O2	T2
O3	T3

[3] Santema, S.C, M. Dingema en N. van Dishoeck 1997. Succesvolle marketingplannen. Denken, kiezen, doen. F&G Publishing, Utrecht, 169 p.

Stage 2: from SWOT to main points of attention

Based on the chosen SWOT-elements from stage 1 a confrontation matrix is made to formulate three main points of attention.

Confrontation matrix

	Opportunities O1 O2 O3	Threats T1 T2 T3
Strengths S1 S2 S3	1 'Attack'	2 'Defend'
Weaknesses W1 W2 W3	3 'Maintain'	4 'Back-off'

By formulating main points of attention it becomes clear which strength or weakness can be related to an opportunity or thread. There are four quadrants in the matrix representing different strategies: "attack" (quadrant 1:strengths/opportunities), "defend" (quadrant 2: strengths/threats); "maintain"(quadrant 3: weaknesses/opportunities) and "back-off" (quadrant 4: weaknesses/threats)

Stage 3: from main points of attention to priorities
For each main point of attention of stage 2 possible options for the realization are being generated. The strategies 'attack, defend, maintain or back-off' point to the direction in which options can be found. To validate these options a set of common criteria will be used, e.g. similar to criteria to evaluate development plans.

Stage 4: from priorities to concrete activities
After proposing as many activities as possible the most desired sequence for the implementation has to be agreed upon. In this stage again priorities are given,. The most relevant activities form the basis for a concrete action plan.

2.2 Results of stage 1

The Dutch round wood trade buys standing timber from forest owners in The Netherlands, Belgium and Germany no matter what the conditions for exploitation and no matter the supply possibilities. If the renewable energy sector goes to the market with a clear demand and willing to pay a reasonable price, than the supply of an extra outlet will be no problem for the forest exploitation and timber trade sector. In the past the market has demonstrated to be able to supply new industries such as OSB and MDF. For the wood suppliers is does not really matter which products are being manufactured, be it sawn wood products, paper, OSB, MDF, HDF, poles or green energy.

Different producers compete for the availability of the raw material wood. A company which intents to make green power from energy wood harvested in Dutch woodlands, will have to position itself in this existing field of competition. The same holds true for any other manufacturer who wants to make a new wood product or who will expand his production capacity. The wood supplier will react to the increased demand by supplier more wood of from different qualities or with a different price.

In a SWOT analysis it is important to make clear from which perspective the strengths and weaknesses are being considered. E.g. from the viewpoint of forest exploitation it would seem a weak point that the energy companies are not (yet) involved in the chipping of industrial round wood, as e.g. the paper and board industries are doing, in which case the biomass supply could easily fit in with the existing round wood logistics. Obviously this is relevant only if energy companies feel the need to diversify their raw material supply, which is not necessarily the case: at present most woody biomass used by the renewable energy sector consists of dried wood pellets in stead of fresh round wood from the forests and landscape plantings[4].

Strengths

S1: many companies combine forest exploitation with round wood trade. This means that the supply chain is in one hand, which guarantees efficient logistics and an optimal use of man and machines.

S2: The sector increasingly uses steeds modern and sophisticated harvesting equipment (harvesters, skidders and forwarders, etc), of which the capacity is well used, e.g. by running these machines in jobs in neighboring countries.

S3: Large Dutch round wood traders are well organized in adjacent countries. It is relatively easy for them to supply energy wood derived from woodlands abroad.[5] (if needed, lorries can be organized for extra cross country transports)

Weaknesses

W1: Transports and logistics take a relatively large proportion of the wood supply costs, because in The Netherlands there are no outlets for lower grade fiber wood[6] and because the wood is being supplied in small qualities from many small woodland areas[7]

W2: The structure of the forest exploitation sector is characterized by many small contractors, which may not be as efficient as a limited number of larger companies, but on the other hand it suites the small scale of the Dutch wood supply (Hence, this weakness can also be considered a ‘strength’, because it enables that small volume of wood can enter the market)

W3: Relationship between woods traders and forest owners lack mutual trust and understanding: the forest owners lack the knowledge, insights and feeling with the market and have not much experience with forest exploitation. That’s why more and more wood (and work in the woods) is being offered by tenders. There is a shift from relationships towards more transactions.

W4: The profit on the exploitation and trade of indigenous round wood is small. This is valid for most of Europe, and not really a weakness, but rather a market fact.

Opportunities

O1: Most round wood in The Netherlands is being sold as standing timber, which implies a central role for the forest exploitation and trading companies.

O2: Utilization rate (the percentage of the annual increment being felled) is rather low in The Netherlands (and the rest of Europe). An extra outlet for energy wood will increase harvesting levels and as such creates extra work for the sector.

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[4] In addition, the potential of fresh wood harvested from landscape plantings located outside managed woodlands is largely unused: often municipalities and water boards who are the owner of many small wood lots, are obliged by law to manage these plantings in such a way that the branches and tree tops need to be removed from the site at relatively high costs. For this biomass material, which has to be taken care of anyway, the use as a feedstock for bio-energy could be an interesting option.

[5] If, however, the supply conditions are competitive with the Dutch demand most of the energy wood will stay abroad.

[6] In The Netherlands two paper mills only offer an outlet for Dutch fiber wood. Fortunately, other outlets, such as Board, MDF, OSB and paper mills in Germany and Belgium are located not very far away from the borders.

[7] In The Netherlands the maximum load is higher than in Germany and Belgium but lower than in Sweden.

O3: The recent vision on timber harvesting by the Ministry of Agriculture and the Dutch Timber Platform has made harvesting a political topic.
O4: Tree tops and branches could become an additional assortment, but only if is technically and economically feasible and the forest owners are in favor to do so (and if there are no major negative environmental impacts).
O5: A large part of the Dutch woodland is being certified for sustainable forest management and many contractors are CoC (group) certified. For end-users who require (or at least appreciate) such a certification energy wood can already be supplied with the preferred documents.

Threats
T1: The small and scattered forest ownership inevitably will result in less efficient use of machines and manpower, which is a competitive disadvantage with respect to neighboring countries. This is a give fact for all form of timber use from Dutch woodlands.
T2: Integrated forest management, characterized by small-scaled forest operations and thinnings instead of clear fellings is responsible for increased harvesting costs
T3: many private forest owners do not harvest at all and other much less than they could (and still work in a sustainable way)
T4: A lack of outlets for energy wood from the forests (wood processing residues and used wood are still plenty available and much cheaper)
T5: During some months the Flora en Fauna law puts restrictions on forest work (e.g. only winter felling allowed).

The most important strengths, weaknesses, opportunities and threats are summarized in the table below. The ranking of the top-3 for each category was made by representatives from the forest exploitation and trading sector.

Summary internal environment

Strengths	*Weaknesses*
S1 Supply chain in one hand	W1 High costs for transport and logistics
S2 Modern harvesting equipment	W2 Many small contractors
S3 NL trade well organized in neighboring countries	W3 Less relationships and more transactions

Summary external environment

Opportunities	*Threats*
O1 Standing timber sales	T1 Scattered small forest ownerships
O2 Low utilization rate	T2 Integrated forest management
O3 Wood harvesting receives political attention	T3 No harvesting by many private forest owners

2.2 Results of stage 2: identifying main points of attention

By means of a so called "confrontation matrix" the top-3 of the strengths, weaknesses, opportunities and threats are related to each other to determine which strength or weakness can best be linked to a certain opportunity or treat.
In the "attack" quadrant the strengths are related to the three greatest opportunities. How can we best use our strength to make use of an opportunity?

"Attack"	**Opportunities**		
Strengths	Standing timber sales	Low utilization rate	Wood harvesting receives political attention
Supply chain in one hand			x
Modern harvesting equip-		x	

ment			
NL trade well organized in neighboring countries	x		

In the “defend” quadrant the strengths are related to the biggest treats.: how can we use our strength to wear off a threat?

“Defend”	Threats		
Strengths	Scattered small Forest ownerships	Integrated forest management	No harvesting by many private forest owners
Supply chain in one hand		x	
Modern harvesting equipment	x		
NL trade well organized in neighboring countries			x

In the “maintain” quadrant weaknesses of the sector are related to the greatest opportunities: how can we strengthen our weaknesses to be able to take advantage of an opportunity?

“Maintain”	Opportunities		
Weaknesses	Standing timber sales	Low utilization rate	Wood harvesting receives political attention
High costs for transport and logistics		x	
Many small contractors			x
Less relationships and more transactions	x		

In The “back-off” quadrant weaknesses are related to the main threats: how can we strengthen our weaknesses in order to wear off a threat?

“back-off”	Threats		
Weaknesses	Scattered small Forest ownerships	Integrated forest management	No harvesting by many private forest owners
High costs for transport and logistics	x		
Many small contractors		x	
Less relationships and more transactions			x

The main points of attention for an attack strategy are:

1. How can the most prominent strength of the sector, i.e. the whole supply chain in one hand, be used to put wood harvesting high on the political agenda?
2. How can the use of modern harvesting equipment be helpful to harvest more of the annual increment?
3. How can the good business relationship of the Dutch forest exploitation sector in countries abroad be used to buy more standing timber?

The main points of attention for a possible defend strategy are:

4. How can the main strength of the sector, i.e. the whole supply chain in none hand, be used to counteract the negative impacts of integrated forest management?

5. How can the use of modern harvesting equipment be used to mitigate the consequences of forest small holdings?
6. How can the good business relationship of the Dutch forest exploitation sector in countries abroad be used to wear off the treat that many private forest owners are reluctant to harvest wood?
7. In a similar way the main points of attention can be formulated for the maintain and back-off strategies..

2.4. Results of stage 3: generate options for the implementation

In this stage for each main point of attention possible options for the implementation have to be generated, preferably by a multi-disciplinary team. Try to use different approaches and angles to look at it. All ideas which spontaneously come up must be collected.

For instance, for the main attention point "How can the use of modern harvesting equipment be helpful to harvest more of the annual increment?", an possible way of looking at options could be: technology assessment, economy, reduce negative impacts for the natural environment, public support, improving the quality of the harvested forest products, increasing the scale or noise reduction When taking a technology angle, harvesting machines may be rented or bought, which are adapted to the small scale and heterogeneous conditions which prevail in Dutch wood lands, e.g. machines with low wheel pressure (caterpillars) and with a narrow working bases so that small forest roads may be used to haul out the logs, etc . The most appropriate options for the implementation form the basis for a concrete plan of activity (stage 4). In this follow-up study, however, we have restricted ourselves to the identification of main points of attention for the attack and defend strategies.

PART 3 CONCLUSIONS

1. This SWOT analysis has clearly demonstrated that trying to increase the harvesting rate of energy wood in Dutch woodlands is not so much a matter of improving the technological and organizational structure of the forest exploitation sector (because they are top of the bill already), but rather to fully utilize market opportunities.

2. The wood harvested will only be used for energy purposes if wood price and supply conditions are competitive with other uses. Thus it is mainly an economic issue. And because the demand for energy wood is not yet competitive with the traditional uses, for the time being very little forestry biomass is being used for renewable energy.

3. Should, however, the demand for energy wood increase in the near future, the Dutch forest exploitation and timber trading sector is ready to deliver. In which case the energy companies (utilities) must be willing to act as a common industrial round wood user in an existing market and willing to pay the same round wood prices. At the moment, however, cheaper biomass steams are available in sufficient quantities.

4. When the market for second generation (ligno-cellulose) bio-fuels starts to develop, which requires rather strict specifications of the raw material, than industrial round wood seems a logical choice: the whole supply chain is already fully operational and can be carried out efficiently by professionals in the business.

5. Thus it seems that the Dutch forest exploitation sector has a strong position to offer professional services to this emerging market.

9

Participation project self support rate woody biomass production

By: an initiative of platform hout nederland and probos foundation

English Summary

This participation survey is initiated by Platform Hout in Nederland[1] in cooperation with Probos foundation. Platform Hout In Nederland was asked by its members to inform policy makers on the issue of the rate of self support. At first the rate of 25% self support was used but eventually a different more up to date approach was needed and the concept of feasibility analyses was used.

Probos foundation as member of BUS has participated in the project with a quick scan.

The result of the quick scan is offered as input the Platform Hout Nederland. The Platform is using the input for its final statement to the Dutch policy makers. The paper is send to the ministry of LNV and Platform Groene Grondstoffen.

Recent policies (EU and Dutch government) on the issue of sustainable energy are aiming at 20% sustainable energy in 2020. The Platform Groene Grondstoffen is aiming at 30% renewable energy sources (replacement of fossil fuels) For this goal, 80 million MT ds is needed.

In 2005, 40% of alle biomass used for energy was woodbased. Probos estimates that this will be so in future as well. So wood will remain an important source of biomass in future as well.

Sources of wood for biomass in the Netherlands are: Waste wood, Industrial waste and fresh wood. The estimated growth of waste and industrial waste is estimated at 1% per year as this volumes are depending on the market developments. Fresh wood is relatively easy to influence and therefore also the source with the most potential.

Potential production from these sources in MT (x1000):

	Fresh	Industrial	Waste	Total
Production 2005	110	150	130	390
Additional, min - max	*440 – 1200*	130 – 330	350 – 1100	920 - 2630
Potential in 2030, min - max	*550 – 1310*	280 – 480	480 – 1230	**1310- 3020**

Additional production of fresh wood is the most important source. In the schedule below an overview is given of the source and quantities per source.

Additional harvest in 2030 per action.

ACTIONS	**Additional Harvest (x million m^3) in 2030**	
	Feasible	**Potential**
Increased harvest: 1 Full service concept 2 Forest management and biodiversity 3 Voluntary services	0,60	0,60

[1] Platform Hout Nederland is a platform with representatives from all timber related branche organisations in the Netherlands.

4 Harvest of top and lop	0.10	0,50
5 Improvement of collection from landscape elements like woods along infrastructure.	0,15	0,20
6 Short rotations crops and fast growing tress along roadsides	0,10	0,30
7 Increasing of forest area 8 National timberbank	0,30	0,75
9 establishment of short rotations crops for biomass	0,15	1,05
Total additional Harvest	1,40	3,40
Total available for energy	**1,0**	**2,75**

Conclusions
The analysis shows that the rate of self support can be significant. Within the perspectife of the government policy, 15 to 40 % is feasible but serious actions have to be taken to increase the current production.

In order to be able to reach the goals a set of recommendations is presented.

1. Fair competition on the market is condidional in order to assure a stable market development. Grant schemes should be developed and implented accordingly.
2. Harvest from existing forest and woods need broad attention from policy and decision makers. Politic ambitions for sustainable energy ask for a different approach of nature and forest management.
3. Reliable statistics about use of wood for energy and annual monitoring of new developments in the forest and timber branche on teh issues of production, trade, logistics and distribution of biomass are neccesary.
4. The current focus on the forest function nature should be diverted more towards sustainable production. Within this perspective more investment in knowledge on theis issue is needed.
5. Harvest of woody biomass as management treatment for increasing biodiversity needs serious attention of the forest managers in the Netherlands.
6. Grantschemesfor afforestation projects and shortrotation plantations are desired. Short rotation plantations can be adapted in the agriculture branche. Willingness of other branches to invest in the sector are conditional for succes.
7. In order to increase timber harvest the following actions are neccesary.
   - Independent communication about teh full service consept additional to commercial oriented communication by existing players on teh market.
   - Optimalisation of the Information collection about timber harvest and communication towards stakeholders.
   - Introduction of the top and lop harvest in the forest management sector and communication about the impacts on soil and vegetation.
   - Research of the currenct market for timber from infrastructural and landcape plantings and a survey of the optimalisation of the harvest.
   - Large scal plantings along infrastructures.
   - Enforcement of the lobby for financing afforestation projects and creating conditions to execute afforestion with 2.500 to 4.500 haectares annually. Inside and outside the so-called eco zones (EHS).
   - Feasibilty studie about the installation of a new national timber bank.
8. In order to produce the projected amounts of timber, hampering national legislation needs ajustment.
   - Rules for the use of so-called B grade timber need ajustment and bottlenecks in the scheme of permitsfor small and medium large production units need to be updated.
   - The current grant scheme (MEP) needs adjustment. The use of biomass from national sources and the development of technique and logistics need stimulation in stead of imports from abroad for feeding of large powerplants.
   - Legislation and regulations concerning the establishment and management of short rotation energy plantations need ajustment.
   - The permit system and regulation for bio-mass plants needs adjustment in order to make the establishement of small scale heat and powerplants more easy. The establishement of small scale power and heatplants should be made more easy in order to be able to use local sources of biomass, make processing and storage on site possible in order to feed the powerplants on demand.
9. More and thourough analyses of the future production cappacity and the possibilities for the use as biomass for energy, in relation with teh developement on the timbermarket is neccecary.

9

Participatieproject zelfvoorzieningsgraad van houtige biomassaproduc-tie

By: Een initiatief van Platform hout nederland En Stichting probos

Voorwoord.
Dit participatie onderzoek is geïnitieerd door Platform Hout Nederland in samenwerking met stichting Probos. Platform Hout Nederland is als belangenorganisatie door haar achterban benadert om beleidsmakers te informeren over zelfvoorzieningsgraad. In eerste instantie werd 25% zelfvoorzienend als doel gesteld maar bij nader inzien heeft men toch gekozen voor een ander aanpak, meer afgestemd op de actuele ontwikkelingen. Daarom is gekozen voor het concept haalbaarheidsanalyse.

Stichting Probos heeft als deelnemer van BUS het initiatief genomen deze vraag als quick scan te onderzoeken en heeft in die hoedanigheid geparticipeerd in dit project.

Het resultaat van het onderzoek, uitgevoerd door stichting Probos is ter informatie opgeleverd aan het Platform Hout Nederland. Het Platform Hout Nederland gebruikt dit schrijven als grondslag voor heer definitieve notitie. De definitieve notitie wordt gepresenteerd aan het platform groene grondstoffen en met een begeleidende brief aan de tweed kamer gestuurd naar de minister van LNV.

Introductie.
Door de Europese Commissie en recent ook door de nieuwe regeringscoalitie zijn ambitieuze doelstellingen geformuleerd voor de bijdrage van duurzame energie aan de energievoorziening. Het coalitieakkoord gaat uit van 20% duurzame energie in 2020. Alhoewel de verdeling over zon, wind en biomassa niet is aangegeven speelt biomassa een belangrijke rol in het realiseren hiervan.
De ambities van het Platform Groene Grondstoffen liggen aanzienlijk hoger. Zij gaat uit van 30% vervanging van fossiele grondstoffen door groene grondstoffen in 2030. Het platform heeft berekend dat hiervoor 80 miljoen ton droge stof nodig is. Zij verwacht dat 60% hiervan geïmporteerd zal moeten worden en dat ca 30 miljoen ton ds in ons land zelf geproduceerd kan worden.
In 2005 maakte hout 40% uit van de ingezette hoeveelheid biomassa voor de productie van duurzame energie. Ook in de toekomst wordt een grote bijdrage verwacht van houtige biomassa. Stichting Probos heeft een eerste analyse gemaakt welke bijdrage verwacht kan worden vanuit de bos- en houtsector. Er is gekeken naar de verschillende bronnen van houtige biomassa in ons land en middels scenario's is verkend welke mogelijkheden hout in de toekomst kan bieden als grondstof voor de productie van duurzame energie. Tevens worden acties aangegeven die nodig zijn om meer hout in ons land te produceren en te oogsten.

Binnenlandse houtbronnen

Er zijn drie binnenlandse bronnen waaruit hout beschikbaar komt:
1. Afvalhout
2. Industrieel resthout
3. Vers hout

1. Afvalhout
Gebruikt hout of afvalhout is hout dat vrijkomt aan het eind van de levensduur van een product. Probos heeft vastgesteld dat in 2004 1,25 miljoen ton afvalhout in Nederland beschikbaar kwam. Vrijwel al het hout dat in het afvalcircuit terechtkomt wordt thans ingezameld. Daarvan wordt ca

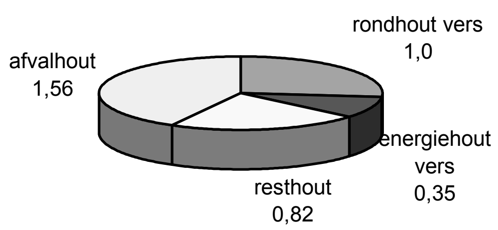
300 kton in ons land ingezet voor energieproductie en voor het produceren van palletklossen, vezelpallets en energiepellets. Circa 0,95 miljoen ton wordt geëxporteerd, waarvan 60 % naar de spaanplaatindustrie in het buitenland en 40 % naar de energie-industrie in Duitsland en Zweden.

2. Industrieel resthout
Industrieel resthout is hout dat vrij komt bij bewerkingen in de houtverwerkende industrie. Dat geldt voor de rondhoutverwerkende industrie en voor de bedrijfstakken verder in de houtketen waar hout wordt toegepast. In totaal heeft Probos vastgesteld dat in 2004 600 kton beschikbaar kwam. Hiervan wordt ca 250 kton door de bedrijven zelf en door energiecentrales omgezet in energie. Een grote afzetmarkt wordt ingenomen door de vezelbedrijven die krullen en zaagsel geschikt maken voor gebruik in de dierhouderij (stallen) en voor de consumentenmarkt (ca 250 kton). Een relatief klein gedeelte gaat naar de spaanplaatindustrie in Duitsland en België.

3. Vers hout
Vers hout komt uit bos en beplanting. In het Nederlandse bos wordt ongeveer één miljoen m3 rondhout met schors geoogst voor diverse industriële toepassingen. Daarnaast is de schatting dat uit bos en landschap ongeveer 350.000 m^3 hout als brandhout wordt gebruikt door particulieren en de laatste jaren ook door de houtgestookte energiecentrales in Cuyk en Lelystad.

Huidige Nederlandse Houtproductie.
In figuur 1 is de hoeveelheid hout die uit bovenstaande bronnen komt weergegeven. In totaal komt er 3,7 miljoen m^3 hout (komt overeen met ca 2,15 miljoen ton d.s.) beschikbaar op de Nederlandse markt. Voor het bepalen van de hoeveelheid resthout uit de verwerkende industrie is alleen gerekend met de secundaire industrie. Resthout dat vrijkomt bij de verwerking van rondhout is niet meegerekend.
Eenderde van het binnenlandse aanbod komt uit het Nederlandse bos, tweederde komt vrij als restproduct bij de verwerking van hout en als afvalhout na gebruik.

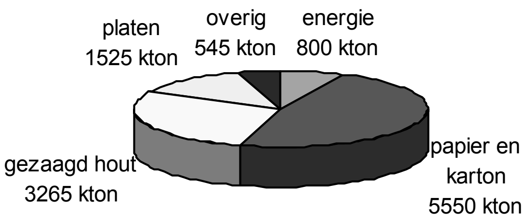
figuur 1. Nederlandse productie in m3 (x miljoen) 2005



Huidige Nederlandse houtverbruik
In figuur 2 is de verdeling van het houtgebruik voor de verschillende toepassingen in ons land weergegeven. Het gebruik van papier neemt bijna de helft van het houtgebruik voor zijn rekening, gezaagd hout en platen ruim 40%. De houtproducten worden ingezet in de bouw en meubel- en verpakkingsindustrie.
De inzet van hout voor energie is in 2005 nog beperkt. Deze bedraagt 7,5% van het totale Nederlandse houtverbruik. In 2005 werd 2,2 miljoen ton droge stof aan biomassa ingezet voor duurzame energie (CBS 2005). Op dit moment maakt hout 40% uit van de totale inzet aan biomassa. De helft wordt als houtpellets geïmporteerd en de andere helft, circa 400.000 ton droge stof, komt uit het bos, houtverwerkende industrie en bouw- en sloopafval.

In 2005 is in ons land in totaal 11,7 miljoen ton d.s. aan hout gebruikt.

figuur 2. Nederlands houtgebruik in kton ds, 2005



Toekomstige Vraag Naar Biomassa Voor Duurzame Energie

Nieuwe Kabinet Naar 20% In 2020

De vraag naar biomassa wordt vooral ingegeven door de ambities van de Nederlandse overheid: het nieuwe kabinet stelt zich ten doel om in 2020 twintig procent van het totale energieverbruik uit duurzame bronnen te realiseren. Het totale verbruik in 2020 is volgens Van Dril in het "Strong Europe scenario" geschat op 3550 PJ (Van Dril, referentieramingen energie en emissie 2005-2020, 2005).

De overheid ziet de komende vijftien jaar als leerperiode om na te gaan welke bijdragen de verschillende duurzame bronnen kunnen geven. Er zijn dus geen beleidsuitspraken over de verdeling over de bijdragen uit zon, wind en biomassa. En ook niet over het soort biomassa. In deze notitie wordt er van uitgegaan dat de verdeling naar bronnen voor 2020 gelijk zal zijn aan die in 2005. In 2005 was het aandeel biomassa 52% (41,5 PJ, bron CBS). Doorberekend zal dan in 2020 ongeveer 20 miljoen ton droge stof aan biomassa nodig zijn. Als deze biomassavraag gelijk aan 2005 voor 40% met hout wordt ingevuld, gaat het na 2020 jaarlijks om 8 miljoen ton d.s. hout.

Grote Ambities Van Het Platform Groene Grondstoffen Voor 2030

Het Platform Groene Grondstoffen heeft in haar recente brochure uitgesproken dat 30% van alle fossiele grondstoffen in 2030 kunnen worden vervangen door groene grondstoffen. Hiermee wordt het ambitieniveau voor de inzet van biomassa zeer fors verhoogd t.o.v. het bestaande beleid van de overheid voor 2020. In plaats van 20 miljoen ton drogestof vraagt de ambitie van het Platform 80 miljoen ton ds biomassa.

Deze ambitie is onderbouwd in de januari 2006 gepubliceerde studie "Biomassa in de Nederlandse energiehuishouding in 2030" uitgevoerd door ECN en de WUR in opdracht van het Platform. De studie hanteert als uitgangspunten een totaal verbruik aan primaire energiedragers van 3000 PJ in 2030 en bijdragen van biomassa van 60% bij transport, 25% bij electriciteitsproductie, 25% bij grondstoffen voor chemie, materialen en producten en 17% bij warmte.

De studie geeft voor 2030 de volgende verdeling voor de biomassa bronnen in Nederland:

- Primaire bijproducten: maximaal 6 miljoen ton ds.
- Secundaire en tertiaire bijproducten: maximaal 12 miljoen ton ds
- Specifieke teelt: 9 miljoen ton ds(deze bijdrage is sterk afhankelijk van het overheidsbeleid)

De maximale binnenlandse beschikbaarheid van biomassa komt overeen met 450 PJ. Dat komt neer op ongeveer 30 miljoen ton ds. Het Platform geeft alleen bij de primaire bijproducten een verdeling naar 3 miljoen ton uit de landbouw en 3 miljoen ton uit de niet-landbouw. Hieruit valt niet af te leiden hoeveel hout men denkt in te zetten. Hetzelfde geldt voor de secundaire en tertiaire bijproducten en de teelt van energiegewassen. Ook hier is geen inzicht te verkrijgen in het aandeel hout. Navraag bij mede-auteur de heer Elbersen van de WUR leverde geen nadere details.

Verhogen Van Het Aanbod Energiehout
De ambities kennende voor 2020 en 2030 wordt in deze notitie nagegaan welke bijdrage hout kan leveren aan de grote behoefte aan biomassa als grondstof voor duurzame energie. Daarbij is geanalyseerd hoeveel méér afvalhout en resthout, dat op de Nederlandse markt komt, als energiehout kan worden ingezet. De vrijkomende hoeveelheden afvalhout en resthout worden vrijwel geheel benut en fluctueren met de economische ontwikkelingen in ons land.
Bos en landschappelijke beplanting daarentegen is een houtbron die sterk te beïnvloeden is door meer te oogsten in bestaande bossen en beplantingen, door het aanleggen van nieuwe bossen én weg- en landschappelijke beplantingen en door de teelt van houtige biomassa in speciale energieplantages. In de hierna volgende analyse krijgt het vergroten van de houtoogst dan ook de meeste aandacht.
Bij de analyse zijn twee scenario's gehanteerd:

1. Scenario *"Zeker haalbaar"* en
2. Scenario *"Potentieel haalbaar"*

Bij scenario 1 gaan we er van uit dat de ingeschatte bijdragen van afvalhout, resthout en vers hout haalbaar zijn, zeker als de vraag naar energiehout zich daadwerkelijk verder ontwikkelt. Het toegenomen aanbod van industrieel rondhout uit het bos gaat voor een belangrijk deel naar de houtverwerkende industrie.
Scenario 2 vraagt aanzienlijk grotere inspanningen, zeker als het gaat om het realiseren van een groter areaal bos en beplanting en het aanleggen van energieplantages. In dit scenario is gekozen voor een te ontwikkelen aanbod van energiehout dat als potentieel haalbaar moet worden gezien. Daarbij wordt er van uitgegaan dat een aanzienlijk deel van het in ons land beschikbaar komende afval- en resthout voor energie wordt ingezet en dat van het additioneel geoogste rondhout de toegenomen behoefte van de houtverwerkende industrie is vervuld en het overige van minder kwaliteit voor energie wordt ingezet.

Méér afvalhout
Afvalhout dat in het buitenland wordt verbrand kan natuurlijk in eigen land ingezet worden. Om dat mogelijk te maken is aanpassing van het Nederlandse vergunningenstelsel noodzakelijk. Het gaat om circa 400 kton, voornamelijk B-hout (scenario 1). Wordt al het *exporthout* voor energie ingezet dan is 950 kton beschikbaar. Voor 2030 is rekening gehouden met een gemiddelde groei van de hoeveelheid afvalhout van 1% per jaar. Dit betekent dat in potentie in 2030 1100 kton d.s. additioneel beschikbaar kan komen (scenario 2).

Méér resthout
De jaarlijks vrijkomende hoeveelheden resthout hangen af van de hoeveelheid verwerkt hout. De concurrentiekracht van de houtmotmarkt zal bepalen hoeveel resthout voor energietoepassing beschikbaar komt. Vooralsnog wordt aangenomen dat 150 kton resthout extra in de energiemarkt afgezet kan worden (scenario 1). Wordt al het resthout ingezet dan is er maximaal 350 kton extra beschikbaar. Voor 2030 is met eenzelfde groeicijfer als het afvalhout rekening gehouden. Dit betekent dat in potentie in 2030 330 kton d.s. additioneel beschikbaar kan komen (scenario 2).

Méér hout oogsten
Bos en landschap kunnen aanzienlijk meer bijdragen aan de voorziening van brandstof voor de productie van duurzame energie. Nederland heeft met 360.000 hectare bos slechts een gering percentage bos. Er kan aanzienlijk meer bos en beplanting worden aangelegd, waarmee tevens wordt bijgedragen aan recreatie, natuur, landschap, waterberging, biodiversiteit, CO2 vastlegging etc. Door meer bos en beplanting aan te leggen, door beter gebruik te maken van het hout dat in onze bestaande bossen en beplantingen beschikbaar komt en door het aanleggen van energieplantages kan aanzienlijk meer (energie)hout op de markt komen. Meer hout oogsten kan langs de volgende hoofdlijnen worden gerealiseerd:

- *Bestaande bos*
  Momenteel wordt er 55% van de bijgroei geoogst. Er kan een beduidend groter percentage van de bijgroei worden geoogst, ook onder de voorwaarde van duurzaam beheer. Wordt 90% van de bijgroei geoogst dan levert dat jaarlijks 600.000 m^3 met schors op.

De grootste winst op korte termijn is waarschijnlijk te behalen bij de kleine boseigenaren die niet professioneel bezig zijn met hun bos. Vaak blijft houtoogst bij hen achterwege door gebrek aan ondersteuning en kennis, zowel over de effecten van oogst als over de financiële opbrengsten. Ook is er winst te behalen bij met name gemeenten en natuurbeschermingsorganisaties als het lukt om aan te tonen dat houtoogst onder bepaalde voorwaarden positieve effecten kan hebben voor de biodiversiteit. Tijdens de exploitatie werkzaamheden blijft veel houtige biomassa in de vorm van tak- en tophout achter in het bos. Dit is prima geschikt als biomassa voor energie.

- *Weg- en landschappelijke beplantingen*
  Er is niet bekend hoeveel hout er wordt geoogst uit weg- en landschappelijke beplantingen. Wel is duidelijk dat de inzameling hiervan efficiënter zou kunnen gebeuren. Op dit moment wordt ruim 100.000 m^3 energiehout voor de installatie in Cuyk geoogst. Dat kan zeker opgevoerd worden met nog eens 200.000 m^3. Van belang is dat dergelijke beplantingen beter ingericht worden op de houtoogst.
  Met grootschalige aanleg van snelgroeiende populierenbeplantingen langs snelwegen en spoorlijnen (denk o.a. aan de Betuwelijn) kan de houtoogst in ons land aanzienlijk worden opgevoerd. Met de aanleg van 5000 hectare productie beplantingen kan jaarlijks extra 100.000 m^3 geoogst worden.
- *Nieuwe bossen*

Nieuwe bossen vormen een toekomstige houtbron. Bij populieren geldt hierbij een horizon van zo'n 15 tot 50 jaar, bij andere boomsoorten 30-120 jaar. De aanleg van nieuw bos zal afhankelijk van de omvang van de behoefte aan energiehout steeds productiever worden ingevuld. Energiehout komt bij snelgroeiende boomsoorten na 12-15 jaar beschikbaar, bij de andere soorten na 20-25 jaar.

- *Biomassa plantages*
  Als de prijs voor energiehout verder gaat stijgen wordt het interessant speciale energieplantages aan te leggen waarin wilgen in korte omlopen worden geteeld. Oogst vindt plaats om de 2 à 3 jaar bij een gemiddelde bijgroei van 25 m^3 per ha per jaar. Deze cultures leveren zeer snel houtopbrengsten en kunnen met enige creativiteit tot aantrekkelijke landschappen worden ingericht.

Verhogen houtoogst vraagt acties

Om daadwerkelijk de houtoogst te verhogen is een aantal gerichte acties nodig. Zeker vandaag de dag is de Nederlandse boseigenaar (van gemeente tot particulier) meer en meer de weg ingeslagen van meer natuurontwikkeling, waarbij de houtoogst achteruit is gegaan (zie de door het ministerie van LNV en PHN in 2005 uitgegeven "Visie op de houtoogst"). Het is nodig om het beleid van de overheid op het gebied van duurzame energie daadkrachtig naar de sector over te brengen, zodat er meer bewustzijn ontstaat om daadwerkelijk aan het oplossen van de klimaatsproblematiek bij te dragen. Daar past natuurlijk een aantrekkelijke prijs voor het hout bij. Het afgelopen jaar zijn de houtprijzen op de internationale markt fors gestegen en de verwachtingen zijn dat die verhogingen structureel zijn.

De acties die nodig zijn om op korte en langere termijn de houtoogst in ons land te stimuleren en te verhogen zijn verder uitgewerkt. Deze actielijst is opgenomen in bijlage1 bij deze notitie. Tevens wordt in dat overzicht het potentiële effect per actie op het verhogen van de houtoogst voor beide scenario's besproken.

EXTRA HOUTOOGST BIJ 2 SCENARIO'S

In tabel 1 wordt voor beide scenario's per (geclusterde) actie aangegeven hoeveel extra m^3 hout in Nederland geoogst kan worden.

In het scenario "Zeker haalbaar" wordt in 2030 jaarlijks 1,4 miljoen m^3 <u>extra</u> hout geoogst.

In het scenario "Potentieel haalbaar" kan met aanzienlijk grotere inspanningen in 2030 3,4 miljoen m^3 <u>extra</u> hout worden geoogst. De extra inspanning wordt o.a. geïllustreerd door het beslag op grond voor uitbreiding van bos en beplanting. In scenario 1 is een uitbreiding opgenomen van 50.000 ha tot 2030 en in scenario 2 van 120.000 ha.

De vraag moet hier gesteld worden hoeveel van deze extra oogst voor energietoepassing beschikbaar is. Gaan we uit van een groei van 1,5% van de rondhoutverwerkende industrie in ons land dan zal deze in 2030 1,4 miljoen m^3 rondhout nodig hebben. Dat is 400.000 m^3 meer dan in 2005 wordt verwerkt. In scenario 1 is hiervoor de helft van de extra oogst uit het bestaande bos (actie 1 t/m 3; = 300.000 m^3) en eenderde van de toekomstige oogst uit de bosuitbreiding (actie 7; =100.000 m^3) beschikbaar gehouden. Daarmee levert dit scenario 1 miljoen m^3 energiehout op.
In scenario 2 is 550.000 m^3 rondhout niet voor energie beschikbaar: 300.000 m^3 uit het bestaande bos en 250.000 m^3 uit het extra bosareaal. Voor de opwekking van duurzame energie komt dan 2,75 miljoen m^3 extra op de markt.

TABEL 1. Additionele houtoogst in 2030 per (geclusterde) actie in miljoenen m^3 voor de scenario's "Zeker haalbaar" en "Potentieel haalbaar".

Acties	**Additionele oogst (x miljoen m^3) in 2030**	
	Zeker haalbaar	**Potentieel haalbaar**
Meer oogsten: 1 Full service concept 2 Bosbeheer en biodiversiteit 3 Gebruik vrijwilligers	0,60	0,60
4 Oogst tak- en tophout	0.10	0,50
5 Verbeteren inzameling hout beplantingen	0,15	0,20
6 Aanleg snelgroeiende wegbeplantingen	0,10	0,30
7 Vergroten bosareaal 8 Nationale houtbank	0,30	0,75
9 Aanleggen biomassa plantages	0,15	1,05
Totaal additionele oogst	1,40	3,40
Totaal beschikbaar voor energie	**1,0**	**2,75**

Totale binnenlandse bijdrage aan energiehout
In tabel 2 worden alle hoeveelheden energiehout die vanaf 2030 jaarlijks uit de verschillende bronnen beschikbaar komen bij elkaar opgeteld. *Met een redelijke inspanning kan jaarlijks 1,3 miljoen ton droge stof aan energiehout op de markt worden gebracht.*
Aanzienlijk meer inspanning is vereist om de *potentieel haalbare hoeveelheid energiehout van 3 miljoen ton droge stof* beschikbaar te krijgen voor de productie van duurzame energie. Hiervoor zal een groot deel van het in ons land beschikbare afvalhout voor energie moeten worden benut en zijn acties nodig om de oogst uit bos en beplanting fors op te voeren.

TABEL 2. De jaarlijks potentieel beschikbare hoeveelheden energiehout in *kton droge stof* uit verschillende bronnen voor twee scenario's (min= "Zeker haalbaar"; max= "Potentieel haalbaar").

	Bos+beplanting	Resthout	Afvalhout	Totaal
Inzet in 2005	110	150	130	390
Additionele inzet, min - max	*440 – 1200*	130 – 330	350 – 1100	920 - 2630
Inzet in 2030, min - max	*550 – 1310*	280 – 480	480 – 1230	**1310- 3020**

Conclusie
De berekeningen laten zien dat in eigen land geproduceerd energiehout 15 tot 40% kan dekken van de totale behoefte aan houtige biomassa in 2020 volgens het beleid van het ministerie van EZ (er van uitgaande dat 50% van de duurzame energie met biomassa wordt opgewekt, waarvan 40% met hout (= 8 miljoen ton d.s.)). Binnenlands hout kan dus een zeer substantiële bijdrage leveren aan de beleidsdoelen van de overheid.
Betrokken op de ambitieuze plannen van het Platform Groene Grondstoffen voor 2030 is de maximaal berekende beschikbare hoeveelheid energiehout van bescheidener aard. De 3 miljoen ton droge stof uit energiehout dekt 10% van de vraag naar binnenlands geproduceerde biomassa. In totaal schetst het Platform een vraag van 80 miljoen ton d.s., waarvan 30 miljoen ton binnenlands geproduceerd zal kunnen worden. Gezien de forse inspanningen die geleverd moeten worden om 3 miljoen ton binnenlands energiehout bij elkaar te krijgen, is het zinvol nog eens goed te analyseren op welke wijze de resterende 27 miljoen ton droge stof in ons land geproduceerd kan worden.

Aanbevelingen.

10. Eerlijke concurrentie en transparantie in de markt zijn voorwaarden om het gebruik van houtige biomassa voor energie in goede banen te leiden. Subsidies op Europees en nationaal niveau dienen zo ingericht te zijn dat daardoor geen marktverstoring optreedt.
11. Brede aandacht is nodig bij politici en beleidsmakers voor de productie en oogst van hout in bestaand en nieuw bos. De politieke ambities voor duurzame energie vragen een trendbreuk in het denken over natuurbeheer.
12. Betrouwbare statistieken over de inzet van hout voor duurzame energie en jaarlijkse monitoring van de nieuwe ontwikkelingen en projecten binnen de bos- en houtsector op het gebied van productie, handel, logistiek en distributie van biomassa zijn noodzakelijk.
13. De huidige focus op de natuurfunctie van het bos in het beleid dient zich meer te richten op duurzame houtproductie. Er zal meer geïnvesteerd moeten worden in de ontwikkeling van kennis voor duurzame houtproductie.
14. De oogst van houtige biomassa als beheermaatregel voor de verbetering/stimulering van de ontwikkeling/instandhouding van biodiversiteit verdient serieuze aandacht van de bosbeheerders in Nederland.
15. Stimuleringsregelingen voor bosaanleg en aanleg van energieplantages zijn gewenst. De laatste zijn goed inpasbaar in agrarische bedrijfsvoering. Ook het bedrijfsleven zal bereid moeten zijn investeringen te doen in de aanleg van bos en plantages.
16. De volgende acties zijn nodig om de houtoogst in ons land te stimuleren:
    - Onafhankelijke communicatie over het full-service concept als aanvulling op de commercieel georiënteerde communicatie door marktpartijen.
    - Het bijeen brengen van informatie over de rol van houtoogst en het communiceren van deze informatie naar de doelgroepen.
    - Het aan beheerders laten zien van de oogst van tak- en tophout en voorlichting geven over de effecten op bodem en vegetatie.
    - Onderzoek naar de huidige afzet van hout uit weg- en landschappelijke beplantingen en mogelijkheden om oogst te optimaliseren.
    - Stimuleren van grootschalige beplantingsprojecten langs wegen en spoorlijnen.
    - Versterken lobby richting overheden voor de financiering van bosaanleg binnen én buiten de EHS. Voorwaarden scheppen om voor een periode van 15 jaar een jaarlijkse bosaanleg van 2.500 tot 4.500 ha per jaar te realiseren.
    - Haalbaarheidsonderzoek naar nieuwe opzet Nationale houtbank.
17. Om de gepresenteerde hoeveelheden energiehout daadwerkelijk in te zetten zijn dient belemmerende regelgeving te worden aangepast:
    - De regels ten aanzien van het gebruik van B-hout moeten worden aangepast en de knelpunten in verlening van vergunningen moet worden aangepakt, met name voor kleinere productie eenheden.
    - Het huidige subsidie stelsel (MEP) vraagt nodig aanpassing. Het gebruik van hout (biomassa) uit eigen bronnen en de ontwikkeling van techniek en logistiek voor de verbe-

tering hiervan moet worden gestimuleerd in plaats van de import van biomassa voor bijstook in grote centrales.

- Wet en regelgeving moet worden aangepast om de introductie van energieplantages te vergemakkelijken.
- Het vergunningenstelsel voor biomassa centrales moet worden aangepast waardoor het makkelijker wordt (kleine tot middelgrote) centrales te bouwen en het mogelijk wordt om op locatie binnenkomende stromen biomassa te verwerken, op te slaan en op de gewenste momenten om te zetten in energie.

18. Een meer grondige analyse van de toekomstige binnenlandse productie- mogelijkheden van energiehout en in relatie daarmee de vraag naar hout van de houtverwerkende industrie is nodig.

Bijlage 1. Overzicht van de acties nodig voor het verhogen van de houtoogst.

Actie 1 Full service concept

Eén van de mogelijkheden voor het verhogen van de houtoogst, die ook in de 'Visie op de houtoogst' is beschreven, is het toepassen van het zogenaamde full service concept. Er zijn momenteel drie commerciële initiatieven op dit gebied. Alle initiatieven hebben het full-service concept op hun eigen manier uitgewerkt. Ze zorgen er voor dat de beheerder nog slechts één aanspreekpunt heeft en alleen de netto opbrengsten ziet. Full service biedt perspectieven voor kleine boseigenaren die nu niet of nauwelijks oogsten. De groep boseigenaren met minder dan 5 ha bos bezit in totaal zo'n 70.000 ha bos met een geschatte bijgroei van 560.000 m^3.

- Actie: Onafhankelijke communicatie over het full-service concept als aanvulling op de commercieel georiënteerde communicatie door marktpartijen.

Actie 2 Bosbeheer en biodiversiteit

Houtoogst en natuurbehoud worden door sommige beheerders nog steeds als tegenpolen gezien. De belangrijkste doelen van natuurbehoud zijn natuurlijkheid en biodiversiteit. Houtoogst en natuurlijkheid zijn inderdaad tegenpolen, maar voor biodiversiteit ligt dit een stuk genuanceerder. De evaluatie van het bosbeleid van Natuurmonumenten laat bijvoorbeeld overduidelijk zien dat lichtbehoeftige soorten in veel (jonge) bossen verdwijnen wanneer houtoogst achterwege blijft. Het besef dat houtoogst juist kan bijdragen aan de biodiversiteit in ons cultuurrijke land begint langzaam door te dringen. De tijd lijkt dan ook rijp om deze boodschap sterk naar buiten te brengen. Het grootste effect hiervan is te verwachten bij gemeenten en natuurbeschermingsorganisaties.

- Actie: Het bijeen brengen van informatie over de rol van houtoogst en het communiceren van deze informatie naar de doelgroep.

Actie 3 Gebruik Vrijwilligers Voor Vergroten Maatschappelijk Draagvlak

De natuurbeschermingsorganisaties en vrijwilligersorganisaties, zoals Natuurmonumenten, De Landschappen, IVN, KNNV e.d. gebruiken duizenden vrijwillige gidsen om de Nederlandse bevolking voor te lichten over allerlei aspecten op het gebied van natuur. Dit is zeer efficiënt, omdat via een relatief kleine groep een enorm grote groep bereikt kan worden. Waarom deze groep niet gebruiken om het maatschappelijk draagvlak voor houtoogst te vergroten door bijvoorbeeld cursussen en voorlichtingsbijeenkomsten voor deze mensen te organiseren? Hiermee kan via de beheersdoelen cultuurhistorie en biodiversiteit het draagvlak voor houtoogst sterk toenemen.

Actie 4 Oogst Tak- En Tophout

Er blijft bij elke oogst veel biomassa in het bos achter in de vorm van tak- en tophout. In meerdere West-Europese landen wordt dit hout verzameld met gespecialiseerde machines voor bio-energiecentrales. De bereidwilligheid voor de oogst van tak- en tophout bij bosbeheerders is sterk afhankelijk van de prijs en de eventuele negatieve effecten op bodem en vegetatie. Volgens modelberekeningen van EFISCEN zou bij een inzamelingspercentage van 15% ongeveer 90.000 m^3 tak- en tophout kunnen worden geoogst.

Gaan we ervan uit dat echt al het tak- en tophout en achterblijvende vellingsrestanten worden geoogst dan levert dit potentieel volgens berekeningen van Karjalainen (2004, Finish Forest Research Institute) zeker 500.000 m^3 extra energiehout.

Actie: Het aan beheerders laten zien van de oogst van tak- en tophout en voorlichting geven over de effecten op bodem en vegetatie.

Actie 5 Verbeteren Inzameling Hout Uit Weg- En Landschappelijke Beplantingen

Er staat een enorm volume hout in weg- en landschappelijke beplantingen, maar dit wordt niet altijd efficiënt gebruikt. Recente cijfers ontbreken, maar ten tijde van de vierde bosstatistiek (1985) was er zo'n 82.000 km lijnvormige beplantingen met een volume van 7,6 miljoen m^3. Ter vergelijk: in het Nederlandse bos staat momenteel bijna 62 miljoen m^3. Over het oogstvolume en de afzetmarkten zijn geen gegevens bekend, maar duidelijk is dat beplantingen een significante bijdrage zouden kunnen leveren aan de houtoogst. Geschat wordt dat hier 150.000 m^3 extra geoogst kan worden met een mogelijke intensivering naar 200.000 m^3

- Actie: Onderzoek naar de huidige afzet van hout uit beplantingen en mogelijkheden om dit te optimaliseren.

Actie 6 Aanleg weg- en landschappelijke beplantingen gericht op oogst
De meeste weg- en landschappelijk beplantingen zijn aangelegd zonder rekening te houden met oogst, zowel qua vormgeving als soortenkeuze. Dit levert zeer hoge oogstkosten op en verhindert de industriële toepassing van dit hout. Door bij de aanleg rekening te houden met oogst kunnen de oogstkosten omlaag en de opbrengsten omhoog.
Willen we in ons land echt bijdragen aan de vraag naar biomassa dan is een grootschalige aanleg nodig van snelgroeiende beplantingen langs wegen en spoorlijnen. In scenario 1 wordt 5.000 ha aangelegd en in scenario 2 15.000 ha. Dit levert jaarlijks 100.000 m^3 resp 300.000 m^3 op.
- Acties: Kennisopbouw en -overdracht over beplantingsplannen waarbij vooraf rekening wordt gehouden met houtoogst. Stimuleren grootschalige beplantingsprojecten langs wegen en spoorlijnen.

Actie 7 Vergroten van het bosareaal
Er is veel interesse voor particuliere bosaanleg op landbouwgronden, maar dan moet het financieel wel aantrekkelijk zijn. Per 1 januari 2005 is niet langer functieveranderingssubsidie beschikbaar voor bosaanleg buiten de EHS. Dat was en is waar het merendeel van de bosaanleg plaatsvindt. Deze situatie moet doorbroken worden. Met het oog op beleidsvoornemens ten aanzien van de productie van energie uit duurzame bronnen en de verantwoordelijkheden ten aanzien van de vermindering van de CO2 emissie, opgelegd door Brussel, dient de overheid mee te werken aan een aanzienlijke uitbreiding van het bosareaal gericht op het waarborgen van een forse verhoging van de houtoogst in de toekomst.
In de berekeningen voor bosuitbreiding wordt er bij scenario 1 uitgegaan dat er jaarlijks 2500 ha bos wordt aangelegd, bij scenario 2 jaarlijks 4300 ha. Scenario 1 kent een gemiddelde bijgroei van 8 m^3 per ha per jaar, die nu in het Nederlandse bos wordt gerealiseerd. In scenario 2 is de samenstelling in boomsoorten meer productiegericht en is uitgegaan van 12 m^3 bijgroei per ha per jaar. Realisatie is mogelijk door het teruglopen van het landbouwareaal tot 2030 met 96.000 ha die potentieel voor bos vrijkomt (H.M. Londo: Energy farming in multiple land use, 2002).
- Actie: Versterken lobby richting overheden voor de financiering van bosaanleg binnen én buiten de EHS. Voorwaarden scheppen om over een periode van 15 jaar een jaarlijkse bosaanleg van 2.500 tot 4.300 ha per jaar te realiseren.

Actie 8 Nationale houtbank
De papierindustrie heeft in het verleden de Nationale Houtbank opgezet. Hierbij verzekerde de industrie zich van het hout door dit al voor aanplant te kopen voor een gegarandeerde prijs. De bebosser kreeg dit bedrag aan het eind van de periode uitbetaald of in jaarlijkse termijnen. De industrie nam in bepaalde gevallen ook teeltrisico's op zich. Een Nationale houtbank gedragen door de houtverwerkende en energiebedrijven kan de bosaanleg sterk stimuleren.
- Actie: Haalbaarheidsonderzoek naar nieuwe opzet Nationale houtbank.

Actie 9 Aanleggen biomassa plantages
Wilgenplantages of wilgengrienden zijn zeer efficiënte biomassa-producenten, maar doordat het niet past in bestaande subsidieregelingen en de bestaande landbouwpraktijk, heeft het tot dusverre nog niet geleid tot grote oppervlakten. In Flevoland hebben Staatsbosbeheer en Probos 60 ha voorbeeldbeplantingen aangelegd op basis van jarenlang praktijkonderzoek door Probos. De productie overtreft alle verwachtingen. Recent is door Probos een monitoringproject opgestart voor de biodiversiteit in dergelijke beplantingen. Er komen nu al verassende resultaten uit.
Als potentieel voor energieplantages met wilgen wordt ingeschat dat minimaal 2% van het totale landbouw areaal hiervoor op boerenbedrijven beschikbaar komt, dat is 40.000 ha in 2020 voor scenario 2. Dit areaal komt vrij door efficiënter grondgebruik en verbeterde gewasopbrengsten in de toekomst bij een gelijkblijvende productie.

Londo gaat er in zijn proefschrift “Energy farming in multiple land use” (2002) van uit dat er in 2030 een nog groter potentieel voor wilgenteelt is van 80.000 ha. Het betreft hier gebieden voor waterbescherming en –extractie, waar wilgenteelt de voorkeur heeft.
- Actie: Het stimuleren van de aanleg van biomassa-plantages. In scenario 1 is 6.000 ha nodig. Het potentieel haalbare scenario gaat uit van 40.000 ha.

10

The harvest of logging residues in the Dutch forests and landscape

By: Mark Vonk and Marieke Theunissen, Probos
Date: November, 2007

Summary

As the market of woody bio fuel has developed in the last decade, logging residues in the Dutch forests have become more and more important as source of biomass. Until today only logging residues from large scale transformation projects were utilised but in the future these projects will occur less frequent. Logging residues in regular managed forests are still an underestimated source and hardly utilized but the interest of several parties is growing. The goal of this paper is to provide decision makers with information from various related research programmes and related aspects of harvesting logging residues under Dutch conditions.

In order to get the framework adjusted to the Dutch conditions, a quick scan of the Dutch situation was made. Timber traders, representatives of the processing branch, forest managers and researchers were interviewed. The results were projected on the future situation and conclusions were drawn. Harvesting logging residues under Dutch conditions in the future is economically feasible, under condition that logging residues from thinning or small scale clear cuts are removed and processed elsewhere. In case of large scale operations material can be collected and processed on site.

In order to get an impression of the possibilities of harvesting logging residues in future, the results of several field tests were compared. These field tests were performed in Austria, US, Germany, France, Italy, Finland and Ireland. The main conclusions drawn from these tests are that harvesting operations need adjusted planning and skilled operators, under Dutch conditions, logging residues from thinning and small clear cuts are best collected with a bundle machine, dried and process elsewhere. In order to reduce the costs per GJ to an acceptable level to make the operation feasible, air drying of woody biomass is conditional.

The quality of woody biomass will be of major importance for marketing in the future. In well developed markets like in Scandinavia, suppliers are already paid per the supplied heat value (GJ) per load. Chemical and physical properties are already standardized and defined in a EU standard for solid bio fuel. Beside particle size distribution, cleanliness etc, moist is the most important quality issue when market value is considered. Drying woody biomass in the forest is the most effective option but in Dutch conditions this is not a favourable option as common forestry practise, legislation and local regulations require immediate harvest, together with the logs.

Taking the forest ecosystem into account, logging residues are an important source for dead wood and woody debris on the forest floor. Several species depend on deadwood and even depend on deadwood in a certain stage of decay. Most species depending on dead wood like Beetles and Fungi migrate easy so the ideal situation does not depend on the quantity of dead wood but the quality of deadwood. All stages of decay and all sizes should be available at any moment, somewhere in the forest.

An important part of the nutrient cycle in the forest is the littering and decaying of dead wood, needles and leaves. Needles and leaves contain the major part of the nutrients that are released from the tree. Within this framework, harvesting logging residues is therefore possible but only once or twice in a rotation of 75 year and preferably no leaves and needles. Clean sweeping of the forest floor should be prevented all time.

Considering the nutrient cycle, the recycling of ash from bio-plants back to the forest in the Netherlands is not an option yet. Levels of heavy metals in ashes from bio fuel are to high to use the ash

as fertilizer in forestry or agriculture. In case ashes can be purified, recycling is a serious option to consider when the harvest of logging residues takes off.

The amount of harvestable logging residues in the Netherlands is estimated approximately 230.000 tonne fresh material per year. This includes woody biomass from forests, landscapes and small woods < 5ha.

1 Problem

In the Netherlands, as in the rest of Europe, the market of woody biomass has developed very rapidly in the last two years. At the moment the competition of biomass for energy with other industries like panel and pulp producers has a clear impact on the price development. The demand for woody biomass is still increasing but the forest managers hardly respond to this development as forest management in the Netherlands is not or marginally driven by the timber market. On top of this development, the Dutch government has agreed to generate 20% more sustainable energy in 2020 from which about one third from biomass. Woody biomass will probably take a major part of this 30%.

This, together with the growing demand for timber in the processing industry, will have a great impact on the demands for woody biomass in the near future. Harvesting logging residues needs serious consideration within the context of these developments.

In Scandinavia the harvest of logging residues is more or less common practice and although only on a small scale, it is getting more and more embedded in the day to day practice in the rest of timber producing Europe. The concept of harvesting forest residues in the Netherlands was introduced about three years ago but is only used under very specific circumstances like transformation of forest into other (non-forest) nature like heath lands or drift sands.

The goal of this study is to collect information from the various research programmes on this issue in order to give decision makers insight in the various aspects of harvesting logging residues under Dutch conditions.

All conclusions are based on foreign research and field tests. For verification of these results, field testing of harvesting equipment and drying tests in the Netherlands is required.

2 Method

- Interview with representatives from the Dutch timber traders and processors association, traders, contractors, forest managers and forest ecologists
- Assessment of the results of international feasibility studies, field tests, production and processing data of the harvest of logging residues
- Literature study on the impact on forest ecosystems and nutrient balance. Assessment of pro’s and con’s of the harvest of logging residues
- Literature study and interview with experts to analyse the conditions and potential of the harvest of logging residues in the Netherlands

3 Technical and economical results

3.1 Harvest of logging residues. A quick scan of the Dutch situation

Various parties already introduced the concept of harvesting forest residues in the Netherlands. In some cases where forest is transformed into non-forest, logging residue is processed on site with a chipper or shredder machine. In the past, forest residues were collected on a small scale with a regular forwarder to a shredder or chipper machine on site. In order to get a clear view on the current situation and developments in the Netherlands, various parties involved in all aspects of the subject, were interviewed.

- *Processing on site*. Direct on site chipping is only economically feasible with heavy equipment with large processing capacity and large quantities of wood to be processed. Economically it is not possible to harvest logging residues with small, self propelled chipping equipment in the forest stands. This equipment is only suitable when whole trees are harvested in a situation with good accessibility like landscape plantings on road sides lanes etc.

- *Dutch forest management practice*. The majority of the Dutch forests are so-called multifunctional. One of these functions, recreation, is becoming more and more important. As an immediate result of this recreational function, forest managers try to minimize the impact of management measures like machine noise and fumes, road blocking etc.

- *Environmental limitations*. The negative environmental side effects of large and heavy equipment, like soil compaction, damage to infrastructure, noise and air pollution, are becoming more and more unacceptable. It is considered most likely that due to these negative environmental impacts, chipping or shredding on site will be allowed only in specific situations like large scale forest transformation projects, infrastructural projects, etc.

In case of harvesting logging residues, bundling and forwarding does not have the environmental disadvantages of the direct chip or shred method. A bundle machine is mounted on a regular forwarder and therefore suitable in regular forest management practice. Production and transport of the bundles is relative expensive although transport of loose material is twice as expensive. Bundles can only be processed with a shredder as the binding material is hard to cut with a chipper and easily blocks the machines. Processing of the bundles into high quality dry and clean chips is not possible with the currently available chipping equipment.

An important factor for the marketing of chips are physical and chemical properties. In general, dry clean chips are more valuable than wet and dirty chips or shreds. In practice the difference between wet (>40%) and dry (<20%) chips makes the harvest of logging residues financially feasible or not.

-*Legislation and regulations.* In the Netherlands the local legislation and regulations are important factors to consider. Harvest is only allowed from 15th of July until the 15th of March and in some cases forest managers allow harvest only in the time frame from the 1st of August until the 1st of March. On the market of woody biomass like forest residues, this results in higher costs as intermediate storage in the supply chain is necessary.

The storage of chips on site is prohibited in most cases, as chips is defined as waste and for waste storage dedicated permits are required. It takes about two to six months to get a dedicated permit. Storage of chips on site is herewith not an option.

Concerning the harvest of logging residues it is also not clear whether logging residues are defined as timber or as litter. According to Dutch legislation it is not allowed to harvest litter from the forest floor. As soon as logging residue is separated from the trunk and left on the forest floor, it will transform into litter eventually but when and in what stage is not exactly clear.

Temporal storage of logging residues on the forest roadsides in order to let it dry and to make a more optimal processing possible also creates conflict situations with the Dutch legislation on nature conservation. Heaps of logging residues on road sides or on the forest floor create nesting and hiding places for fauna. In order to be allowed to collect this material, prior to the harvesting and processing, flora and fauna surveys and ecological assessments are mandatory in a lot of cases.

Furthermore, depending on the local regulations concerning fire prevention, storage of logging residues on the roadside is not or only during a limited period permitted.

Conclusions from interviews

- Harvest of logging residue in the Netherlands is only feasible in case material is harvested and removed together with the round wood in one harvesting season.
- Processing on site in small scale operations is not favourable because of negative environmental impacts and disturbance.
- Low moist content of the woody biomass is a key factor for marketing.
- Storage of forest residues outside the forest is a condition for optimising the economic yield and preventing the flow in the supply chain from hampering due to environmental legislation and other limiting regulations.
- Harvesting forest residues with a bundler is from Dutch perspective the most favourable for the future as storage of logging residues in the forest for drying and on site processing is not possible due to legislation and environmental limitations and other forms of collecting and forwarding has proven to be to expensive.
- Processing bundles with a shredder machine is well possible but processing bundles into high quality chips needs technical improvements. More knowledge about drying techniques under Dutch conditions is needed.

Harvest of logging residues in the Netherlands summarized

	Supply chain							
	Processing of logging residue	**forwarding**	**Intermediate storage**	**transport**	**drying**	**Intermediate processing**	**transport**	**End product**
1	Cut and chip whole trees	Chips are forwarded by the feller chipper combination	Fresh chips are collected in a container on the road side	Container truck	No option	Not applicable	Container truck	Fresh unscreened chips
2	Direct chipping of logging residue in the stands	Chips are forwarded by the chipper machine	Fresh chips are collected in a container on the road side	Container truck	No option	Not applicable	Container truck	Fresh unscreened chips
3	No processing in the forest stands	Logging residue is forwarded to the forest road	Logging residue piled on the forest road		No option	Forwarded piles are chipped or shredded in on the forest road	Container truck.	Fresh unscreened chips or shreds
4	No processing in the forest stands	Logging residue is forwarded to the forest road	Logging residue piled on the forest road	Container truck	No option under Dutch conditions	Processing of fresh logging residue by a stationary machine	Container truck	Fresh screened chips or shreds
5	Bundling of logging residues	Bundles are forwarded by a regular forwarder	Bundles are stored on the forest road	Logging truck	Drying is optional.	Processing of dry bundles by a stationary machine	Container truck	Dry screened shreds

3.2 International field trials and feasibility studies on the harvest of forest residues

Taking the results in paragraph 4.1 into account, harvesting logging residues in the Netherlands in the future is most likely feasible in large scale clear cuts or when biomass is removed from the forest and processed elsewhere. As large scale projects like transformation of forests into non-forest will fade out in future, harvesting of logging residue will only take place on small scale. Within this context, on-site processing scenario's are not assessed, various field tests with equipment suitable for small scale operations with processing outside the forest were compared.

Harvest of logging residues

In 2004 the US forest service organized field trials with a bundle machine. This study was useful for this assessment as the equipment was also tested in thinnings.

In 2005 the timber processing and trading industry in Austria initiated field trials with a prototype bundling truck developed by the company Von Atzigen. The prototype is a Timberjack bundler mounted on a MAN truck (figure 1). The equipment was tested on various mountain sites. Trees were all felled with a cable processor combination. Logging residue was collected on the road sides. Productivity of the equipment was not as expected from other time trials especially the truck mounted bundler produced far under its theoretical potential.

[1] In the same study, information from trials in Italy, France and Finland was collected and analyzed.

Table 1. Bundling production rates

Location of the field test	**Machine**	**Production (Bundles/h)**	**Bundle length (m)**
Austria	Truck mounted bundler Timber jack 1490D	9,1-12,6	3
France	Forwarder mounted Timber jack FB370	11-24	3
Germany	Truck mounted bundler Timber jack 1490D	22	3
Finland	Forwarder mounted Timber jack FB370	24,5	3
Italy	Truck mounted bundler Timber jack 1490D	13	4
US	Forwarder mounted Timber jack 1490D	10-30	3

Figure 1.

Bundling pre-concentrated slash with a truck mounted Timberjack bundling machine in Austria [2]

[1] Kanzian, 2005
[2] Moos, 2006

Transport
Major issue with transport is safety on the road. Bundles made of old material crack easily and loose material during transport (figure 2). Best results from the various field tests was transport with a regular log truck with a solid floor (figure 3).

Average truck load was 80% of the maximum loading capacity.

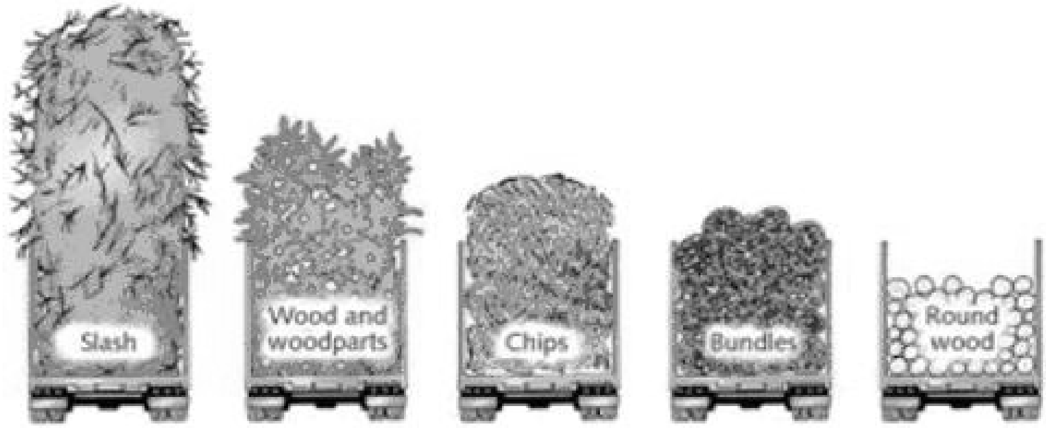


Figure 2. Volumes of different kind of forest products compared per full truck load [3]

Figure 3. Transport with a short log truck in the US [4]

Further Processing with shredder and chipper
In all cases the bundles were processed with a mobile shredder machine (figure 4). Processing bundles into chips is not successful as the equipment is blocked easily with the wrapping material. Tests with alternative wrapping material (sisal) were not successful as the sisal rotted and fell apart after a few months[5].

Table 2. Results of various field test with the shredder machine

Location	Equipment	Bundles specs.	Production
Austria	Shredder Jenz, loaded with a four wheeled front loader	Coniferous	52-59 bundles/h.

[3] Rohrmoser and Stampfer, 2003
[4] Rummer et al., 2004
[5] Parenco pers. com.

Austria	Shredder TIMenvipro, loaded with a four wheeled front loader	Coniferous	64-75 bundles/h
US	Shredder loaded with a grapple loader	Coniferous	60 bundles/h.
US	Shredder loaded with a grapple loader	Broad leaf	52 bundles/h.
US	Shredder loaded with a four wheeled front loader	Mixed	70 bundles/h.

Figure 4.
Mobile horizontal grinder in the US processing bundled slash [6]

Bundle specifications

Length	3m
Diameter	70 cm
Volume	1,15 m³
Weight	500-700 kg (fresh weight)
Energy (At 50% moist , energy value is on average 2 kWh/kg)	1000-1400kWh/bundle (3,6 GJ-5,04 GJ)
Chips/shred volume per bundle	1,4 m³

Conclusions from the field trials

- Experience and skills of the operators have a great impact on the level of productivity.
- Logging residues, polluted with sand and stones decrease the production substantially. Stand time of the chain decreased from 100 bundles to 26 bundles. (The Austrian experience compared with the Finnish test).
- Preparation of the logging residue during the felling has a great impact on the production efficiency as the difference between the Austrian and Finnish results show. In Finland residue was collected and piled properly by the harvester operator before bundling. For optimal bundle production, clean logging residue and a close cooperation between the harvester operator and the bundler operator is necessary.
- The same conclusion was drawn from the field trials in the US. Especially in thinnings a proper arrangement of logging residue by the harvester operator would have decreased the handling by the bundler operator substantially. The production per bundle in the thinning

[6] Rummer et al., 2004

was 5,5 to 11,7 minutes and in a clear cut with enough material to bundle, the production per bundle was 2,5 to 5,5 minutes.

- In the US trial, in a pre-commercial thinning in pine, whole trees were bundled without any problem (figure 5). The advantage of bundling long and thick material is that bundles can be made longer than 3 m. According to the difference between the Austrian and Italian trials, bundles longer than 3 m increases the production substantially.
- Old (older than 2 year) and short material is not suitable for bundling as branches become brittle over time. Bundles with short or old material break easily or loose material during transport
- Transport with a truck and solid floor log trailer is favourable as material is lost easily from the bundles when old or short material is bundled

Figure 5. Bundles made of material from a pre-commercial thinning [7]

Figure 6. Bundler operating in a stand after a thinning[7]

Figure 7. Direct chipper system[8]

Figure 8. Press collector[8]

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[7] Rummer et al., 2004
[8] Wellink, 2007

3.3 Physical and chemical properties; crucial factors in the marketing of woody bio-fuel

In order to be able to serve the bio-fuel market, the products need to meet high quality standards. Not only the supply chain is a bottleneck but also the properties of woody bio-fuel have to meet high standards on today's bio-fuel market.

The market value of woody bio fuel is greatly influence by the moist content, particle size distribution and cleanliness.

In simple terms: the more equally sized, the more dry and the more clean, the better. Logging residues like tops and branches consist of small material with a high content of bark and green parts like leaves and needles. In case logging residues are not treated properly during the various steps in the harvesting pro-cess the material can also be polluted with sand and stones.

EU standard for solid bio-fuel CEN/TS 14961. The following parameters are classified and specified in the standard:

- Moist content
- Ash content
- Particle size distribution
- Bulk density
- Nitrogen and Chlorine content
- Energy content

The most important parameters for solid biomass are summarized in Appendix 1.[9]

The net heating value and moist content of wood
Moist content of wood has a dramatic effect on the net heat value. The table below shows the relation between the % moist content and the net heath value per kg wood. With 20% less water, heat value increases almost 100%.

Table 3. Net heat value and moist content of wood [10]

Coniferous			**Broadleaf**		
Moist %	**Kg/m³**	**KWh/kg**	**Moist %**	**Kg/m³**	**KWh/kg**
0	148-160	5,38	0	230-270	5,03
25	197-213	3,86	25	307-360	3,60
40	247-267	2,95	40	383-450	2,74
50	296-320	2,34	50	460-540	2,17
60	370-400	1,73	60	575-675	1,59

Air drying of wood
Research has proven that forced drying of woody biomass is only feasible in combination with a power plant or other industry. In this situation rest heath is used to dry fresh biomass. In order to maximize the yield of harvesting logging residue in the Netherlands, air drying of biomass in the supply chain is conditional as only a small part of the customers are able to process and dry on site. Moist content of wood depends strongly on the relative humidity of air (MA). In table 4 the relation between humidity en moist content of wood is summarized.[11]

[9] Hansen, 2007
[10] Verscheure 1998
[11] Wiselius, 1994

Table 4. The relation between humidity and moist content of wood of different tree species

Timber species	40% MA	60% MA	85% MA	90% MA	Saturation point
Scots pine	9-10	12-13	15-18	17-19	30
Spruce	8-9	12-14	18-21	20-23	30
Douglas fir	9-10	12-14	18-21	20-23	29
Oak	9-10	12-13	17-20	19-22	32
Poplar	7-8	11-13	17-20	19-23	32

In table 5, the moist content of Spruce (stored in a rain covered shed[11]) in the East of the Netherlands is summarized.

Table 5. Average moist content of Spruce (% of weight)

jan	feb	mar	apr	may	jun	jul	aug	sept	oct	nov	dec
19,5	18	15	13	12	12	14	14	16	17	19	21

Drying experiments

The only known experience with air drying of woody biomass in the Netherlands was gained in a research project with willow from short rotation coppice. In this case coppiced shoots were stored in piles on the field. Moist content was monitored throughout the piles for a period of 200 days from the harvest until August. The results of the project:

- In the period of 200 days, the moist content decreased from 1 to 0,3-0,2 kg water/kg DM.
- A pile dries more or less uniform. No 'crust' of dry shoots over more wet shoots in the pile.
- Covering the piles did not have a significant long term effect on the moist content of the piles.

To determine the potential for use of this material as woody biomass (e.g. wood chip bio-fuel) an experiment on the natural drying of *Chamaecyparis obtusa* logging residue stems was carried out in Japan. The experimental residue logs, i.e., unused stems left after logging, were placed along a forest road at high altitude and on a paved landing at low altitude. At each site, half the material was naturally dried in the sun and the other half in the shade for about three months. Moisture content of the logs (MCL; dry basis) was almost constant at the forest road site, while it decreased from 82% to 38% within three months at the paved landing site. There was no significant difference between MCL dried in the sun and in the shade, whereas the MCL placed directly on the ground was about 10% higher than the MC of elevated logs. Average air temperature at the forest road site and at the paved site differed by 7 degrees (higher at the paved site) and average humidity was also 20% higher there. There was no significant effect of substrate type, i.e. soil vs. pavement. Thus, differences in air temperature and humidity between the sites were the main determinants in natural drying of logging residue stems. [12]

Experiments in Finland show that moisture content of well ventilated piles may be lowered in one summer below 40% and after 12 months stock piling the average moist content was further reduced to 26,7% for Pine and 32,1% for Birch. Only for Birch a significant difference was found between covered and uncovered piles. For pine there was no statistical significant difference. More interesting was the difference found between the moment of harvest. It seemed that harvesting earlier benefits from the drying months April and May.[13]

In Austria, during the same experiment with the bundler as described above, bundles were stored for drying during a period of four months, starting in the period from January until the end of April. In one case the bundles were stored in the forest, covered with tarpaper. In the other case bundles were stored uncovered in the open field. Moist content in the first trial

[12] Miyata et al., 2005
[13] Nurmi and Hillebrand, 2005

increased from 55% to 69 %. In the field test moist content remained on a constant level of 52%

Conclusions

- Moist content has a dramatic effect on the net heat value of wood. In terms of costs per Giga Joule 1% less moist equals about 5% cost reduction per GigaJoule
- As no data are collected in the Netherlands, further experiments are needed to find the optimal site conditions and stacking methods under Dutch conditions
- Drying period in Dutch conditions is optimal from December/January until the beginning of September. After September on average, wood tends to get more humid again and takes up the same amount or more than is dried out during the drying period
- Result from the Japanese experiment prove that a moist reduction of 44% in only three months is possible
- Finnish experiments show that covering piles is effective under conditions of wet snow in spring time
- The best option for drying bundles is a situation where air flow is not hampered by surrounding buildings, vegetation or cover. Bundles should be stacked in a way that enables the wind to go freely through the piles
- Bundles should contain a low rate of leaves or needles in order to provide sufficient air flow within the bundle

3.4 Costs

The US study has made a cost analysis. The US study is based on a production rate of 20 bundles per machine hour. Forwarding capacity is estimated on 4 loads per machine hour. Transport distance is 50 mile.[14]

Bundling costs per oven dry tonne is	$16,-- (€ 19,50)
(Forwarding costs per oven dry tonne is	$ 5,--)
Transport costs per oven dry tonne is	$10,-- (€ 12,19)
Chipping/shredding costs per oven dry tonne is	$ 3,--
Total costs per oven dry tonne[15]	**$29,-- (= € 35,35)**

The Austrian study made a cost analysis with the following results:
The figures are an average over three field tests. Production was on average 10.9 bundles per machine hour. Transport distance on average 46 km. In all three field tests logging residue was forwarded to the roadside as the timber was cable yarded from the mountain sides.

Bundling costs per oven dry tonne	€ 73,33
Forwarding	(not included)
Transport	€ 25,--
Shredding	€ 17,67
Total costs per oven dry tonne	**€ 116,--**

As part of the Irish Forest Energy programme 2006, field tests were performed in order to gain more knowledge on the harvest of timber for energy production. During these field tests, several methods were compared and within the frame work of this study the results of an integrated method is relevant. During this test in coniferous forest trees were harvested for energy wood and industrial assortments with a harvester forwarder and chipped on the road side. Costs per GigaJoule were € 6,78. Moist content of the chips varied between 58 and 66 %

The Irish study made a cost analysis with the following results. Only the results of the integrated harvest are shown. With this harvest, trees are felled, industrial assortments are cut from the stems and logging residue and low value logs were harvested and processed on site.

Costs per oven dry tonne	
Harvester	€ 78,90
Forwarding	€ 9,90
Transport	(not included)
Chipping	€ 7,80
Total costs per oven dry tonne	**€ 96,60**

Conclusions

- As both calculations show, the costs of bundling represent 55-63% of the total costs
- Harvest and processing on site is by far the cheapest option but only feasible in large scale operations in the Netherlands
- Bundle production rate is a major factor for breaking even. Optimal production is crucial and needs special attention when harvesting logging residues is planned

[14] Exchange rate in 2004 US$ 1= € 1,219
[15] Without forwarding

4 Ecological results

4.1 Dead wood

With regard to responsible stewardship, deciding where, when and how the harvest of logging residues is possible, insight in the role of woody debris in the forest ecosystem is important. In managed forests harvesting activities are, next to natural causes like wind blow, branch disposal and illnesses, the main provider of woody debris on the forest floor. The supply of debris as a result of human activities lik harvest can be considered as artificial and discontinuous in time compared to the natural causes that provide dead wood in the forest ecosystem. During this study of national and international research, the role of dead wood in the forest ecosystem and in the nutrient cycle has been determined and where possible quantified.

The last decades dead wood has been recognized as an important part of the forest ecosystem. The Ministerial Conference on the Protection of Forest in Europe, that was held in 2002, stated dead wood as '*a habitat for a wide array of organisms and after humification an important component of forest soil.*' And '*because of lack of dead wood many of the dependent species are endangered*'. In the Netherlands dead wood is a part of the subsidy programme 'Programma beheer' since 2000. For nature oriented forests. It aims at a minimum of three standing or lying dead trees per hectare thicker than 30 cm dbh.[16] Logging residues are not mentioned.

Many research has been done on the importance of dead wood in the forest. Most of these studies where focused on thick dead wood, the so-called coarse woody debris (CWD) (>10 cm)[17].

The last few years, fine woody debris (FWD) (5-9 cm)[17] has been studied as well. As the harvest of tops and branches has become a management option, ecologists would like to know the effects on different organisms.

4.2 Biodiversity

Several studies studied factors, like diameter, tree species and stage of decay, that make dead wood suitable for certain organisms.[18,19,20] At first sight, small logs seem to be less important for wood-inhabiting species, however, when the amount, volume and surface area of all small logs is considered, it might represent a potentially important substrate.[17] In this chapter the importance of FWD is studied for insects, fungi and mosses, as these species groups consist of many species that depend on dead wood.

4.2.1 Insects

The saproxylic insects, which live on dead wood, are most affected by the low availability of dead wood in managed forests.

Most studies find a positive relation between species richness of insects and the diameter of dead wood. Dead wood with a bigger diameter is thought to have many different habitats, more fungus species and related insects present, a low rate of decay and thus a stable microclimate and by this a higher species richness.[18] On the other side, fine material that is spread through the forest may result in a much bigger variation in gradients of moisture and temperature and by this in a higher species richness.[21] Some insects even seem to be specialised in utilising the thinnest wood.[22] Besides, in a managed forest small branches and stumps are sometimes the only dead wood available. The branches can act as a substrate itself. Next to that, beetles with a preference for shaded conditions are more abundant on clear cuts where logging residues, which provide shade, are left.[23] The

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16 Wijdeven, 2005
17 Kruys and Jonsson, 1999
18 Grove, 2002
19 Similä et al., 2003
20 Jagers op Akkerhuis et al., 2005
21 Moraal, 2005
22 Jonsell et al., 2007
23 Hjältén et al., 2007

stumps can also act as a habitat for saproxylic insects. But as the stumps can become very wet because of their smooth cutting surface, or very dry in a clear cut area, they are not always a suitable substrate. In some management systems stumps only occur at clear cut areas, and in this case specialised insects must be able to migrate very well to be able to survive. A forest with a selective cutting management will be better for more different species to survive. Next to specialists of stumps and small branches, only species with a broad niche can survive in managed forests.[24]

The primary source of logging residues are clear cuts, where the small material is highly available and easy to collect. Removing all logging residues on clear cuts might have a major impact, especially for saproxylic beetle species that depend on dead wood on sun-exposed sites. The beetle fauna on logging residues of aspen, birch, oak and spruce, with diameters between 1 and 15 cm, was investigated. A difference was found in species abundance in one-year-old and 3-5-year-old clear cuts, where the latter was more species rich. Diameter did not show a very large difference in associated species. However, the coarser residues (8-15 cm) where for most tree species somewhat richer compared to the finest residues (1-4 cm), but the species composition was different. Also few similarities in species composition between different trees have been found. But as spruce seemed to be the most species-poor tree, whereas birch and oak had the highest number of associated species and aspen a very high number of red-listed insects, one may conclude that harvesting deciduous logging residues may involve a bigger threat for biodiversity.[25]

The value of retained wood has been studied in northern Sweden. A difference was found in abundance and species composition between different substrate types (logs, snags and tops), which suggests that variation in substrate types might provide habitats for a diverse group of dead-wood living beetles.[26] It also has been suggested that diversity and continuity of dead wood is important to maintain the diversity of saproxylic insects.[27]

Conclusion

- *saproxylic* insects are most affected when dead wood is fully removed in managed forests
- some insects seem to be specialised in utilising the thinnest wood
- a difference in species composition between insects on CWD and FWD was found
- harvesting broadleaved logging residues has bigger implications for species richness of insects than harvesting logging residues from coniferous forests

4.2.2 Fungi

Fungi are important for decomposing wood (dead or alive) and play a key role for the diversity of e.g. saproxylic insects.[28] More then 25% of all fungi-species need dead wood for their survival.[29] The current fungal species composition that is found in a forest depends, among others, on the history of forest management. In Swiss forests the fungal species richness dependent significantly on the number of years since the last forestry intervention and the number of host tree species represented in the plot. More fungi species were found on deciduous trees compared to coniferous trees.[30]

Spores of fungi can distribute over very long distances, but when a species is established on a site, it is important that there is enough and good substrate in time and space. As fungal species decompose the wood themselves, dead wood is a temporary substrate for them. The species composition in the later stages of decay depends on the composition in the previous stages, as the fungi change the substrate in a specific way.[31]

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[24] Moraal, 2005
[25] Jonsell et al., 2007
[26] Hjältén et al. 2007
[27] Similä et al. 2003
[28] Nordén et al., 2004
[29] Arnolds et al, 1995 in: Veerkamp, 2005b
[30] Küffer and Senn-Irlet, 2004
[31] Veerkamp, 2005b

In temperate broadleaf forests in southern Sweden the importance of coarse (>10 cm) and fine (1-10 cm) woody debris for the diversity of wood-inhabiting fungi was studied. In the study conservation stands where investigated in which 75% of the ascomycetes and 30% of the basidiomycetes was exclusively found on FWD.[32]

Thicker trees contain more species, as individual thick and small trees are compared.[33] Except when species density as the number of species per dead wood volume and as the number of species per forest area are compared. With similar volumes FWD seems more important than CWD, but for basidiomycetes CWD might be more important on landscape level. It was also found that several FWD objects contained more species than a few CWD objects (with the same volume), which might be explained by the spread of the FWD resulting in a variation of a-biotic factors.[32] FWD also has more surface area per volume, so more place for different species.[33]

Some points of interest about small tops and branches have been suggested. Leaving fine woody debris might not be enough to increase the natural values of the forest. The small material decomposes very fast and does not act as a stable substrate.[33] However, the CWD and FWD in the Swiss forests were relatively species poor, whereas the thin branches and twigs showed to be quite species rich. The researchers could mark only 5,5% of the dead wood in their plots as coarse (>10 cm)[34] or fine (5-9 cm)[34] woody debris.[35] They therefore proposed a new definition, namely very fine woody debris (VFWD, < 5 cm). Of the 238 species found, 142 were found exclusively on the VFWD. Small and highly fragmented forests tended to be species poor, compared to the large, less severely fragmented forests. The researchers conclude that the availability of dead woody debris with a wide range of different characteristics is the most important factor, as there are more fungi present if there is variation in tree species, volumes of dead wood and different degrees of decomposition. Forests with little or no management contain more dead wood of different qualities and therefore harbour more species than managed forests. However, when CWD is lacking, FWD and VFWD may serve as an alternative, as they harbour many fungal species and may serve as a refuge.[35] But species that induce rot of the core and species of later decay stages do not get a chance.[33]

Also research has been done on ectomycorrhiza. In the Netherlands the humus layer increases very fast by acidification and nitrification, resulting in a decrease of the mycorrhiza. The mycorrhiza are most abundant in places where the nitrogen deposition is low and the humus layer is thin, for example next to path ways and on small hills and embankments. Especially the mycorrhiza that are associated with coniferous trees and the species that are characteristic for dry and nutrient-poor sandy soils have declined in number. Species that are associated with broadleaved trees are found near coniferous trees, certainly when a thick humus layer is present. Leaving logging residues in the forest may not serve as a good substrate. The tops and branches may also capture leaves which are blown away on open sites. The forest soil is enriched by accumulation of wood residues and leaves, resulting in a decline of mycorrhiza that are characteristic for nutrient-poor situations.[36]

Conclusion

- deciduous trees are richer in fungal species compared to coniferous woody debris.
- especially ascomycetes perform very well on FWD (75% was exclusively found on FWD)
- removing FWD in managed forests will therefore have negative implications for fungal diversity
- in Swiss forests VFWD is very species rich. As CWD is absent, FWD and VFWD may act as a refuge for fungal species
- ectomycorrhiza perform better on nutrient poor sites with a thin humus layer. For these species tops and branches can better be removed

[32] Nordén et al., 2004
[33] Veerkamp, 2005b
[34] Kruys and Jonsson, 1999
[35] Küffer and Senn-Irlet, 2004
[36] Veerkamp, 2005a

4.2.3 Mosses

Several mosses (also called bryophytes) that are characteristic for the forest ground, seem to need dead wood as a substrate to establish. After the wood has gone they expand on the forest ground. This might be caused by the water delivery capacity of the dead wood and the absence of leave material on the dead wood. Most mosses that prefer dead wood can be found on acid, nutrient-poor rotten wood in areas with a high rain surplus.[37] Many mosses can occur on dead wood, but few mosses seem to have a preference for it. The presence of dead wood becomes significantly more important when other substrates, as humus rich ridges and forest soil are absent. This was found at the south-east Veluwe (Netherlands) where the species richness of mosses was investigated. If the availability of embankments and humus rich ridges decreases some mosses show a shift in habitat of humus rich soil to dead wood.[38] Also stem bases of birch seem to be a good substrate.[37]
In mid and northern Sweden the species richness of lichens, mosses, hepatics and fungi on Norway spruce has been examined. A higher species richness was found on CWD (>10 cm) when looking at an equal number of logs and no significant difference was found between FWD and CWD for equal log surface area. However, when the species richness on equal volumes of FWD and CWD was compared, more species were found on FWD. The results suggest that when having small volumes (1-4m^3) the species richness increases in proportion with the share of FWD, but with bigger woody volumes (32-64 m^3) the species richness increases more with CWD.[39]

The supply of decaying wood on the ground and the occurrence of bryophytes on dead wood in a natural and a managed forest in Sweden has been compared. The number of measured units of decomposing wood was higher in the managed forest, because of many small pieces there. Most of the logs in the managed forest had a maximum diameter of 10 cm. More bryophytes were found in the natural forest. In general, the mean number of mosses that are epixylic specialists (well decayed, soft wood) increased significantly with increasing diameter of the logs.[40] This was also found in the forest reserve Kersselaerspleyn in Belgium.[41] However, not only substrate availability is important, also the substrate quality or the environmental context must be considered.[42] For example, branches that fell off the beech often lay in the shadow, saw stumps of beech are situated in small open areas in the forest and are therefore a much better place for mosses to grow.[37]

Tree species seems to be important for species composition of mosses as well. A difference in species composition of bryophytes on hardwood and softwood species has been found, but this difference diminishes when decay strides along.[42] This can be supported by other studies, which found that common epixylic specialists did not seem to be restricted to any special tree species.[40] The epixylic mosses are of later decay stages, where the wood is well decayed.[42] On Populus tremula the highest number of epixylic species was found.[40]

It seems that mosses are most abundant on coarse woody debris. However, small logs (5-9 cm) must not be considered unimportant for species richness of wood-inhabiting species. The bigger substrates provide habitats for red listed species, while on FWD mostly common species are found. Removing the small logs for biofuel, may have consequences for the species that are still common today.[39]

Conclusion

- Mosses need dead wood to establish, but few species seem to have a preference for it
- The presence of dead wood is important when other substrate types (e.g. embankments) are absent
- Mosses perform better on CWD

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[37] Bijlsma, 2005b
[38] Bijlsma, 2005a
[39] Kruys and Jonsson, 1999
[40] Andersson and Hytteborn, 1999
[41] Van Dort and Van Hees, 2001
[42] Mills and MacDonald, 2005

4.2.4 General conclusion for biodiversity

- Fine woody debris contains a high number of microsites, providing habitats for a large number of species
- FWD seems especially important for insects that are specialized in using small material and ascomycetes
- Most studies show a higher species richness of organisms on deciduous dead wood compared to coniferous wood
- Dead wood of different tree species in different stages of decay must be available for species to survive.
- Small 'deadwood reserves', allocated evenly spread in a forest can be used as a refuge from which species can disperse. Managed forest should contain places with a high availability of dead wood, acting as 'stepping stones' [43]
- Fine woody debris is quite interesting for the more common fungi and insects, but mosses and rare species perform better on coarser wood
- Ectomycorrhiza perform better when tops and branches are removed and a thin humus layer is present
- Availability of woody debris in a wide range of different characteristics and stage of decay in time, allocated in an unbroken forest complex is a more important factor for the presence of insects, fungi and mosses than the quantity of deadwood.

4.3 Soil fertility and nutrient removal

Most intensively studied are the amounts of nutrient removal during harvest, the effects of different harvest treatments on soil fertility and the effects on site productivity in the long run. In this chapter only articles about the effect of different *thinning*-regimes are used, as large scale clear cuts are not common practice in Dutch forestry.

The most important elements for tree growth are ammonium (NH_4^+), potassium (K), calcium (Ca), magnesium (Mg), nitrate (NO_3^-), sulphate (SO_4^{2-}), and phosphorus (P).[44]

Branches, twigs and needles (litter) clearly hold the larger part of the nutrients contained within the tree.[45] The distribution of minerals in fully stocked stands of European trees (spruce, fir, pine, beech, oak) on average sites shows that for phosphorus and calcium between 70-90 % of the total amount can be found in the litter, while litter represents only 6% of the total dry matter of the tree.[46] Variation exists between mineral concentration in leaves. Hardwood litter usually has a higher nutrient concentration than coniferous litter. Leaves usually contain the highest mineral content of all tree parts, therefore the decay of leaves is a very important process by which minerals are returned to the soil.[47]

Since the early 1980s the removal of biomass for the production of woody chips in Denmark has been intensified and in order to make the first thinning (≤20 cm diameter) of Norway spruce and Sitka spruce had to become economically profitable, whole trees were harvested. The effect of this Danish whole-tree harvesting practise on the nutrient status has been studied. One study compared the removed nutrients between whole-tree harvest with immediate removal of trees (WTH_{green}), whole-tree harvest leaving trees one growing season on the site to dry (WTH_{dry}), and stem-only harvesting. In one thinning the WTH_{green} removed 20-75% more nutrients compared to WTH_{dry}. Compared to $WTH_{green,}$ the stem-only harvest reduced the nutrient removal with, 85% for nitrogen, 90% for phosphorus, 70% for potassium, 70% for calcium, and 75% for magnesium. When the nutrient removals were calculated for one rotation period of 90 years, the removals increased with

43 Jagers op Akkerhuis et al., 2005
44 Baule and Fricker, 1967
45 Møller, 2000
46 Baker, 1950 in: Kramer and Kozlowski, 1960
47 Kramer and Kozlowski, 1960

25-75% for WTH_{green} and with 15-40% for WTH_{dry}. All these data originate from one single stand.[48]
During another study in Denmark the effects of different thinning treatments on the stand and site productivity of nutrient poor, sandy soils were assessed. The treatments include no thinning (NT), WTH_{green}, WTH_{dry}, and harvest of stems and coarse branches leaving needles and twigs on the site (SCB). The WTH_{green} resulted in a short term decrease in volume increment compared to the WTH_{dry} and SCB-plots. The effect might be caused by the increased removal of the nutrients N, P, K, Mg and B. The nutrient status of the WTH_{green} trees for example showed the lowest concentration of P.[49]

In Sweden the effects of repeated slash removal in thinned stands on soil chemistry and under storey vegetation have been studied. No significant differences in soil pH, C and N were found when comparing whole-tree and conventional (stem-only) thinning. Lower concentrations of the exchangeable cations Ca and Mg were found in whole-tree thinned stands, which can have an effect on the capacity to buffer acidity. Four years after the second removal of thinning slash they found there was no clear effect on the cover of vascular plants or bryophytes. The remaining trees will probably compete with the vegetation for released nutrients.[50]

To evaluate the long-term effects of an intensive harvest system you should calculate the input and output of nutrients on a site. Deposition and weathering are examples of inputs. Leaching and the removal of biomass are outputs. The values are site-specific. The deposition of ammonium-nitrogen for example depends on the distance from animal farming. In Denmark deposition of sea salt results in the input of calcium, magnesium and potassium.[48] In the Netherlands the nitrogen deposition is on average 50 kg per hectare. The influence of the North Sea for Dutch forests is not known.

The amount of nutrients that is removed by harvesting, has been calculated by several researchers. Equations have been developed by which dbh (cm) and height (m) must be measured, where after the nutrient content of the removed material can be calculated for WTH_{green}, WTH_{dry} and stem-only harvesting.[48] A French study tried to quantify the nutrient loss by biomass removal for Douglas fir, Norway spruce, Scots pine and European beech. They compiled data from literature and came to equations by which the nutrient amount in the removed biomass could be calculated for the stem and for the whole tree (including tops and branches). They also calculated the nutrient concentrations (kg) of different tree species per ton biomass (*table 6*).[51]

Table 6. The ratio between the nutrient concentration in the stem and in the whole tree

	Nitrogen		**Calcium**		**Kalium**	
	Stem only	Whole tree	Stem only	Whole tree	Stem only	Whole tree
Douglas fir	1	1,7	1	1,9	1	1,6
Norway spruce	1	2,4	1	1,7	1	2,0
Scots pine	1	2,1	1	1,2	1	1,7
European beech	1	2,5	1	1,9	1	1,7

It was found that trees on rich sites have a higher nutrient concentration than the same species on a poor site.[51] This might explain that in absolute terms growth reductions tend to be larger on fertile sites.[52] However, it are complex interactions and instead of assessing the effect of whole-tree harvesting on each site, it is recommended to reduce the extraction of minerals to the minimum by

[48] Møller, 2000
[49] Nord-Larsen, 2000
[50] Rosenberg and Jacobson, 2004
[51] Augusto et al., 2000
[52] Egnell and Leijon, 1997

leaving trees to dry during summer. Leaves, needles and twigs (the nutrient rich parts of the tree) will be returned to the forest floor.[49]

Conclusion

- Branches, twigs and needles make up 6% of the total dry mass of a tree, but contain 70-90% of the total amount of nutrients within the tree
- WTH_{green} removes 20-75% more nutrients compared to leaving the logging residues for one year on the site to dry (WTH_{dry})
- Tops and branches of trees on nutrient rich sites contain more nutrient concentration than trees on nutrient poor sites

4.4 Ash recycling

Considering the nutrient cycle and the nutrient le3aching with the removal of biomass from the system, recycling of ashes seem to be a logic step to close the leak. There have been experiments in which woody biomass was burned for energy production and the ash was returned to the site, to reduce the removal of nutrients. The environmental impacts of ash application have been reviewed. The composition of the wood ash is strongly related with the nature of the wood fuel (wood residues, bark, paper mill, soft- or hardwood, tree species). For example, the ash of hardwood species contains more macronutrients. Besides, it is important which form the ash has, as loose ash might lead to health risks because of its small particles and it may contain higher levels of dioxins and heavy metals. Granulated ash, on the other hand, is more easily spread and the chemical elements are slowly released. The application of more than 5 ton ash per hectare affects ground flora. Species like *Calluna* and *Vaccinium* decline, and communities of bryophytes and lichens show major changes. Swedish research shows that forest areas where the N air pollution is very high, wood ash use should be reduced, as the possibility of N leaching to the groundwater is increased. The soil type and site characteristics are very important for the consequences of the ash application.[53]

The recycling of wood ash in the Netherlands has been assessed, but seems not feasible yet. The present legislation does not allow the application of ash from bio-energy plants in agricultural areas and in forests, because of the high levels of heavy metals in it.
A closed circle where the biomass of one forest plantation is burned where after the ash will be returned to the same site is not possible. The plantations in the Netherlands are too small to give enough biomass to burn at once. Furthermore, the Dutch forests are used for recreation as well. The ash application should therefore meet certain requirements.
At this moment the recycling of ash is not an option, but in case the harvest is applied on a large scale and more frequent in time, ash recycling is an important factor to consider in the nutrient balance of the forest.[54]

Conclusion

- The composition of wood ash depends on the nature of the wood fuel.
- The ash of hardwood species contains more nutrients.
- More than 5 ton ash per hectare affects ground vegetation (*Calluna*, *Vaccinium*, lichens).
- Application of ash recycling in the Netherlands is not an option yet, but an important factor to consider in the nutrient balance of the forest.

[53] Pitman, 2006
[54] Pels et al., 2004

4.5 Harvest of logging residues and regeneration

Besides the negative effect on soil fertility, the biggest concern of forest owners, when discussing the removal of logging residues, is the increasing competition by bramble or grass and more intense browsing of the regeneration.

As mentioned in chapter 5.3 the amount of soil organic matter and the C and N pools did not differ between whole-tree harvesting and the conventional way of harvesting in most studies. However, the exchangeable cations Ca and Mg decreased in the soil when tops and branches were removed.[55]

In southern Sweden a lot of research has been done on the effects of the removal of slash.[56,57,58] Mostly the whole-tree harvest and the conventional way of harvesting (stem-only) have been compared.

A third kind of harvest has been added to the comparison: removal of all tree parts except the needles. The results of this study show the effect of the logging residues on the vegetation. Leaving slash increases on one hand the amount of nutrients on the site, which favours nutrient-demanding species like *Rubus*. On the other hand the slash acts as a physical barrier for the nutrient demanding grasses. The grass species *Deschampsia flexuosa* therefore showed a higher cover in the plots where only the needles were left and the lowest cover of the grass was found in the plots where the conventional way of harvest had been applied. Plots where slash was removed showed a higher abundance of the nutrient-poor *Calluna* heaths. Also lichens were more present at places where whole-tree harvesting was applied.[56] The effect of slash removal on tree density has been investigated as well. Pine and birch responded positively to slash removal. This might be explained by the possibility that slash acts as a physical barrier for seeds, preventing them to reach the ground. Secondly, during slash removal the humus layer may be disturbed, creating favourable sites for the seeds to germinate. Furthermore, the absence of slash increases growth because of an increase in light.[58]

Slash can act as a refuge for species that are typical for the late stages in forest succession, as they need some shade to survive.[60] There also have been suggestions that tops and branches might act as a physical barrier for browsers. On the other hand slash releases many nutrients during its decomposition, which make plants more palatable when they take up these nutrients.

In southern Sweden both deer browsing and slash removal affect plant succession, however, deer browsing more strongly than slash removal. The vegetation in enclosures contained more tree and shrub species, whereas outside the enclosures grasses dominated. The trees on the slash-retained parts of the clear cuts had a higher biomass.[57]

When harvesting of logging residues is applied only once, the long-term effect of this single removal on the vegetation in the nutrient-poor coniferous forests is probably small. However, repeated removal may have more drastic changes. The location of the forest is also important when deciding to start slash removal: in northern Sweden the trees are nitrogen-limited and removing slash may decrease the amount of available nitrogen even more. In southern Sweden the nitrogen deposition is higher and may compensate for the nutrients removed.[58] The effect of repeated slash removal in thinned stands on under storey vegetation seems not significantly different from plots where slash had been retained. This might be caused by competition between the under storey vegetation and the retained trees.[59]

The effect of the removal of logging residues is not clear yet. Some studies find an accelerated regeneration of trees[60] while others do not find any specific influence.[57]

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[55] Rosenberg and Jacobson, 2004
[56] Olsson and Staaf, 1995
[57] Bergquist et al., 1999
[58] Karlsson et al., 2002
[59] Rosenberg and Jacobsson, 2004
[60] Olsson and Staaf, 1995

Two Dutch forest ecologist were asked to give their opinion of the effect of the removal of tops and branches on the forest. One forest ecologist thinks the harvest of tops and branches will certainly have a big impact on the nutrient cycle, the humus layer and the water holding capacity. Furthermore, the logging residues are an important brood substrate for several insects, other related organisms (wasps, birds) and fungi. Many insect and mite species that are bound to dead wood have a poor dispersion capacity. By the removal of logging residues in certain forests, the infrastructure for those organisms will get lost. Other aspects of tops and branches are the possibility for spiders to attach their webs to it. It can also act as a cover for small mammals and might reduce the browsing of seedlings by deer and pigs by giving physical protection. The only place where the harvest of logging residues could be argued are constructed forests, plantations, which do not have been forests before or did have any natural value.[61]

The vision of an other ecologist is that the amount of thick dead trees in the forest should be more stimulated, but that this will become more difficult with the rising timber prices. Thick dead wood is more important from an ecological point of view, leaving tops and branches is, to his opinion, not that important. The effects are not really investigated, but in young coniferous forests on poor soils he expects an accelerated development in the bush and herb layer, with more ferns and bushes with berries. Leaving logging residues might also increase the risk of forest fire. Then it is obvious to remove the tops and branches around camp sites, bungalow parks, etc. When the logging residues are removed later than the stems are harvested it might increase the disturbance of organisms in the forest.[62]

Conclusion

- Leaving slash increases the amount of nutrients on the site, favouring *Rubus spp.*
- Slash acts as a physical barrier for nutrient demanding grasses
- *Calluna* and lichens perform better on sites where logging residues are removed
- Where slash is retained trees have a higher biomass compared to sites where slash has been removed
- Pine and Birch regenerate better on sites where slash has been removed and the humus layer is disturbed
- The environmental conditions of the site are important in deciding to harvest logging residues
- The harvest of logging residues in Dutch forest might have important consequences for the nutrient cycle, the humus layer and for insects and other organisms. But research is necessary to investigate the real effects

[61] Moraal, pers. com.
[62] Bijlsma, pers. com.

5 Harvest of logging residues in the Netherlands

5.1 Availability of woody biomass in the Netherlands

The potential amount of woody biomass from regular managed forest has been estimated to be around 140.000 m³ round wood equivalents. This is based on an estimation that around 15% is available as biomass in addition to the total harvest of round wood. In terms of harvestable biomass this is considered as an overestimation as most of the timber in the Netherlands is harvested from small scale, spatially highly fragmented thinnings with a relatively low rate of additional biomass per hectare. This requires a well organized, well developed and sophisticated, state of the art, collecting and processing.[63]

In Germany a useful rule of thumb for the estimation of available biomass for energy in the field was made. It was estimated that per 100 m³ standing timber approximately 15-25 bundles with an equivalent of 20-35 m³ chips can be harvested in addition to the regular round wood assortments.[64]

Woody biomass seems to be available in the Dutch forestry, but now the question rises where the harvest of logging residues can be applied, taking into account technical, economical and ecological considerations.

Forest management in the Netherlands has a multifunctional character. Timber production, recreation, cultural history and natural values are the major aspects that have to be taken into account by the management. The managers of nature areas have a certain vision for every area. One vision might be the creation of a nutrient poor environment, like a forest of Scots pine with lichens, a heath land or a drift sand landscape. For all these three goals the removal of tops and branches might be an option, however, for the latter two also the top soil layer must be removed.

As Scots pine can grow on poor soils and has a high share in the cover of the Dutch forest, the harvest of tops and branches in these forests is one of the first thoughts that comes up. Much woody biomass is available and the amount of nutrients that will be removed might not affect the growth of Scots pine very drastically. However, the availability of logging residues, dead wood, forms an important substrate for insects, fungi and the creation of a good soil. The difference in species composition on thick and thin wood, on broadleaved and coniferous wood, on fresh and decayed wood, suggests that dead wood of different sizes, of different tree species and of different decay stages must be available for the highest biodiversity possible. Removing all tops and branches in all (pine) forests, constantly in time is therefore no option.

Under Dutch conditions, additional harvest of forest residues once or twice in a rotation of 75 year is considered feasible in the following situations:

Forests
- *Clear cuts or group cuts*. The average standing volume in the Netherlands is 208m³/ha[65]: this corresponds with a potential of 41,6 m³/ha chips for biomass.
- *Thinning from forest with pioneer species like Scots pine* etc. Average harvest from thinning with a 5 year cycle is approximately 24 m³/ha . (4,8 m³ chips for biomass)
- *Thinning from forest under transformation management with so-called exotic species*. Average harvest from thinning with a 5 year cycle is approximately 24 m³/ha. (4,8 m³ chips for biomass)
- *Clearings of heath land*. No data available. (estimated harvest of biomass from heath is 2,6 odt/ha/y[66] it is not clear if this is woody biomass or just heath cuttings)
- *Fist (non-commercial) thinning* approximately 24 m³/ha available as biomass.

Total potentially harvestable fresh woody biomass from the forest as mentioned above is estimated on 122.500 tonne/year.

[63] Kuiper and Oldenburger, 2006
[64] Rohrmoser and Stamfer, 2003
[65] Dirkse et al., 2007
[66] Tolkamp et al., 2006

Landscape
- *Lanes*: 4100 ha (approximately 200 trees/ha with an annual harvest 50 kg wood per tree[67]). Equals about 41.000 tonne biomass/year.
- *Other line shape plantings* (singels en houtwallen): 3900 ha (annual harvest 80 tonne/ha). Equals about 31.200 tonne biomass/year
- *Coppice*: 6400ha (25 ton/ha/y) 160.000 tonne biomass/year This is considered not available for biomass.
- *Other woods:*10.000 ha (No harvest data available but estimated on 4 tonne/ha/year) 40.000 tonne/year

Total potentially harvestable fresh woody biomass from the landscape: 112.200 tonne/year

5.2 Conclusions

- The ecological value of dead wood and debris in the forest is more a matter of quality than of quantity and depends much on the availability in time and the allocation. Also the timing of removal is crucial as with the removal of the logging residues in the growing season, also insects are removed. In terms of quality, it must be avoided to damage logging residues by harvest equipment, in order to provide as much as possible 'natural' debris
- The harvest of logging residues has both positive and negative impacts on the next generation of trees. Positive: extra soil disturbance creates a seed bed for pine and birch; less brambles, and grasses settle with the released nitrogen from the logging residues. Negative: protecting cover is removed what gives opportunities to browsers
- Removing tops and branches more than once in a short time at one place may have drastic effects on the nutrient cycle.[68] When logging residues are removed in a coniferous forest and nutrient recycling is important, the residues should remain in the forest for at least one year to release needles from the branches
- Recycling of nutrients needs strong considerations when the harvest of logging residues becomes common practise
- Recycling of ash is not possible yet. Bio-fuel, used in power plants is originating from a wide range of sources and products. Current levels of heavy metals are too high. Developing techniques to purify the ash from bio fuels could be an option
- Organising a closed circle from the forest back to the forest is practically impossible. Even if the clean wood ash could be returned back to its source, technical application of ash to the forest need improvements
- Considering responsible stewardship (toward the forest ecosystem), harvest of logging residues is possible when places with a lot of residues are left in the forest at 40-50 m distance (stepping stones) or when management is aiming at more poor site conditions in order to create chances for specific forest types
- The economic feasibility of harvesting logging residues in the Netherlands depends on well tuned planning and adjusted harvesting practises. Logging residues should not be used as pavement on the skid tracks and logging residues should be pre-concentrated and piled, together with the logs
- Harvesting and processing in the Netherlands *on site* is only feasible in large scale clear cut situations
- Harvesting logging residues from thinning and small scale clear cuts is economically feasible when the material is removed, dried and processed elsewhere. With drying, the net heat value will increase dramatically and with large scale processing, material can be screened from small parts, stones and sand in order to produce high quality bio-fuel

[67] Boomrooierij Weijtmans, pers. com.
[68] Jonsell et al., 2007

References

Andersson, L.I., and H. Hytteborn, 1991. Bryophytes and decaying wood – a comparison between managed and natural forest. *Holarctic ecology* 14: 121-130

Augusto, L., J. Ranger, Q. Ponette and M. Rapp, 2000. Relationships between forest tree species, stand production and stand nutrient amount. *Annals of Forest Science* 57: 313-324

Åström, M., 2005. Effects of slash harvest on bryophytes and vascular plants in southern boreal forest clear-cuts. *Journal of Applied Ecology* 42: 1194-1202

Baule, H., and C. Fricker, 1967. *Die Düngung von Waldbäumen.* München.

Bergquist, J., G. Örlander and U. Nilsson, 1999. Deer browsing and slash removal affect field vegetation on south Swedish clearcuts. *Forest ecology and management* 115: 171-182

Bijlsma, R.J., 2005a. Natuurlijkheid en biodiversiteit: een verstoorde relatie. Vakblad Bos, Natuur, Landschap 2 (2): 7-11

Bijlsma, R.J., 2005b. Dood hout, habitatdiversiteit en mossen. In: *Jagers op Akkerhuis G.A.J.M., S.M.J. Wijdeven, L.G. Moraal, M.T. Veerkamp & R.J. Bijlsma, 2005. Dood hout en biodiversiteit. Een literatuurstudie naar het voorkomen van dood hout in de Nederlandse bossen en het belang ervan voor de duurzame instandhouding van geleedpotigen, paddenstoelen en mossen*. Alterra-rapport 1320. Wageningen.

Dirkse, G.M., W.P. Daamen, H. Schoonderwoerd, J.M. Paasman, M. Japink, M. van Jole, R. van Moorsel, P. Schnitger, W.J. Stouthamer, M. Vocks, 2007. *Meetnet Functievervulling bos 2001-2005.* Vijfde Nederlandse Bosstatistiek. Expertise centrum LNV, rapportnr 2007/065, Ede, 95pp.

Egnell, G., and B. Leijon, 1997. Effects of different levels of biomass removal in thinning on short-term production of Pinus sylvestris and Picea abies stands. *Scandinavian Journal* 12 (1): 17-26

Gigler, J., 2000. *Drying of willow biomass in supply chains*. Wageningen.

Grove, S.J., 2002. Saproxylic insect ecology and the sustainable management of forests. *Annual Review of Ecology and Systematics* 33: 1-23

Hansen, H., 2007. *Marktùbersicht Hackschitzel Heitzungen.* Fachagentur Nachwachsende Rohstoffe e. V. Gùlzow Germany

Hepperler, F., 2006. Prognoses regionaler energieholzpotentialer. *FVA Einblick*. 3.

Hjältén, J., T. Johansson, O.Alinvi, K. Danell, J.P. Ball, R. Pettersson, H. Gibb, J. Hilszczański, 2007. The importance of substrate type, shading and scorching for the attractiveness of dead wood to saproxylic beetles. *Basic and Applied Ecology* 8 (4): 364-376

Jagers op Akkerhuis G.A.J.M., S.M.J. Wijdeven, L.G. Moraal, M.T. Veerkamp & R.J. Bijlsma, 2005. *Dood hout en biodiversiteit. Een literatuurstudie naar het voorkomen van dood hout in de Nederlandse bossen en het belang ervan voor de duurzame instandhouding van geleedpotigen, paddenstoelen en mossen*. Alterra-rapport 1320. Wageningen.

Jonsell, M., J. Hansson and L. Wedmo, 2007. Diversity of saproxylic beetle species in logging residues in Sweden – Comparisons between tree species and diameters. *Biological conservation* 138: 89-99

Kanzian., C., 2005. *Bereitstellung von Waldhackgut Verfahren Energieholzbundel im Gebirge.* Institut für Forstechnik, Vienna Austria.

Karlsson, M., U. Nilsson and G. Örlander, 2002. Natural regeneration in clear-cuts. Effects of scarification, slash removal and clear-cut age. *Scandinavian Journal of Forest Research* 17: 131-138

Kofman, P.D., and T. Kent, 2007. *Harvesting and processing forest biomass for energy production in Ireland.* COFORD, National Council for forest research and development, Dublin Ireland.

Kramer, P.J., and T.T. Kozlowksi, 1960. *Physiology of trees*. McGraw-Hill Book Company, USA.
Kruys, N., and B.G. Jonsson, 1999. Fine woody debris is important for species richness on logs in managed boreal spruce forests of northern Sweden. *Canadian Journal of Forest Research* 29: 1295-1299
Küffer, N., and B. Senn-Irlet, 2004. Influence of forest management on the species richness and composition of wood-inhabiting basidiomycetes in Swiss forests. *Biodiversity and Conservation* 14: 2419-2435
Kuiper, L., and J. Oldenburger, 2006. *The harvest of forest residues in Europe.* BUS ticket D15a.
Mills, S.E., and S.E. MacDonald, 2005. Factors influencing bryophyte assemblage at different scales in the western Canadian boreal forest. *The Bryologist* 108 (1): 86-100
Miyata, D., Y. Suzuki, J. Goto, 2006. Natural Drying of Logging Residue Stems along a Forest Road and on a Paved Landing. *Journal of the Japanese Forest Society*
Moller, I.S., 2000. Calculation of biomass and nutrient removal for different harvesting intensities. *New Zealand Journal of Forestry Science* 30 (1): 29-45
Moos, A. von, 2006. Äste sinvoll nutzen statt teuer entsorgen*. Wald und holz 1*
Moraal, L.G., 2005. Dood hout en geleedpotigen. In: *Jagers op Akkerhuis G.A.J.M., S.M.J. Wijdeven, L.G. Moraal, M.T. Veerkamp & R.J. Bijlsma, 2005. Dood hout en biodiversiteit. Een literatuurstudie naar het voorkomen van dood hout in de Nederlandse bossen en het belang ervan voor de duurzame instandhouding van geleedpotigen, paddenstoelen en mossen*. Alterra-rapport 1320. Wageningen.
Nordén, B., M. Ryberg, F. Götmark and B. Olausson, 2004. Relative importance of coarse and fine woody debris for the diversity of wood-inhabiting fungi in temperate broadleaf forests. *Biological Conservation* 117: 1-10
Nord-Larsen, T., 2002. Stand and site productivity response following whole-tree harvesting in early thinnings of Norway spruce (Picea abies (L.) Karst.) *Biomass and bioenergy* 23: 1-12
Nurmi J. and Hillebrand K. 2005. *The characteristics of whole tree fuel stocks from silvicultural cleanings and thinnings.* Finnish Forest Research Institute Kannus Finland
Olsson, B.A., and H. Staaf, 1995. Influence of harvesting intensity of logging residues on ground vegetation in coniferous forests. *Journal of Applied Ecology* 32: 640-654
Pels, J.R., D.S. de Wie, W.J.J. Huijgen and J.H.A. Kiel, 2004. *Askwaliteit en toepassingsmoge-lijk heden bij verbranding van schone biomassa (BIOAS).* ECN.
Pitman, R.M., 2006. Wood ash use in forestry – a review of the environmental impacts. *Forestry* 79: 563-588
Rohrmoser, C, and K. Stampfer, 2003. *Optimierung der Bereitstellungskette vond Waldhackgut.* Austria.
Rosenberg, O., and S. Jacobson, 2004. Effects of repeated slash removal in thinned stands on soil chemistry and understorey vegetation. *Silva Fennica* 28(2): 133-142
Rummer, B., D. Len, and O. O'Brien, 2004. *Forest residues bundling project.* US forest service Auburn Alabama*.*
Similä, M., J. Kouki and P. Martikainen, 2003. Saproxylic beetles in managed and seminatural Scots pine forests: quality of dead wood matters. *Forest Ecology and Management* 174: 365-381
Tolkamp, G.W., C.A van den Berg, G.J. Nabuurs & A.F. Olsthoorn, 2006. *Kwantificering van beschikbare biomassa voor bio-energie uit Staatsbosbeheerterreinen.* Alterra-rapport 1380. Wageningen.
Van Dort, K., and A. van Hees, 2001. *Mossen en vaatplanten op dood beukenhout in bosreservaat Kersselaerspleyn.* Alterra-rapport 418. Wageningen
Veerkamp, M.T., 2005a. *De diversiteit van paddestoelen in het Nederlandse bos.* Alterra-rapport 1157, Wageningen.

Veerkamp, M.T., 2005b. Dood hout en paddestoelen. In: *Jagers op Akkerhuis G.A.J.M., S.M.J. Wijdeven, L.G. Moraal, M.T. Veerkamp & R.J. Bijlsma, 2005. Dood hout en biodiversiteit. Een literatuurstudie naar het voorkomen van dood hout in de Nederlandse bossen en het belang ervan voor de duurzame instandhouding van geleedpotigen, paddenstoelen en mossen*. Alterra-rapport 1320. Wageningen.

Verscheure, P., 1998. *Energiegehalt von Hackschnitzeln.Überblick und anleitung zur Bestimmung.* Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg Abteilung Arbeitswirtschaft und Forstbenutzung. Freiburg

Wijdeven, S.M.J., 2005. Dood hout in het Nederlandse bos. In: *Jagers op Akkerhuis G.A.J.M., S.M.J. Wijdeven, L.G. Moraal, M.T. Veerkamp & R.J. Bijlsma, 2005. Dood hout en biodiversiteit. Een literatuurstudie naar het voorkomen van dood hout in de Nederlandse bossen en het belang ervan voor de duurzame instandhouding van geleedpotigen, paddenstoelen en mossen*. Alterra-rapport 1320. Wageningen.

Wijdeven, S.M.J., 2006. *Factsheets Dood hout in het bosbeheer.* Alterra-rapport 1430. Wageningen

Wiselius, S.I., 1994. *Houtvademecum.* Stichting Centrum Hout, Almere.

Background information

Kielder forest products Ltd., 2001. *Commercial woodchips storage and drying trials.* ETSU B/U1/00674/REP DTI/Pub URN 01/1175

Ioannidi, M., 2002. *Woodchips fuel supply chain: from forest to hopper*. Department of mechanical engineering. University of Strathclyde Glasgow.

Appendix

CEN/TS 14961 and the German Önorm M17133 compared.

Particle size distribution				
Önorm M17133	CEN/TS 14961			
Class	Class	Main fraction >80% of weight	Fine fraction <5% of weight	Course fraction max length
G30	P16	3,15-16mm	< 1mm	Max. 1% > 45 mm All < 85 mm
G50	P45	3,15-45mm	< 1mm	Max 1% > 63 mm
G100	P63	3,15-63mm	< 1mm	Max 1% > 100mm
	P100	3,15-100mm	< 1mm	Max 1% > 200mm

Moist content			
Önorm M17133	CEN/TS 14961		
Class	Class	Value in %	Remarks
W20	M20	<20%	Dried
W30	M30	<30%	Suitable for storage
W35, W40	M40	<40%	Suitable for limited storage
W50	M55	<55%	Not suitable for storage
	M65	<65%	Not suitable for storage

Ash content		
Önorm M17133	CEN/TS 14961	
Class	Class	Value in % of dry matter
A1 (<1%)	A0,7	≤0,7%
A2 (1-5%)	A1,5	≤1,5%
	A3,0	≤3,0%
	A6,0	≤6,0%
	A10,0	≤10%

Sulphur (only normative for chemically treated biomass and if sulphur containing additives have been used)		
Önorm M17133	CEN/TS 14961	
Class	Class	Value in % of dry basis
	S0,05	≤0,05%
	S0,08	≤0,08%
	S0,10	≤0,10%
	S0,20+	>0,20 (actual value to be stated)

Nitrogen (normative only for chemically treated biomass)		
CEN/TS 14961		
	Class	% of dry basis
	N0,3	≤0,3%
	N0,5	≤0,5%
	N1,0	≤1,0%
	N3,0	≤3,0%
	N3,0+	≥3,0% Actual value to be stated)

11

Oil palm for biodiesel in Brazil. A different picture?

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Introduction

Oil palm (African Oil Palm, *Elaeis guineensis* jacq.*)* is the most productive oil producing plant available. In recent years oil palm has overtaken soy oil as the largest oil crop in the World with an annual production of more than 30 million ton. Due to its high yields and low cost of production oil palm is also considered a prime source of biodiesel production.

In 2003 the EU introduced the Biofuels Directive (2003/30) which aims at replacing 5,75% of transportation fuels by biobased transportation fuels such as biodiesel and ethanol in 2010. MVO (2006) estimates that by 2010 the EU rape oil production will be 9,9 million tons while the EU demand for biodiesel will be 11,1 million tons and the food demand will be 2,9 million tons. This will lead to a production shortfall of 3,8 millions tons of oil (for biodiesel) which has to be compensated by imports. Fediol estimates a shortfall of 4,5 million tons by 2010 (MVO, 2006).

Brazil is seen as a potential source of oils for biodiesel production for the EU. The Netherlands would be an important port of entry for this imported biodiesel (or vegetable oils). It is therefore of interest to investigate what options there are to import sustainably produced vegetable oils for production of biodiesel in the coming years.

In Brazil oil palm is seen as an interesting and sustainable crop for production of oil for biodiesel. In many countries, notably is Southeast Asia, oil palm expansion is associated with tropical forest destruction and consequently large scale biodiversity loss and large emissions of Green House Gasses. Together with concerns about social issues in the producing areas this has led to the RSPO initiative to guarantee the sustainability of palm oil production. The RSPO is an organization of stakeholders that has developed sustainability criteria for palm oil production. At the same time in the EU, The Netherlands, The UK and Germany there are initiatives to develop and introduce sustainability criteria specifically for biofuels (and bioenergy in general). The Green House Gas balance of production and the impact on carbon stocks (soil, forest, peat, etc) will be important criteria which determine whether biofuels are considered sustainable.

The first impression is that sustainability issues of palm oil production in Brazil are not viewed negatively in Brazil. In Brazil palm oil production is small and the crop appears to be viewed favorably by NGO's. It is claimed that palm oil plantations can be used to recover degraded lands in Amazonas of which there are many millions of hectares.

Objective

The objective of this short report is to give an overview of Brazilian palm oil industry and the sustainability of Brazilian palm oil biodiesel production in the context of the worldwide debate on palm oil and the demand for biodiesel.

We will first analyse the local Brazilian biodiesel policies and demand. Then give an overview of current palm oil production in Brazil and try to answer the question why oil palm such a small crop is at this moment. We will then discuss sustainability of palm oil production in Brazil in referring especially to Greeghouse gas criteria formulated by The Roundtable on Sustainable Biofuels (http://cgse.epfl.ch/page65660.html).

The Brazilian biodiesel policy

Brazil is well known for its ethanol production for replacement of gasoline. In the past 30 years it has developed and optimised this option and made it into an expel for the rest of the world. The introduction of biodiesel to replace diesel has only started very recently.

In 2004 Brazil launched the National Program of Production and Use of Biodiesel (PNPB). The goals are:

- The production and use of biodiesel in a sustainable way, including positive social inclusion;
- The warranty of competitive prices, quality and supply;
- The diversification of raw material and areas of production

Other drivers encountered were:

- Soy oil (is/was) a by-product of protein production
- Biodiesel is an option in isolated areas (18 % of diesel is used for electricity production, often in isolated areas where access to the grid is not possible and where diesel supply is costly)

In 2005 a Federal Law (11.097, January 13, 2005) was passed which creates the Brazilian Biodiesel Production and Utilization Program. It includes a mandatory blend of 5% biodiesel to petrodiesel in 2013, with an intermediary blend of 2% in 2008. This will require 840 million liters of biodiesel in 2008 and 2,4 billion liters of biodiesel in 2013. With current high vegetable oil prices it may prove hard to achieve this goal. As Brazil intend to satisfy its own demand for biodiesel export options may be limited in the short run.

At the same time a law has been passed (11.116/2005) which defines a Federal biodiesel taxation policy and creates the "Social Fuel Certificate". It essentially means that biodiesel production in poor dry areas in the North and Northeast are partially exempted from federal taxes on diesel (Normal Federal Tax = R$ 218 / m3 (~ US$ 100 / m3):[1]

- 31% tax reduction: castor / palm oils + agribusiness producers in North, Northeast or "Semi-arid" Area
- 68% tax reduction: small farm producers in any country region with any oilseed
- 100% tax reduction: castor / palm oils + small farm producers in North, Northeast or "Semi-arid" Area

So the Brazilian biodiesel programme has only started very recently and one of its min drivers is social. The main feedstock option for the short term is soy which has a 87 % share in Brazilian vegetable oil production (in 2005). Still soy has to be considered mostly as a protein crop with less than 500 l of oil per ha per crop. There are some annual crops that may be used such as rape in the south, sunflower and ricinus. Still, these are often more expensive or limited in production potential. It is believed that perennial crops such as Jatropha and oil palm may offer higher yields and better returns. Palm oil may be a small crop in Brazil at the moment, it appears to have a large potential in Brazil. Furthermore knowledge of agronomic aspects and the total production chain is well established making fast expansion possible. At this moment the only known biodiesel production from palm oil in Brazil is the at the Agroplama oil refinery in Belem which converts free fatty acids, which were previously not used, into biodiesel.

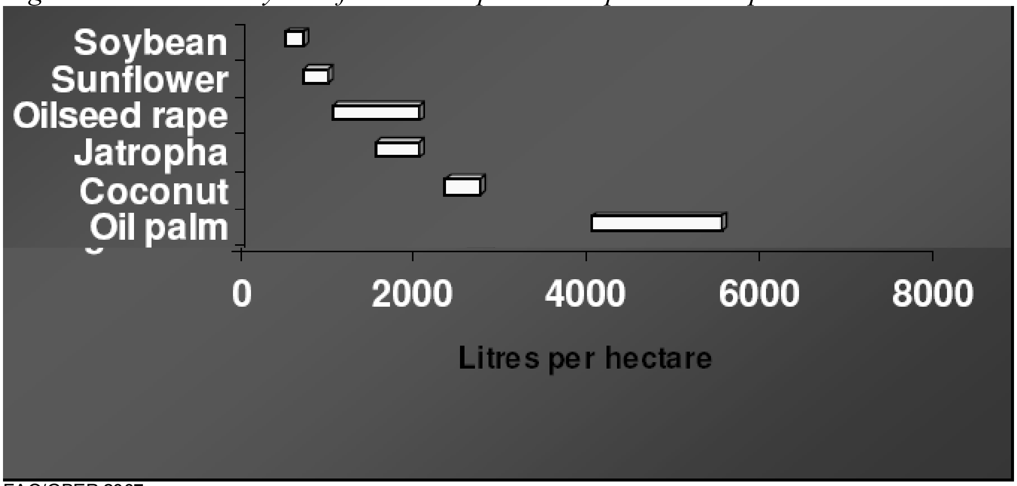
Oil palm in Brazil

Oil palm is the most productive oil crop currently available. Yields of 4 tons oil per ha per year are common under well managed conditions (see Figure 1). Yields of up to 8 tons of oil per ha are possible. It is no surprise that oil palm has become the leading oil crop in the world with an annual

[1] Ref: Embrapa, 2007

production of more than 30 million tons. Due to its high yields and low cost of production oil palm is also considered a prime source of biodiesel production.

Figure 1. common oil yields for some important tropical oil crops.



FAO/GBEP 2007

Oil palm requires a average temperature between 24°and 28° C, precipitation (mm/yr): 1800 a 2000 mm/year and radiation of 1500 – 1800 hours/yr (Embrapa Amazonia Oriental). The range of adaptation in the World for palm oil is shown in Figure 2. Brazil probably has the largest potential area for palm oil production in the World. At the moment palm oil production is concentrated only in a few areas in the state of Para and near the Northeast Coast. Estimates of the actual area that is potentially available for palm oil production in Brazil ranges varies widely from 20 million ha as mentioned by Kaltner et al., 2005 to 7 million ha by Gazzoni, 2007. Kaltner et al. (2005) reports that some 3 million ha of degraded /altered is available in the short run where basic infrastructure is available for palm oil production. This is necessary as oil palm requires processing within 24 hours of harvesting and needs a scale of more than 1000 ha of plantation area to be economically viable.

In all cases oil palm is seen as an option for recovering degraded and abandoned land. The land has been abandoned after clear cutting followed by production of crops and/or grazing for a few years without sufficient inputs leading to degradation. The factors leading to deforestation followed by unsustainable use common in the Amazon are complicated and involve government regulations and upholding them, human pressure, poverty, disputed land tenure, lack of lack of access to credit, etc. In this short study we cannot elaborate on this, though it clearly is of much importance if we want to determine the potential to produce palm oil for biodiesel in Brazil in a sustainable way.

In table 1 current palm oil area, productivity and production of palm oil in Brazil is shown. It is clear that Agropalma and its associated producers is the dominant company in production of palm oil in Brazil. It also possesses the only palm oil refinery in Belem (PA). A larger share of young plantations (expansion, a lack of data and suboptimal production systems may explain the relatively low productivity of 2,58 tons per ha.

Figure 2. Land suitable for oil palm production in the world.

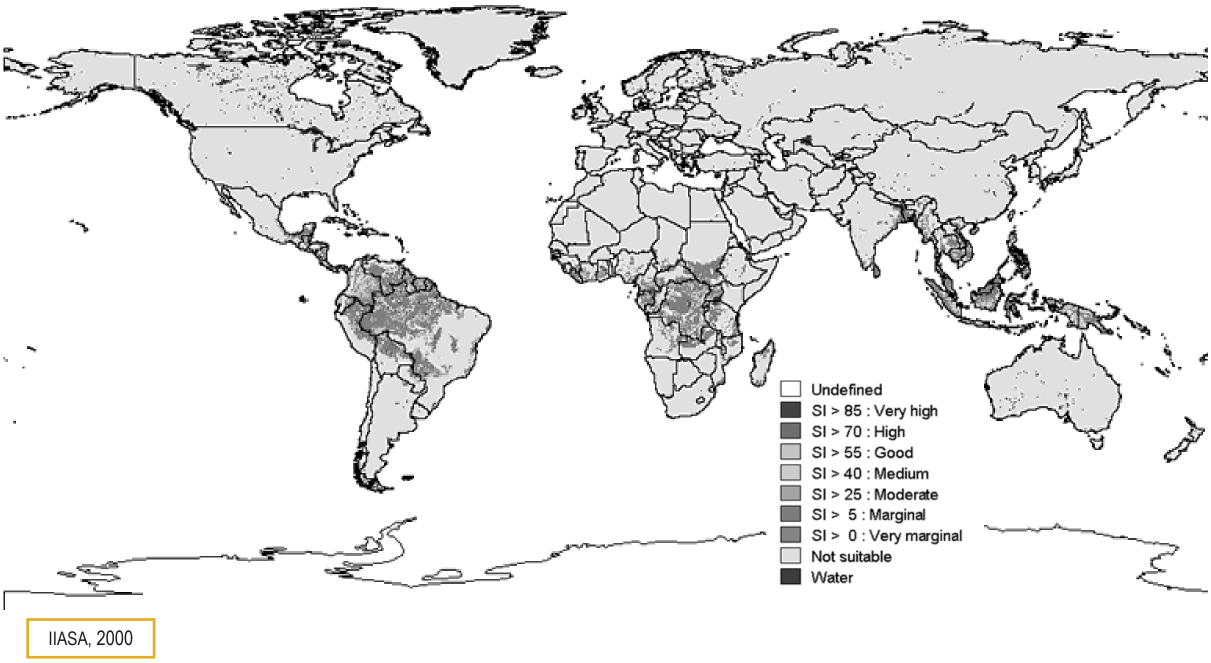


Table 1. Brazilian palm oil area, production and imports (Palmasa, 07/2007; http://www.neac.gov.my; FAOstat)

	2007	2007	2007
	Area (ha)	Productivity Ton oil/ha	Production ton CPO+PKO
Para			
Agropalma and dependent producers	33198	3.96	131400
Other producers (7)	20000	1.69	33850
Bahia	1400	?	9000
Amazonas	6510	?	?
Total	67453	2.58*	174250

Despite the large potential production area palm oil production in Brazil does not even cover local demand. At this moment Brazil is importing increasing amounts of palm oil. In 2005 39.000 tons CPO (crude palm oil) and 42.000 tons of PKO (palm kernel oil) were imported (*Palmasa, 07/2007; http://www.neac.gov.my; FAOstat)*. The demand for trans-fat free products has increased demand for palm oil in Brazil.

Palm oil production cost estimates for Brazil have been made (Kaltner et al., 2005). He reported production costs for palm oil in Brazil of just over 250 $ per ton which was slightly higher than for soy oil in Brazil or palm oil in Indonesia and Malaysia. Still, the cost price of palm oil in Brazil appears only marginally higher than for soy oil or for palm oil produced in Southeast Asia.

Why is palm oil such a small crop in Brazil?

Brazil is a net importer of palm oil and palm oil products even though it has the largest area suitable for the cultivation of oil palm in the world (Figure 2). This strange contradiction begs the question why there is so little palm oil production in Brazil. In interviews with several people involved the following reasons were given for the very small area of palm oil plantations in Brazil:

- Most “suitable areas” are still covered with natural vegetation – Only degraded areas should be considered an option for palm limiting actually available land area.

- Soy is cheap to produce in Brazil and soy oil has until recently been very cheap because the soy protein has been the driver for production and export. This has made palm oil relatively uncompetitive compared to soy. Opportunity costs are high – other investments have a better return.

- Palm oil production is not a tradition in Brazil. Large scale production near Belem did not start not until 1970’s.

- Land tenure in Para and many areas of Brazil is often unclear and can easily lead to land disputes. If the ownership of land on which a plantation has been established is disputed successfully a large investment is lost. This makes establishing palm oil plantations costly and potentially risky.

- Establishing a palm oil plantation requires a large investment which takes at least 4 to 5 years before it starts delivering revenues. This requires access to capital or loans which together with the risks are often not possible at a reasonable interest.

- Official labour costs were reported to be high compared to competing countries. Since Palm plantations require a large centralised organisation with a large work force official wages and costs have to be incurred.

- Not all the land owned can be used for palm production. Regulations exist that require 50 to 80% of land has to be maintained as forest) in the Amazon. As an example Agropalma owns >120.000 ha of land of which some 37.500 ha are planted with oil palm plantations. The other remaining area is managed as a forest reserve (adding to the total cost)

Palm oil offers the option for production of margarine without hydrogenation and production of trans fats. This has contributed to the demand for palm oil also in Brazil.

Sustainability of the Brazilian palm oil system

During a visit to Belem it was confirmed that palm oil plantations are generally viewed much more favourable by NGO’s (personal communication Conservation International and Instituto Peabiru, November 1, 2007) than most other activities in the Amazon. Currently palm oil plantations are mostly limited to the large Agropalma plantation in Tailândia in the state of Para and a limited number of farmer cooperatives such as the one in Tome Acu. Generally NGO concern was mostly focused on illegal logging for timber and for charcoal production. Also the cattle breeding and the pressure on land is seen as very negative. Expansion of palm oil plantations was not mentioned as problematic at the moment (November 2007).

At the end of 2007 it was observed that new large scale palm plantations were being implemented south of Belem. This was thought to be in view of the Brazilian demand for biodiesel which cannot depend on soy oil as local demand for biodiesel will increase to 2,4 billion litres of biodiesel per year in 2013.

In order to evaluate sustainability of biofuels criteria are being developed both nationally and internationally. (Cramer, 2006; The Roundtable on Sustainable Biofuels, 2007). These criteria are still under development and need to be operationalised. See Annex 1 for the criteria formulated by the Round table on Sustainable Biofuels.

Apart from the specific sustainability for biofuels the already mentioned RSPO criteria should be relevant. We should be able to assume that for sustainability of plam oil is guaranteed if a plantation complies with RSPO sustainability criteria. These criteria have been established and are being implemented. Agropalma expected to be RSPO certified in 2008 (pers. Comm.. Agropalma, 2007) as one of the first companies in the world. This would mean that most of the Brazilian palm oil could be RSPO certified in 2008.

Does that mean that Brazilian palm oil also is a sustainable biodiesel option?

Greenhouse effect of expansion of palm oil for biodiesel production

The most important difference between RSPO certification and Biofuels certification, which is being developed in Europe, (Cramer, 2006; The Roundtable on Sustainable Biofuels, 2007) is the demand for a positive GHG balance.

The Roundtable on Sustainable Biofuels (http://cgse.epfl.ch/page65660.html) (see annex 1) has formulated the criteria on GHG effects as follows:

"3. Biofuels shall contribute to climate stabilization by reducing GHG emissions as compared to fossil fuels. Emissions shall be estimated via a consistent approach to lifecycle assessment, with system boundaries from "root to tank". This shall include direct and indirect GHG emissions, for instance from fossil energy used in growing, transporting and processing biofuels. It shall also include GHG emissions resulting from land use changes as land is converted to biofuel crop production, or as other production is displaced."

In our opinion this means that we want to establish:

1. The GHG efficiency of the whole production chain. This includes the whole chain from field production to delivery of biodiesel to the consumer in Europe.
2. The GHG effect of land converted directly for the plantation.
3. The indirect GHG effect resulting from indirect competition for land and land conversions. This is also referred to a leakage.

With respect to 1, GHG efficiency of the whole chain; it has been proven sufficiently that palm oil production (for biodiesel) can have a very positive GHG balance. Fargione et al., 2008 assume a GHG saving per ha of 7,1 tons of CO2 per year when palm oil is used for biodiesel production. It is assumed that certain measures are taken in the production chain in order to avoid GHG emissions (Wicka et al., 2007). They include utilising secondary by-products for powering the extraction plant, avoiding methane emissions from POME (palm oil mill effluent) and recycling nutrients to the fields (Elbersen et al., 2005).
We observed that at the largest Agroplama FFB (fresh fruit bunch) processing plant in Thailandia by-products such as shells and fibre were being used for steam production for the processing plant and electric energy production. Anaerobic digestion of POME was or would become available. Empty fruit bunches were recycled to fields, thus returning nutrients to the plantation. This shows that at least at the largest FFB processing plant in Brazil requirements for a positive GHG balance (of the production chain) of palm oil biodiesel are largely in place.

With respect to 2, the GHG effect of land converted directly for the plantation; Current plantations have been converted from forest many years ago and we can assume that recent and future plantations have been or can be established on "degraded land". The conversion of this degraded land will generally have a positive GHG effect within a relatively short period of time. This is also reported by Wicka et al. (2007) for conversion of degraded lands to plam oil plantations in Southeast Asia.

With respect to 3, the indirect GHG effect resulting from indirect competition for land and land conversions; things are not completely clear.

If palm oil from current plantations in Brazil is used for biodiesel production it will be in competition with food and other applications. This will likely result in more imports into Brazil of palm oil. Under the current high prices this is very likely to lead to expansion of palm oil production somewhere else in the world which is likely to lead to GHG effects which take many years to compensate for as is argued by Fargione el al (2008).

In order to avoid this, biodiesel should be produced on new palm oil plantation which have been establsied on degraded and otherwise not used land, as has been argued by Dehue (2005). This will take at least 5 years to give yields. As argued above (2) it should be possible in Brazil to establish these new plantations for biodiesel on "degraded lands" avoiding unacceptable GHG emissions. Still long term conversion from "degraded land" into palm oil plantation makes this land unavailable for 25 to 30 years. What would have been the use of these degraded lands in the coming 30 years? Could they have been upgraded for food production? Could it have accumulated biomass as a secondary forest?

Rules and regulations to protect the Amazon and rules and regulations that stimulate economic development are quite complicated and often counteract each other. An analysis of the rules, regulations and forces economic and social factor behind deforestation in the Amazon are far too complex to discuss in this short report.

Conclusions
Palm oil production is currently very small in Brazil. At the same time potentials are very large. Expansion on degraded lands should be possible in a sustainable way according to RSPO criteria.

The GHG balance of palm oil biodiesel should be considered positive if an unutilised by-products, such as free fatty acids, are used as a feedstock. Large scale dedicated production of biodiesel from palm oil will require establishment of new palm oil plantations if the GHG balance is to be positive. The direct effect of establishment of new palm oil plantations on degraded land should have a positive GHG balance if precautions are taken. Indirect (GHG) effects of the conversion of degraded lands in the Amazon into palm oil plantations are hard to predict and need to be evaluated in order determine if and how indirect GHG effects of using these lands can contribute to reducing GHG emissions in the long term compared to using fossil diesel.

Literature

Dehue, B. (2006). Palm oil and its by-products as a renewable energy source: Potential, sustainability and governance. Environmental Policy Group, Social Science Group. Wageningen, the Netherlands, Wageningen UniversityMSc. Thesis.

Elbersen, H.W.; Dam, J.E.G. van; Bakker, R.R. (2005). Oil palm by-products as a biomass source : availability and sustainability. Paris, France : Agrotechnology & Food Innovations, 14th European biomass conference & exhibition : biomass for energy, industry and climate protection.

Gazzoni, D. 2007. EMBRAPA presentation "Overview of the Brazilian biodiesel industry.: Present status and perspectives"at the Workshop on "Biodiesel from Brazil; Technology and sustainability" in The Hague, November 19th.

Kaltner et al., 2005. Biofuels for transportation in Brazil.

MVO, 2006. Market analysis Oils and fats for fuels. 2006. Product board for Margarine, fats and oils. June 2006.

Wicke, B., V. Dornburg, A. Faaij, M. Junginger. 2007. A greenhouse gas balance of electricity production from co-firing palm oil products from Malaysia. Tech. Report No. NWS-E-2007-33. (Copernicus Institute, Utrecht University, 2007).

Annex 1: Principles on Sustainable Biofuel Production

http://cgse.epfl.ch/page70341.html (Temporary version approved by the RSB Steering Board in October 2007).

Legality
1. Biofuel production shall respect all applicable laws of the country in which they occur, and all international treaties and agreements to which the country is a signatory.

Consultation
2. Biofuel projects shall arise through fully transparent, consultative and participatory processes that involve all relevant stakeholders.

Climate Change and Greenhouse Gas
3. Biofuels shall contribute to climate stabilization by reducing GHG emissions as compared to fossil fuels. Emissions shall be estimated via a consistent approach to lifecycle assessment, with system boundaries from "root to tank". This shall include direct and indirect GHG emissions, for instance from fossil energy used in growing, transporting and processing biofuels. It shall also include GHG emissions resulting from land use changes as land is converted to biofuel crop production, or as other production is displaced.

Human and Labor Rights
4. Biofuel production shall not violate human rights or labor rights, and shall ensure decent work and the well-being of workers.

Socio-economic Development
5. Biofuel production shall not violate land or water rights, and shall contribute to the social and economic development of local, rural and indigenous peoples and communities.

Food Security
6. Biofuel production shall not impair food security.

Conservation and Biodiversity
7. Biofuel production shall not directly or indirectly endanger wildlife species or areas of high conservation value. "Biofuel production should avoid negative impacts on biodiversity and areas of High Conservation Values".

Soil
8. Biofuel production shall not directly or indirectly degrade or damage soils.

Water
9. Biofuel production shall not directly or indirectly contaminate or deplete water resources.

Air
10. Biofuel production shall not directly or indirectly lead to air pollution.

Biotechnology
11. If biotechnologies are used in biofuels production, they shall improve the social and/or environmental performance of biofuels, and always be consistent with national or international biosafety and

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Agro-economics and biofuel

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Agricultural Economics Research Institute, The Hague.
Date: November, 2007

1. Introduction

Global biomass potentials

There is a worldwide orientation on the possibilities to produce fuels on the base of biomass. It helps to reduce the CO2-emission, as a renewable source it reduces the depletion of sources and the dependence of political instable systems is less. The expectations for bio-energy are high. Targets for bio energy in many national policies are ambitious, reaching 20-30% of total energy demand in various countries.

Current global energy supplies are dominated by fossil fuels (388 EJ per year), with a much smaller contribution from biomass (45 ± 10 EJ). However, biomass is by far the most important renewable energy source used. The contribution of biomass is the highest in the developing countries (20-30%), most of it non-commercial uses. In the industrialised countries biomass contributes less than 10% to the total energy supplies. Commercial energy production from biomass for industry, power generation, or transport fuels makes a lower contribution: some 7 EJ per year in 2000. This share is growing. Biofuels, mainly ethanol produced from sugar cane, corn and cereals, and to a far lesser extent biodiesel from oil-seed crops, represent a modest 1.5 EJ (about 1.5%) of transport fuel use worldwide. Global interest in transport biofuels is growing, particularly in Europe, Brazil, North America and Asia (most notably Japan, China and India). Global ethanol production has more than doubled since 2000, while production of biodiesel, starting from a much smaller base, has expanded nearly threefold. (Lysen and Van Egmond, 2007)

Bio-energy seems to have a huge potential. Lysen and Van Egmond (2007) have analysed several studies. Studies show energy farming on current agricultural (arable and pasture) land could, with projected technological progress, contribute 100 - 300 EJ annually. Then the agricultural sector could also meet the demands of world's future food. Some 200 EJ in 2050 could be produced at rather low production costs (in the range of 2 €/GJ), acoording to Hoogwijk (2005b). This amount could be produced by perennial crops. Less energy (100 EJ) could be produced from biomass on marginal and degraded lands, resulting in biomass with higher production costs. Regenerating such lands requires more upfront investment, but competition with other land-uses is less of an issue and other benefits (such as soil restoration, improved water retention functions) may be obtained, which could partly compensate biomass production costs. When using the more average potential estimates, organic wastes and residues there could be another 40-170 EJ produced on biomass, with uncertain contributions from forest residues and potentially a significant role for organic waste, especially when bio-materials are used on a larger scale. [Smeets, et. al., 2007].

Global biomass potentials vary widely, see figure 1. The high biomass potential for 2050 determined by Smeets et al. (2007) shows potentials under intensive, very high technologically developed agriculture. On the contrary, the low biomass potential for 2050 calculated by Wolf et al. (2003) is caused by high population growth, high food demands and extensive agricultural production systems. The study of (Hoogwijk et al. 2005) refers to production of energy crops on abandoned, marginal and rest land assuming global and regional trends as described in the IPCC SRES scenarios, under increasing agricultural efficiency over time Finally, the study of Rokityanski et al. (in press) determines economic potentials of afforestation and reforestation, excluding other types of biomass and assuming extensive forestry management. As a result, the economic potentials for 2100 are rather low.

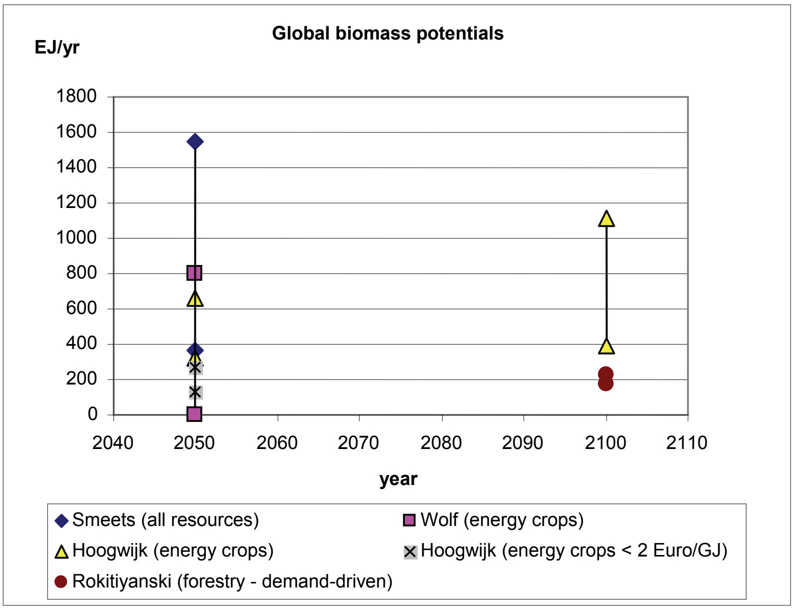

Figure 1: Ranges of estimated global biomass potentials
Source: Lysen and Van Egmond, 2007

Lysen and Van Egmond (2007) assessed the potential studies and concluded that none of al the studies done yet, do include all critical aspects. One of the important issues that remain unresolved are, of which the impact of large-scale biomass production on the prices (and subsequently) demands of land and food can be mentioned.

This paper focuses on the economics of biomass and bio-energy. Agrimarkets and energy markets have an influence on the feasilibility of biofuels on four points:

- Oil prices determine the feasibility of bio-energy in two ways:
    - The cost price of biofuel – due to the energy required for the production of biofuel and
    - The price for biofuel made by biomass – competing with fossil oil.
- Agrimarkets determine the feasability of bio-energy in two ways:
    - The price of the feed stock and
    - The price of by products for feed.

This paper discusses the four points of interaction.

2. Oil prices and feasibility of biofuels

Higher oil prices affect world markets for agricultural products in two ways, namely (a) higher production costs of agricultural products and (b) more production of biofuels.

The influence of oil prices on production costs of biomass
Concerning the influence of oil prices on cost price of biomass the OECD-study is relevant. According to the OECD (2006) the share of energy costs in total production costs is 25 to 43%. Furthermore, energy is required in the processing phase. Urbanchuk (2006) calculates a contribution of 25% of the cost price due to the use of electricity and natural gas.

The influence of oil prices on biofuel business
Concerning, the influence of oil prices on market prices for biofuel a number of studies can be mentioned. Figure 3 and 4 give the threshold oil prices for the bio-ethanol and biodiesel at which they are competitive to the petroleum based fuels. The figures show that Brazil is the only producer able to produce at lower costs than the marketprice of petrol-based gasoline in 2004 (USD 39 per barrel). However – when expressed in USD per litre of gasoline equivalent (taken into account

the differences in the energy content) – the production costs of bio-ethanol based on maize is higher than the price of gasoline (without taxes) in 2004 (USD 39 per barrel). It would be competitive at a price of USD 44 per barrel. For bio-ethanol based on wheat or sugar beets from EU, Canada and USA the threshold price is higher: up to 60 USD per litre of gasoline equivalent. For the Canadian bio-ethanol from wheat the threshold price is even 140 USD per litre. Bio diesel production costs are almost 1,5 to 2 times the oil-based diesel price net of tax in 2004 (USD 39 per barrel). Bio diesel is competitive at a higher threshold price than bio ethanol. The Canadian bio diesel is competitive at a oil price of 60 USD per litre, but the other bio diesels from EU, USA and Brazil are less competitive. The oil price has to rise to the level of 80-90 USD per litre to be competitive.

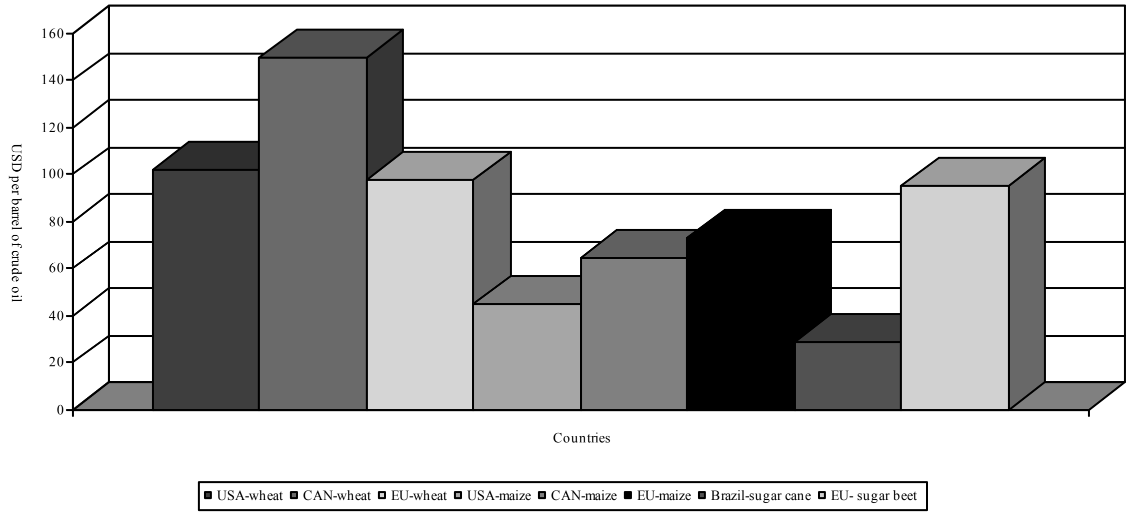

Figure 2: Threshold oil price at which bio-ethanol is competitive, in USD per barrel
Source: OECD, 2006

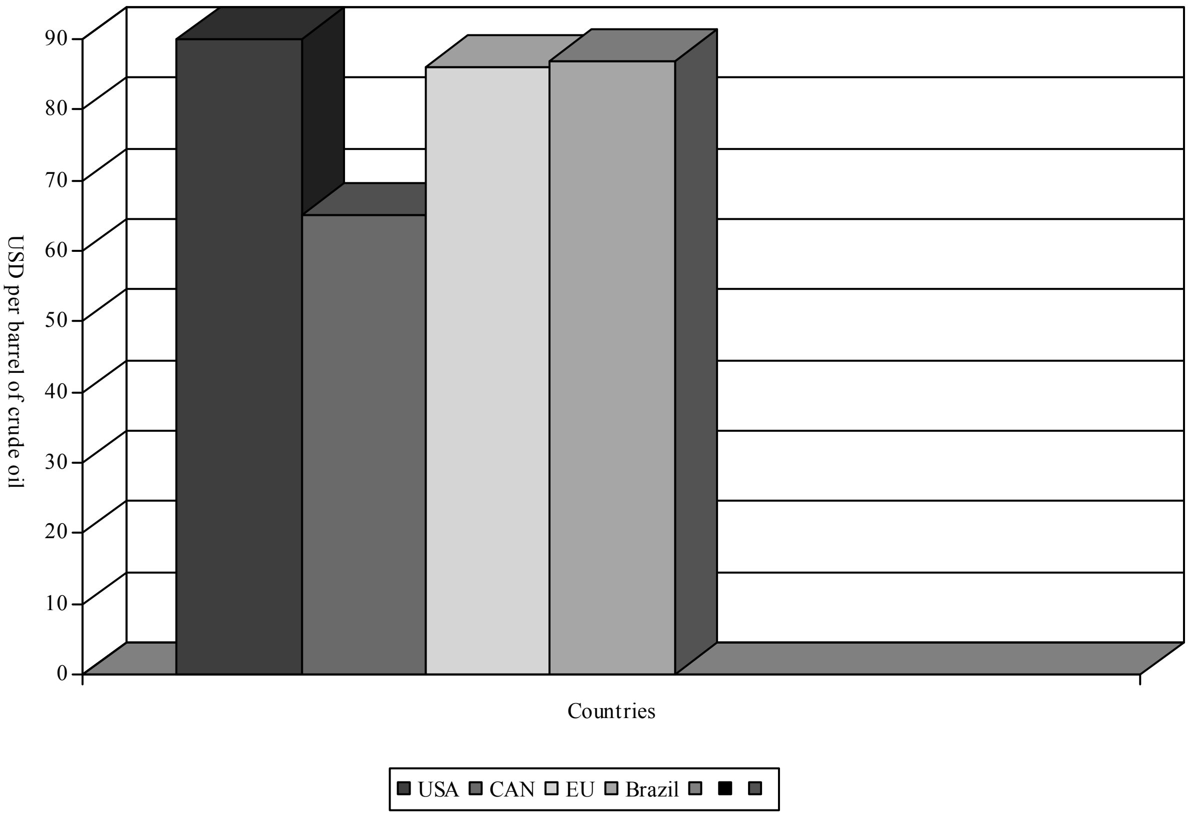

Figure 3: Threshold oil price at which bio-diesel is competitive, in USD per barrel
Source: OECD, 2006

Nowicki *et al*. (2007) have analysed the impact of the EU biofuel directive on the European agricultural and rural economy on the horizon of 2020. The results of this study (Scenar2020) indicate that crop production for biofuel purposes (including cereals, sugar and oilseeds) will increase in the coming 15 years in the EU even without the implementation of the mandatory blending obligation imposed by the EU biofuel directive. Under this scenario crop production expands in all regions of the EU and contribute 3.6 percent of total fuel consumption for transportation. Nowicki *et al.* (2007) conclude that the major uncertainty with regard to all conclusions concerning the future of biofuels is the tightness of oil/energy markets. Therefore any scenario result depends on the assumption made on future development of crude oil price[1]. Banse and Grethe (2006) come to the same conclusions. Sweden together with Germany and the Czech Republic are EU-countries with the highest share in the use of biofuels in transportation. Under a scenario which assumes no mandatory blending the use of biofuels in transportation will increase endogenously due to changes in relative prices (prices of bio-based crops versus crude oil). It becomes clear that even without a mandatory blending the share of biofuels use in transportation increases significantly. The OECD-study (2006) also mentions the importance of the crude oil prices. They expect a higher biofuel production under unchanged policies and higher crude oil prices. However, the degree to which biofuel quantities would increase strongly depends on parameters that are yet unobserved. The FAPRI-Outlook (2006) explains the increased price of ethanol by the increased demand for ethanol and the high gasoline prices. Within the ethanol chain based on sugar-cane the influence of the gasoline price is also indisputable, according to Tokgoz and Elobeid (2006).

3. Production costs of biofuel

Production costs of bio-ethanol

The OECD-report "Agricultural market impacts of future growth in the production of biofuels" (2006) aimed to look at the economics of biofuel production. The study is based on available data on production technologies and costs; many assumptions has been made due to a lack of data. In the report the production costs of agricultural based fuels have been calculated for several countries. Those production costs have been compared (a) across countries and (b) to the oil-based fuel prices. The OECD mentions a "rough" estimation of the functional relationship between fuel prices, production costs and biofuel production. Table 1 gives the production costs of bio-ethanol based on agricultural feedstocks.

Table 1: Production costs of bio-ethanol based on wheat, maize, sugar cane and sugar beet, in USD per litre fuel

	Wheat	Maize	Sugar cane	Sugar beet
USA	0.545	0.289		
Canada	0.563	0.335		
EU-15	0.573	0.448		0.560
Poland	0.530	0.337		0.546
Brazil			0.219	

Source, OECD, 2006

The production costs of bio-ethanol vary widely. Firstly, they vary across regions. One can conclude that mainly for bio-ethanol based on maize the production costs vary between 0.289 USD per litre fuel in the USA up till nearly 155 % more in the EU-15. Secondly, they vary according to the feedstock that has been used. Using sugarcane in Brazil leads to production costs of 0.219 USD per litre fuel, while the used of wheat in the EU-15 leads to production costs of 260% more: 0.573 USD per litre fuel. The differences in production costs are not related to different cost prices of technology; they are based on the differences in costs of (a) feedstock, (b) energy used and (c) prices that are received for the co products from the production process. It is clear the costs of feed

[1] For this study an increase of crude oil price by 1.5% p.a. has been assumed. Therefore, the impact of biofuels on European agriculture may be under-estimated.

stock have a high impact. Another study underlies some of these conclusions. Table 2 also shows the costs of production of bio-ethanol in several countries. Again the difference between countries and between feed stock is clear. However, the final cost prices differ from table 1. For bio-ethanol based on USA-corn the cost price is lower, while for bio-ethanol based on EU-feed stocks (wheat as well as sugar beets) the cost price is higher. As the calculated method is not quite clear, it is difficult to explain the causes of the differences.

Table 2: Production cost of bio-ethanol based on several feed stocks from several regions in the world, in euro per litre

	Bio-ethanol based on US corn	Bio-ethanol based on EU sugar beet	Bio-ethanol based on EU wheat	Bio-ethanol based on Brazil sugar cane
Feedstock cost	0.20	0.23	0.25	0.06
Operating cost	0.11	0.23	0.20	0.08
Co-product credit	-0.10	0.00	-0.11	0.00
Capital repayment	0.04	0.00	0.09	0.04
Factory gate cost	0.26	0.45	0.42	0.18
Cost per gasoline-eq.litre*	0.38	0.68	0.64	0.27

*adjusted for the lower energy content of bio-ethanol
Source: International Energy Agency (2004)

According to Urbanchuk (2006) corn is the largest expence in the production of ethanol, representing about 57% of total ethanol production costs in 2006. McAloon *et al.* (2000) calculated the operation costs of a corn to ethanol process of a 25 MM gallon per year and concluded that the costs of the corn take 77% of the total production costs.

The studies show also the necessity to sell by products at good prices. Urbanchuk calculate a 11% contribution to the overall revenue and McAloon *et al.* (2000) figured out that the byproducts contribute 30% to the production costs.

Production costs of bio diesel
Table 3 show the production costs of bio-diesel based on vegetable oils. According to the OECD (2006) the production costs for bio-diesel are the lowest in Canada. His (2004) comes to a lower cost price of bio-diesel: 0.35 to 0.65 euro per litre (10.5 to 20 euro per GJ).

Table 3: Production costs of bio-diesel based on vegetable oil, in USD per litre fuel

USA	0.549
Canada	0.455
EU-15	0.607
Poland	0.725
Brazil	0.568

Source: OECD, 2006

The OECD (2006) concludes that the production costs for bio-diesel are within or close to the range of production costs for ethanol from wheat and sugarbeets. They are higher than the production costs for ethanol from maize and sugarcane. In the biodiesel production, the cost of raw materials i.e. vegetable oil makes up about a high share of the total production cost.

The importance of low prices of feed stocks and good sales of by products
Despite the differences in precise share, it's clear that feed stock cost are responsible for a huge part of the cost price. Furthermore, the sales of by products of corn-ethanol and by products of bio

diesel is important to compensate costs of production. Both displace corn and soybean meal in livestock ratios.

4. Agromarkets and the feasibility of biofuels

A huge area of biomass is required to meet policy goals
As illustrated in chapter 4 prices of feed stock and byproducts have a high impact on the feasilibity of biofuel. At the same time, these prices are influenced by the markets of biofuel themselves. Nowicki *et al.* (2007) find that meeting 10% of the EU energy requirements for transport in 2010 requires 43% of current land use for cereals, oilseeds, set aside and sugar beet. Meeting the 5,75% goal requires 15.03 million tonnes biofuels, equivalent to 12.02 million hectare or 9,4% of EU-25 agricultural land demand – when all feed stocks for the biofuel is domestically grown. The European Commission (2006) estimates that 0.75 mio hectare oil seeds and 2.5 mio hectare is necessary to meet the goals of the biofuel policies. The OECD (2006) has figured out that replacing 10% of the transport fuel consumption by biofuels requires 30% to 70% of the current crop area in United States, Canada and European Union (15). This is the case assuming unchanged production technologies, feedstock shares and crop yield. Furthermore, is assumed there is no international trade and no marginal or fallow land is used. These figures are convincing in the influence of the biofuel policies and the (potential) impact on agri-food markets.

Economic models show the effects on agro commodity markets
Within the study of Lysen and Van Egmond (2007) some economic studies have been assessed. They all show the impact of the higher demand on agrocommodity markets.

De La Torre Ugarte and Ray (2000) used the Policy Analysis System (POLYSYS) to conclude for the US-case that an increase of 1% of middle distillate fuels replaced by biodiesel would result in higher prices of several agro crops. Prices of soybean oil would rise with 37,7%. At the same time prices of soybean meal would fall with 12,4%. They assumed that farmers would maximize their net returns above variable costs (including seed, fertilizer, pesticide, machinery services etc.) selecting from available crop enterprises and subject to policy and flexibility constraints. The POLYSYS-model contains crop demand modules with utilization for each crop by use: food, feed, industrial, export and stock carryover and fuel. The additional demand requires oilcrops. The area of soybeans is increasing while the area of corn decreases. The demand results in higher prices of vegetable oils. Higher prices for oil and soybeans can be expected. However, due to the fact that the feed market is not increasing while the supply of soy bean meals is growing, the price of soy bean meals declines. This would results in only a small increase of the price of soybeans.

The OECD (2006) conducted the study “Agricultural Market impacts of future growth in the production of biofuels” which aimed to look at the economics of biofuel production and the likely impacts of an expected growth in biofuel-related demand for agricultural products on commodity markets. The OECD assessed the impact for three scenario’s[2]. The study clearly shows the additional demand for agricultural commodities is likely to substantially affect the outlook for their markets. Besides the effects on export and import volumes, there is an impact on world market prices. The strongest impact on international price levels are expected for sugar where world prices could increase by up to 60% in 2014 compared to a situation with constant biofuel quantities at

[2]

- A constant biofuels scenario including an exogenous assumption of biofuel production, crop demand for biofuels and by product generation at their 2004 level throughout the projection period (of ten years). It’s a no-change scenario with respect to biofuels.
- The policy-target scenario: the scenario that includes growth of biofuel quantities in line with the officially stated goals given baseline prices for agricultural commodities.
- The high oil price scenario: the scenario in which the oil price is assumed to be high: 60 USD per barrel from 2005. This high price will affect the agricultural markets in two ways. First it will increase the production costs of agricultural commodities. Secondly it will increase the demand for biofuels.

their current levels. Other prices would respond less dramatically, but could still gain some 4% in the case of cereals and up to 20% in the case of vegetable oils.

The OECD/FAO-study (2007) clearly illustrate rising prices for several kind of agrocommodities, which might result in higher prices for feed (and thus meat) and food (see table 5). Those high prices won't decrease on short term. They are expected to be high in the nearest future: "prices will be above the historic equilibrium levels during the next 10 years" (OECD/FAO,2007). However, these prices do not only rise due to biofuel policy. This seems to be an important factor, but it's not the only one. Another factor with impact is the rising income in a number of developing countries. These countries show higher incomes, resulting in a higher demand for meat – and therefore feed, like grain. Together with the growing world population the demand for grain as feed is rising. Secondly, there are the consequences of weather conditions. During 2006 there was a serious drought with a huge impact on cereal production. These weather conditions might occur more often. Finally, there is the speculation with it's own effect on prices. The percentage of rising highly depend on the assumptions that have been in the models. It's clear that a new economic equilibrium has to be found: an equilibrium between supply and demand.

Table 5: World prices of some commodies, in USD per ton

	Average 2001/2002-2005/2006	2016/2017	Price of 2016/2017 related to price of 2001/2002-2005/2006
Wheat	152,0	183,2	120%
Coarse grain	103,6	138,2	133%
Oilseeds	266,0	299,6	113%
Oilseed meals	201,0	200,8	100%
Vegetable oils	520,6	613,9	118%
Sugar	217,6	242,5	111%

Source: OECD/FAO, 2007

Banse and Grethe (2006) assessed the effects on production and prices of grain and oilseeds due to the blending obligation of 5,75% or 11,5% within the EU. They formulated several scenario's based on two criteria: reduction of the market prices support and change in the income report. Figure 5 shows that the EU biofuel policy is likely to have a significant impact on agricultural prices. Biofuel policies may heavily affect the price level for agricultural products.

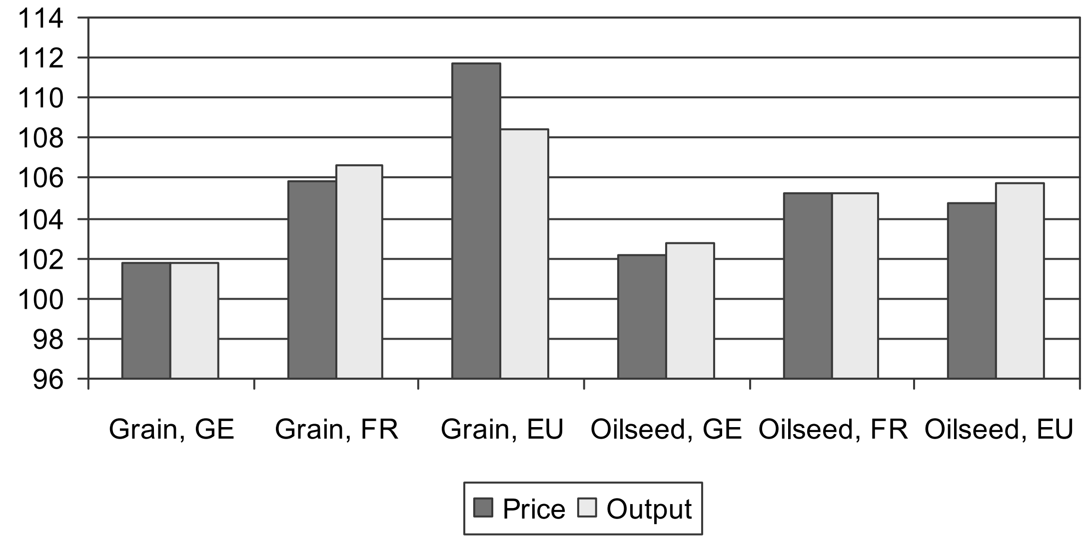

Figure 5: The impact of biofuel directive on production and price
Source: Banse and Grethe, 2006

Finally, the Scenar2020 study shows how non-food demand of agricultural products (e.g. energy) competes with food demand. This implies that first, increasing food prices with possible adverse effects on food importing (developing) countries; and second, a land expansion with implications for the environment. A trade-off between lower greenhouse gas emissions and adverse effects of this expansion and intensification in terms of for example biodiversity.

Recent developments on agro commodity markets
The Food and Agricultural Policy Research Institute (FAPRI) yearly presents the world agricultural production, consumption and trade. In 2006 they present "The FAPRI 2006 US and World Agricultural Outlook" in which the new bio-energy policies in several large countries have been included in the 2006-baseline. Other major drivers of the 2006 baseline include the EU-sugar policy reform, the sanitary and phytosanitary shocks in livestock and poultry markets and the movements in the exchange rate. FAPRI concluded the corn prices increased by roughly 5% above baseline levels, with smaller price increases for other grains. Prices of corn by products fell due to increased ethanol production. By products of corn-ethanol contribute to 10% reduction in soybean meal prices.

Blom (2007) analysed the developments in the grain market. He observes a substantial increase in prices and he explains this increase by several factors. First, the higher income, especially in the developing countries results in a rise in demand for meat – and therefore feed based on coarse grains. The higher demand of pig and poultry increased even more than 3% a year. Also the impact of weather conditions on the agricultural sector is a factor, according to Blom (2007). There has been a serious drought during 2006 in Australia, resulting in less supply. IPCC expects such phenomena to occur more often. However, they expect an overall slight positive effect on production due to climate changes. Finally, there is the extra demand from the biofuel industry.

5. Conclusions

The importance of understanding the dynamics of the relationship between biofuel and agricommodity markets
This paper started with the statement that a huge amount of biomass would be available to produce biofuel, meeting the desire of producing and using sustainable bio-energy. Those potentials didn't take into account the economic dynamics of the agro markets. This paper discussed the four points at which agromarkets and energy markets relate to the feasibility of biofuels. It clearly shows the influence of oil prices on the feasibility of the biofuel business. The feasilibity of biofuel is also highly affected by the prices of agro feed stocks. Finally, the extra demand of biomass has an impact on the agro commodity markets. Higher prices of several agro crops are observed, yet and they don't will decrease on short term. One has to have three comments in mind. First, the high prices are not caused by only biofuel policy. Secondly, models and practice are based only on the first generation biofuel, while the second generation biofuel might have other consequences. Finally, the agro markets needs time to find new equilibriums, for example concerning the use of by products of bioethanol and biodiesel.

Higher world price are felt by several market actors
The higher prices are felt by several market actors.

Farmers growing arable crops receive higher prices for their biomass. For example the market perspectives appear to be moderately positive for most EU cereals, according to the European Commission (2006). The emerging bioethanol and biomass demand is one of the factor responsible. Market perspectives for the EU oilseed sector seem to be positive also due to the increasing demand for biodiesel in the European Union.

Animal farms – however – are negatively affected by the higher prices of crops. Feed prices are rising. On the other hand, demand for meat is rising and corn can be replaced by (cheaper) protein feed from byproducts of biodiesel and bioethanol production. It requires a change in composition of animal feeds towards more protein rich feeds at the expense of cereals. The feed industry is rather flexible in using several feedstocks, so after some time a new equilibrium is expected to be found.

Producers of biofuel are confronted with higher prices of feedstock which has a negative impact on their viability. For example the US (bron vermelding) announces the first negative returns on bioethanol due to high corn prices.

Agribusiness is facing higher prices, retail is worried and consumers have to pay higher prices for food. In the *well developed* countries there is worry about the higher food prices and the question “will food manufacturers and energy companies compete in the future?” is relevant. Furthermore the question “do consumers want cheaper food or cleaner fuels in their cars?” becomes relevant. In the *less developed* countries there is the more fundamental question: “what impact do biofuels have on our food supply and food prices?”. The OECD and FAO (2007) state “the higher commodity prices are a particular concern for net food importing developing countries as well as the poor in urban populations”.

References

Blas, J. and J. Wiggins, *Surge in biofuels pushes up food prices* in: Financial Times 16 July 2007 (pp. 2)

De La Torre Ugarte, D.G. and D.E. Ray (2000) “*Biomass and bioenergy applications of the POLYSYS modelling framework*” Biomassa and Bioenergy 18 291-308

European Commission – Directorate-Generatl for Agriculture (2006) *Prospects for agricultural markets and income in the European Union 2006-2013*

His, S. (2004) Panorama 2005: A look at Biofuels Worldwide, IFP-Information

International Energy Agency (2004, Biofuels for Transport, Paris

Lönner, G. and A. Törnqvist, (1990) *Economic Evaluations of Biomass Oriented Systems for Fuel* in Biomass 22 187-194

Meeusen-van Onna, M.J.G. (1998) New methods for feasibility studies on establishemnt of new agricultural production chains, Agricultural Economics Research Institute (LEI-DLO), The Hague

OECD, (2006), Directorate for food, agriculture and fisheries, committee for agriculture, *“Agricultural market impacts of future growth in the production of biofuels”*, AGR/CA/APM(2005)24/FINAL

Shapouri, Conference Agro-Demain reims, France

Wright et al., 2000, Biomass Feedstock Research and Development for Multiple Products in the United States, Bioenergy Feedstock Development Program, 1st World conference and Exhibition on Biomass for Energy and Industry, Sevilla, Spain, June 5-, 2000

(http://www.woodycrops.org/mechconf/turnbull.html).

De La Torre Ugarte, D.G. and D.E. Ray – Biomass and bioenergy applications of the POLYSYS modelling framework in: Biomass and Bioenergy 19 (2000) 291-308

EURURALIS Newsletter – Volume 1 – april 2006

FAPRI, (2006) The FAPRI 2006 US and World Agricultural Outlook, Food and Agricultural Policy Research Institute, Iowa, USA.
Klijn, J.A. et al. (2005) The EU-RURALIS study: Technical document, Alterra, Wageningen

Lysen, E. and S. van Egmond (editors) (2007) Biomass Assessment: Assessment of the applicability of biomass for energy and materials – Supporting document: inventory and analysis of existing studies, WAB

McAloon, A. et al., 2000, Determing the cost of producing ethanol from corn starch and lignocellulosic feedstocks, Nationa Renewable Energy Laboratory

NN, LEITAP: Illustration of Underlying Assumption of the Baseline Scenario until 2020

Nowicki, P., M. Banse, H. van Meijl and A. Knierim, Prospective study 2020 – SCENAR 2020 Understanding Change – The Future of Agriculture and teh Rural World – presentation SCENAR 2020 – 2nd Workshop

Tokgoz, S. and A. Elobeid, (2006) An Analysis of the Link between Ethanol, Energy and Crop Markets, Center for Agricultural and Rural Development, Iowa State University, Working Paper 06-WP-435

Von Lampe, M. (2005) Agricultural Market impacts of future growth in the production of biofuels, Organisation for Economic Co-operation and Development, Working Party on Agricultural Policies and Markets, AGR/CA/APM (2005)24/FINAL

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Bio-ethanol from cassava

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Date: November, 2007

Preface

The Biomass Upstream Committee (BUS) has organized an annual meeting on November 20, 2007, to discuss a number of interesting opportunities in the field of upstream biomass. Topics have been selected by the BUS participants themselves. The selected themes will contribute to a better understanding of the supply-side of the emerging market for bio-energy and they will be presented in such a way to stimulate an open and lively discussion about the feasibility, sustainability and possible impacts that their deployment may have on the environment.

Ecofys has selected the topic “Bio-ethanol from cassava”. Cassava is grown in many countries with a warm and moist tropical climate. Cassava yields well on soils of relatively low fertility where the cultivation of other crops would be uneconomical. Such growth conditions are widely available throughout the Tropics, especially in Africa. Cassava is the third largest source of carbohydrates for human consumption in the world, due to its efficient growth, year round availability, its tolerance to extreme stress and its suitability to be incorporated into traditional low-input farming systems, which predominate in Africa. Recently, the cultivation of cassava for the production of ethanol has been intensified. In situations where water availability is limited (i.e. not enough for the cultivation of sugar cane), cassava is the preferred feedstock for ethanol production.

This new use to make bio-fuels from cassava may affect the development of rural Africa both in a positive and in a negative way, which was the main reason why this quick-scan report looks at cassava cropping and utilisation from different angles: general agronomy, suitability as a feedstock for ethanol production, use of co-products, current status and markets, its economic feasibility in comparison with other ethanol crops and aspects of sustainability. It is the result of a limited quick-scan performed by 6 members of the Bio Energy group at Ecofys, which implies that just an overview of the main issues is presented, without going into much detail.

Utrecht, 30 November 2007

Summary

This paper examines the possibilities for ethanol production from cassava: the cropping system, the technological design of a cassava ethanol plant, the use of waste streams for biogas production, the economics of production, current market and potential for cassava ethanol production and sustainability issues have been addressed.

Cassava cropping
Cassava is a major source of low costs carbohydrates and a staple food for 500 million people in the humid tropics. On infertile land where the cultivation of other crops is difficult cassava still has a reasonable yield. Numerous cassava cultivar exist with differences in e.g. size, yield, shape and starch content. Although cassava can produce a crop with minimal inputs, optimal yields are recorded from fields with average soil fertility levels (suitable for most food crops) and regular moisture availability. Young tubers contain much less starch than older tubers, so harvesting must be delayed until a certain amount of starch is accumulated in the tubers. Because fresh cassava roots deteriorate rapidly and can only be kept in good condition for one or two weeks after harvesting, cassava fields are rarely harvested in one pass.

Technology
The technology of producing ethanol from starch is internationally well developed. Cassava is performing average to good on all processing steps. Under optimal conditions ethanol yield from cassava is the highest of all the main ethanol crops (up to 6 t/ha). Moreover, a cassava ethanol plant requires less complex processing equipment resulting in lower investments.

Waste streams to biogas
Waste stream of cassava-ethanol production can be used for the production of biogas. Root fiber represents 30% of the dry weight organic matter and 20% ends up in the wastewater (stillage). These two sources can be used for biogas production. Per tonne of fresh cassava root theoretically 42 m^3 methane can be extracted and 28 m^3 from the wastewater. The global potential of biogas production from cassava ethanol facilities is approximately 3,000 million m^3 (when assuming theoretically that all 'industrial' cassava is used for ethanol production only). This is equal to 105 PJ per year.

Economics
The final costs of ethanol from cassava is the sum of cassava cultivation, cassava processing into dried chips and ethanol conversion. Total ex distillery costs are €0.47 per litre which is about the same as for wheat ethanol. Costs for cassava tuber production contribute most to overall production costs. Taking into account that imports from APC countries face no import tariff, cassava ethanol could sell at competitive prices in Europe.

Markets
The largest cassava market by far is in Nigeria, responsible for 18% of world cassava production. Other important cassava producing countries are Brazil (upcoming), Indonesia, Thailand, Congo and Mozambique (upcoming). Approximately 2% of world cassava is traded, mostly in the form of dried chips or pellets. Cassava is mostly used for food (53%). Feed and seed uses contribute 24% and 22% is used for 'other uses' (mainly industrial uses). The latter cassava volumes could be used for ethanol production in the future. This would avoid competition with food. Most countries that have a large potential for cassava growing, already show industrial uses of cassava. These countries are: Benin, Mozambique, Ghana, Nigeria, Indonesia and Thailand. In these countries also cassava ethanol initiatives have been identified, either existing or planned. Currently approximately 100 kton of cassava ethanol is being produced. In the short term this could increase up to 2000 kton if large production facilities in Thailand and China start operating and if Nigeria implements its ambi-

tious plans for future ethanol production. On a global scale 6000 kton of cassava ethanol could be produced per year, when restricting to the share of cassava that is now being used for other industrial purposes.

Sustainability
In order to assure a sustainable supply chain for ethanol from cassava, price increases of cassava for food purposes have to be avoided. This could take place if demand for feed would decrease, but this is not likely to happen. Ethanol production could make additional cassava volumes available by drying the volumes which are now lost due to storage problems. Increasing the yield of existing plantations or the planting of cassava on idle land could provide additional cassava volumes designated to ethanol. For a truly sustainable supply chain ecological criteria have to be addressed, such as carbon storage in previous land use systems, decreased biodiversity, soil quality, water use and water pollution and air quality. Social criteria, such as labour conditions and respect to land right. have to be taken into account as well.

1 Introduction

1.1 Cassava

Cassava (*Manihot esculenta*), sometimes also called manioc, is the third largest source of carbohydrates for human consumption in the world, with an estimated annual world production of 208 million tonnes. In Africa, which is the largest centre of cassava production, it is grown on 7.5 million ha and produces about 60 million tonnes per year. It is a major source of low cost carbohydrates and a staple food for 500 million people in the humid tropics. On infertile land where the cultivation of other crops is difficult, unless considerable inputs are applied, cassava still has a reasonable yield.

Figure 1 Cultivation of cassava

The plant grows tall, some reaching 15 feet, with leaves varying in shape and size (see Figure 1). The edible parts are the tuberous root and leaves. The tuber (root) is somewhat dark brown in colour and grows up to 2 feet long.

The crop is highly efficient in producing starch, it is year-round available, it is tolerant to extreme stress conditions and it fits nicely within traditional farming systems. Fresh roots contain about 30% starch. Cassava starch is one of the best fermentable substances for the production of ethanol. At the moment sugar cane is the most widely used crop for bio-ethanol in the Tropics, but sugar cane requires a lot of water. Consequently, sites suitable for sugar cane growing are very limited (and on most of them sugar cane plantations have ready been established). A much larges area in the Tropics is available andsuitable for cassava.

However, there are some environmental and agronomic constraints to cassava growing and processing: the crop has a high uptake of nutrients and especially a high demand for potassium. Thus a lack of adequate supply of potassium in the soil may limit cassava yields considerably. Excessive nitrogen fertilization on the other hand, may create a high level of poisonous glycosides in the tuber, making it less suitable for human consumption. Furthermore, weed competition can be very detrimental to cassava growth during the initial 3 months after planting, until it has formed a more or less closed canopy. Cassava is rather drought tolerant, except in the first few weeks after planting, when it requires ample soil moisture. On clay soils or poorly drained soils, root growth is poor and root rot is frequent. Gravelly or stony soils are unsuitable for cassava growing, because these soils tend to hinder root penetration. Thus it thrives best on light sandy loams with good drainage. Yet on these "ideal" soil types other food crops can be grown as well, which could imply some serious competition, which puts some question marks to the sustainability of the supply chain.

Figure 2 Cassava tubers

In each locality where the crop is grown, numerous cassava cultivars exist, with different leave sizes, plant heights, colours, tuber shape (see Figure 2), timing of maturity, overall yields, dry matter content, starch content and cyanogenic glycoside content of the roots. Roots with irregular shapes are more difficult to harvest and to peel, resulting in greater losses of usable root material. Traditionally, cassava roots are processed by various methods into numerous products, which are utilised in various ways according to local preferences.

Main industrial uses of fresh cassava roots are for the production of chips, pellets and starch. Recently, cassava has started to be used for bio-ethanol production too (Table 1).

Table 1. Demand of fresh cassava roots for industrial purposes in Thailand in 2007.

Current industries	Ethanol industry	Total demand	Unit
19.15	2.14	21.29	Million tonnes/year

In Chapter 6 current uses and markets of cassava are described in more detail and initiatives that deal with cassava ethanol are presented.

1.2 Conversion factors

Because of the high starch content cassava is a high yielding ethanol crop. However, a distinction has to be made between yields from dried cassava chips and fresh cassava roots. For one kilogram of cassava chips, approximately two kilograms of fresh cassava roots are required. One litre of ethanol can be produced from:

- 5 - 6 kg of fresh roots (containing 30% starch)
- 3 kg of cassava chips (14% moisture content)

On a per tonne cassava basis:
- 1 tonne of fresh cassava roots yields 150 litres of ethanol
- [1]
- 1 tonne of dry cassava chips yields 333 litres of ethanol

Cassava tuber has the following composition:
- Peel 10-20%
- Cork layer 0.5-2%
- Edible portion 80-90%, of which:
  - Water 62%
  - Carbohydrate 35%
  - Protein 2%
  - Fat 0.3%
  - Fibre 1%
  - Ash 1%

1.3 Structure of the report

Chapter 2 deals with the cropping system, yields and processing of cassava. In Chapter 3 the technology is described for producing ethanol from cassava. The use of waste stream of cassava ethanol production are treated in Chapter 4. Economics of cassava ethanol are described in Chapter 5. Then in Chapter 6 current cassava markets are identified and an inventory is made of cassava ethanol initiatives. Sustainablity issues are addressed in Chapter 7. Finally, results are summarized in Chapter 8.

[1] However, a recent study in Indonesia assumes that 1 ton of cassava yields about 155 liter of anhydrous ethanol (FAS/Indonesia, 2007)

2 Cropping systems and yields

Cassava, sometimes called manioc, is a tropical root crop. Traditionally it is grown in a savannah climate, but is can grow in a wide range of rainfall conditions (1000-2000 mm/a). In dry areas it looses its leaves to conserve moisture and produces new leaves when rains resume. Under adverse growth conditions it takes about 18 months to produce a crop; under favourable conditions it takes 8 months. Cassava tolerates a wide range of soil pH (4.0 to 8.0). It grows best in the full sun. Under most favourable conditions, yields of fresh roots can reach 40 tonnes/ha[1], while average yields from low-input subsistence agriculture are 10 tonnes/ha.

2.1 Cassava growing

In traditional agriculture, the most common form of seedbed preparation for cassava planting is on mounts or on unploughed land. On unploughed land, no tillage is done other than required to insert the stem cuttings into the soil. The soil can e.g. be opened up with a machete or hue. In improved agriculture, the land is first ploughed and than harrowed. Thereafter cassava may be planted on the flat, on ridges or in furrows. Flat plantings of cassava seem to produce higher yields of tuber than ridge or furrow plantings. However, flat planting is unsuitable on heavy clay soils, because the tubers tend to rot.

Cassava is propagated vegetatively as clones. Generally, cuttings are taken from the mature parts of the stems, which give a better yield than those taken from the younger portion of the stems. The cuttings should have at least 3 nodes, which serve as origins of shouts and of roots. Recent releases from agricultural breeding programmes include clones with resistance to many of the major diseases and pests. Cultivar names are usually based on pigmentation and shape of the leaves, stems and roots. Cultivars may vary in yield, root diameter and length, disease and pest resistance levels, time to harvest, temperature adaptation. Storage root colour is usually white, but a few clones have yellow-fleshed roots. Each region has its own special clones. Most farmers grow several clones in a field.

Cassava is planted using 10-30 cm portions of the mature stem as propagules. These stem cuttings are sometimes referred to as "stakes". The cuttings are planted by hand in moist, prepared soil, burying the lower half. In Brazil mechanical planters have been developed to reduce labour costs. Obviously, the top of the cuttings has to be placed up. Typical plant spacing is 1 x 1 m (i.e. 10,000 plants/ha). In areas of high soil fertility and high rainfall the plants should be spaced further apart. In Kenya and Uganda, cassava is always accompanied by intercrops such as maize, beans, millet and sesame. In traditional agriculture where intercropping is practised, planting is often delayed until the later part of the rainy season when the intercrops are nearly ready for harvest.
Cuttings produce roots within a few days and new shoots appear soon afterwards. Early growth is relatively slow, thus weeds must be controlled during the first few months. Although cassava can produce a crop with minimal inputs, optimal yields are recorded from fields with average soil fertility levels (suitable for most food crops) and regular moisture availability.

Cassava responds well to P and K fertilisation. Vascular-arbuscular mycorrhizae benefit cassava by supplying phosphorus to the roots. High N fertilization (more than 100 kg N/ha), however, may result in excessive foliage production at the expense of root development. Fertilizer is only applied during the first few months of growth. Plants are ready for harvest as soon as the storage roots are large enough to meet the requirements of the consumer. Typically, harvesting can begin eight months after planting. In the tropics, plants can remain unharvested for more than one growing season, allowing the storage roots to enlarge further. However, as the roots age, the central portion becomes woody and inedible.

[1] In Brazil, in intensely managed field trial even yields of 80 tonnes of tubers/ha have been reported

2.2 Harvesting

Most cassava is harvested by hand, lifting the lower part of the stem and pulling the roots out of the ground. The roots are than removed from the base of the stem by hand. Frequently before harvest, the upper parts of the stems with the leaves are cut off to a few centimetres from the ground. In Brazil and Mexico a mechanical harvester has been developed and mechanical harvesters are being tested out in other parts of the world as well. It grabs onto the stem and lifts the roots from the ground. During the harvesting process, care must be taken to minimize damage to the roots, as this greatly reduces shelf life. During the harvesting process, the stem cuttings for the next crop are selected. Young tubers contain much less starch than older tubers, so harvesting must be delayed until a certain amount of starch is accumulated in the tubers. Because fresh cassava roots deteriorate rapidly and can only be kept in good condition for one or two weeks after harvesting, cassava fields are rarely harvested in one pass. The best timing of harvesting depends on the cultivar, but usually ranges from 10 to 24 months. Table 2 gives an idea about cassava cultivation costs in Thailand, which total 294€/ha, at an average yield of 17 tonnes/ha (i.e €17.7/tonne). Farmer sales price for the cassava roots is €28.3/tonne.

Table 2. Costs of cassava growing in Thailand in 2005 (Source: Office of Agri cultural Economics, 2005[2])

Variable costs	**255**
1. Labour costs	**150**
- land preparation	37
- planting	18
- weed control	45
- harvesting	50
2. Material costs	**82**
- planting stock	25
- fertilisers	36
- herbicides	18
- fuel	0.8
- other	0.5
3. Miscellaneous costs	**23**
- maintenance and reparation	0.2
- interest	23
Fixed costs	**39**
- Land rent	36
- Depreciation	2
- Interest	1
Total production costs (€/ha)	**294**
Production cost per tonne	17.7
Yield in tonnes/ha	17
Sales price/tonne	28.3

2.3 Processing

The shelf life of fresh cassava roots is only a few days. Removing the leaves two weeks before harvest, increases the shelf life to two weeks. Traditional methods to keep the roots in good condition include packing the roots in moist mulch. The roots can also be dipped in paraffin or in wax or stored in plastic bags. Fresh roots for human consumption can be peeled and frozen. Fresh roots

[2] Sriroth, K et al. 2006. Present situation and future potential of cassava in Thailand.

can be sliced thinly and deep fried to make a product similar to potato chips. Dried roots can be milled into flour, which can be used for baking breads. Typically, cassava four may be used as partial substitute for wheat flour in making bread.

Cassava chips industry
In Thailand, which exploits the industrial prospects of cassava on a large scale, cassava chip factories usually are small-scale enterprises, located in close proximity to the cassava growing area. They use simple equipment consisting mainly of a chopper. Roots are loaded into the hopper of the chopping machine by tractor. After chopping the roots into small pieces, the chips are sun-dried on a cement floor. During drying, which typically requires 2-3 days, a vehicle with a special tool for turning over the chips is used to ensure uniform drying. When it starts raining, chips must be quickly pushed into piles and covered with plastic. This prolongs the drying time and inevitably results in lower chip quality. The final moisture content should be 14%. It takes 2 to 2,5 kg of fresh roots to produce 1 kg of chips. Sun drying of peeled cassava is practised too in many parts of Africa. This method has the advantage that it reduces the cyanogenic glucoside levels from 400 to 56 eq/kg dry weight.

Figure 3 Cassava drying

Pellets industry
Dried Chips are usually sold to pellet manufacturers, who either directly export the chips/pellets or sell to traders. Most factories in Thailand do not have silos for storage. Thus, time from purchase of dried chips to their sale is short. Some portions of cassava chips are used locally for animal feed or as a feedstock for bio-ethanol production. Exports to Europe are mainly in the form of hard pellets rather than chips (see Table 3).

Table 3 Exports of cassava products from Thailand in 2004

Chips	Hard pellets	Starch	Total	Unit
2.57	2.01	1.77	6.36	Million tonnes

The development of a cassava pellet industry in Thailand was stimulated by a need to improve the uniformity in shape and size of cassava chips required by the animal feed producers. In addition, loading and unloading of cassava chips caused serious air pollution, putting pressure in the importers in Europe to improve the handling methods.

Chips are grinded followed by steam extrusion. Upon cooling hard pellets are created. The cassava chips used for pellet manufacture are purchased from drying yards; pellet factories do not produce chips themselves. There are about 200 pellet factories in Thailand with a total capacity of about 10 million tonnes per year. However, the EU export quota is only 5 million tonnes and this is the sole market for the product. Thus the Thai pellet factories are only working at 50% of their capacity.

Starch industry
Cassava starch may be produced from fresh roots, by grating the roots, mixing with water, followed by sedimentation and sun-drying or by conductive heating. The strong increased demand for cassava starch has lead to a modern starch manufacturing process, in which the processing time from the grating of fresh roots to dried starch is less than 30 minutes. About 4.8 tonnes of fresh roots produce one tonne of dry starch. 40 percent of the cassava starch produced in Thailand is used domestically (800,000 tonnes) and 60% is exported by the Thai Tapioca Flour Industries Association. In 2004 about 1.77 million tonnes of starch was exported. Of the various cassava-based products mainly cassava starch and pellets are exported. In the future, starch exports are expected to increase in volume due to the international starch market expansion.

Diseases
About 30 diseases of cassava are known. In many regions cassava is normally not much affected by diseases or pests. However, in other areas it may be attacked by virus diseases (mosaic, brown streak and leaf curl viruses) and bacterial diseases such as *Phytomonas manihotis, Bacterium cassava* and *Bacterium solanacearum*. In Africa the cassava mealybug (*Phenacoccus manihoti*) and cassava green mite (*Mononychellus tanajoa*) can cause up to 80% crop loss, which is extremely detrimental to the production of subsistence farmers. These pests were rampant in the 1970s and 1980s but were brought under control following the establishment of the Biological Control Centre for Africa. The cassava mosaic virus causes the leaves of the cassava plant to wither, limiting the growth of the root. The virus is spread by the whitefly and by the transplanting of diseased plants into new fields. Sometime in the late 1980s, a mutation occurred in Uganda that made the virus even more harmful, causing the complete loss of leaves. This mutated virus has been spreading at a rate of 50 miles per year, and as of 2005 may be found throughout Uganda, Rwanda, Burundi and Congo.

2.4 Agronomic Research & Development

The development of high-yielding varieties of cassava has significantly increased production in many countries. In Ghana, the introduction of improved varieties helped boost the cassava harvest by nearly 40 percent between 1980 and 1996. The International Center for Tropical Agriculture (CIAT) and the International Institute of Tropical Agriculture (IITA) are playing a leading role in developing improved cassava varieties and preserving the genetic diversity of this important staple crop[3]. On average, African farmers produce about 10 tonnes of cassava per hectare, but yields can reach as high as 40 tonnes per hectare. It is estimated that the introduction of high-yielding varieties, improved pest and disease control and better processing methods could increase cassava production in Africa by 150 percent. In a recent article in Plant Biotechnology Journal[4] it was reported that cassava has one of the highest rates of CO_2 fixation and sucrose synthesis for any C_3 plant. With this in mind, researchers from Ohio State University develop transgenic cassava with starch yields up 2.6 times higher than normal plants by increasing the sink strength for carbohydrate in the crop. This means cassava makes a 'super crop' when it comes to both CO_2 fixation and carbohydrate production. Commercial cassava producers and processors need to find ways of increasing production, reducing labour costs and improving product quality in order to be able to compete with grains.

In Africa and Latin America, the domestic market for cassava-based animal feed shows potential for growth. More than 30 percent of the cassava produced in Latin America is used for domestic animal feed, compared to less than 2 percent in Africa. Research in Cameroon has shown that poultry breeders could lower their production costs by 40 percent by incorporating cassava into their chicken feed.

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[3] http://www.fao.org/NEWS/2000/000405-e.htm
[4] Plant Biotechnology Journal, Volume 4/Issue 4, July 2006

In Asia, Thailand leads the way in the production of starches derived from cassava. Cassava starch has unique properties, such as its high viscosity and its resistance to freezing, which make it competitive with other industrial starches.

3 Ethanol production technology

3.1 Introduction

Ethanol is traditionally produced from feedstock high in sugar and/or starch content. A third possible feedstock is lingo-cellulose. These obsolete feedstocks are attractive, but the technology to convert cellulosic material to ethanol (sometimes referred to as 'second generation') is not yet commercially available. Most used feedstocks for fuel ethanol are wheat, corn, sugar cane and sugar beet. The sugars can be fermented to ethanol, while starch first has to be hydrolyzed to obtain free sugars. Next, the sugars are fermented to ethanol which is followed by a purification step yielding pure ethanol.

The process of extracting starch from cassava is a well-known technology. Cassava has been used as source of starch for decades. Cassava is high in starch content (70 – 85%, dry base / 28 – 35% wet base) and the starch from cassava is of a high quality compared to other starch sources. Cassava starch is used as raw material in many industries, among which paper-, food- and textile industries. Also the technology of producing ethanol from starch is internationally well-developed.

3.2 Process description

After harvesting, the roots are chopped into chips and transported to drying floors. The roots are usually dried in the sun. Once the chips are dried, they can be stored for months. However, during storage, the starch yield decreases somewhat, depending on storage temperature: typically 5% reduction of starch yield in 8 month storage (Abera et al, 2007). Another advantage of chips is the easy transport.
A big advantage of cassava over many other traditional crops is that it can be grown and harvested throughout the year. This results in a constant supply of cassava to the ethanol production facility in contrast to more seasonally crops.

The ethanol production process consists of three basic steps are (Table 4).

Table 4: Main steps in ethanol production from starch

Step	**Goal**	**Type of process**
Milling and liquefaction	Breaking down starch molecules into its building block molecules: glucose	Enzymatic
Fermentation	Convert glucose to ethanol	Yeast
Purification	Separate ethanol from other reaction products and inert materials	Distillation

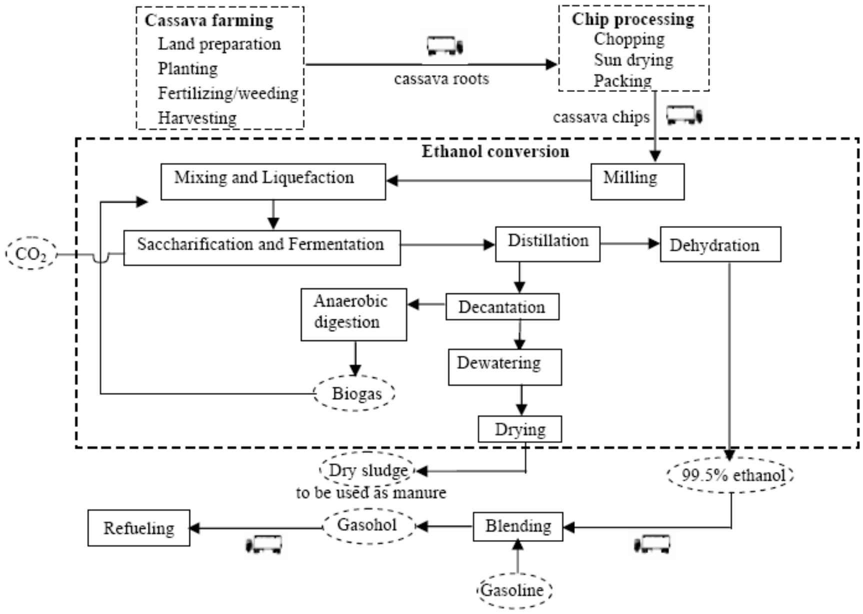

Figure 4 Flowchart of Cassava ethanol production (Nguyen, et al. 2006).

On an industrial scale, the process described in Table 4 is carried out with two distinguishable technologies[5]:

1. Wet milling process
2. Dry grinding process

The two processes differ with respect to complexity and associated capital costs, the numbers and types of co-products produced, and the flexibility to produce different kinds of primary products. The principal differences between the ethanol dry-grind process and the wet mill process are the feedstock preparation steps and the numbers and types of co-products recovered. Once the starch has been recovered the process of converting it to fuel ethanol and recovering the ethanol is similar in both wet mill and dry-grind facilities. Currently, most new facilities use the dry grinding process.

The wet milling process starts with soaking the cassava chips in an acid to soften the material which results in the separation of starch from other components. The fibres are recovered in several separation steps. Next the starch and protein are separated. In this process the steams are fractionated and several co-products can be recovered. Most streams are recovered before the fermentation step.

The dry grinding process starts with grinding the chips. This is done by hammer mills or roller mills. Next the ground material is mixed with water, cooked and mixed with enzymes. This process produces only one co-product that is separated at the end of the whole process, after fermentation: distiller dried grains with solubles. This is mostly used as animal feed. The use as animal feed is, however, limited due to the high fibre content.

3.3 Comparison with current commercial crops

The process of producing ethanol from cassava is almost the same as for starchy crops like corn and wheat. However, there are also some differences in the processing.

[5] Apart from dry grinding and wet milling, a third (less applied) technology exists: dry milling.

The ethanol yield is determined by the efficiencies of several consecutive processing steps along the production chain. These factors differ from crop to crop. There is not a single crop performing best at all these steps. Cassava is performing average to good on all steps, resulting in an excellent overall efficiency (Table 5).

Table 5: Comparison of ethanol yield from different crops (reproduced from Wang, 2007)

Crop	**Yield (tonne/ha/yr)**	**Conversion rate to sugar/starch (%)**	**Conversion rate to ethanol (L/tonne)**	**Overall ethanol yield (kg/ha/yr)**
Cassava	40[6]	25	150	6000
Sugar cane	70	12.5	70	4900
Corn	5	69	410	2050
Wheat	4	66	390	1560

Table 5 shows that under optimal conditions the ethanol yield of cassava (in kg/ha/a) is the highest of all the main ethanol crops. Moreover, a cassava ethanol plants requires less complex processing equipment resulting in lower investments. This is due to the unique characteristics of cassava starch (Wang, 2007) and the low amounts of impurities which makes the extraction of starch from the root, relatively easy.

3.4 Green house gas performance

A complete life cycle analysis (LCA) for the production of ethanol from cassava would be necessary to determine the greenhouse gas (GHG) performance of cassava ethanol. However, this is beyond the scope of the present study. Instead, the results of a recent study (Nguyen, 2007) on the GHG-performance of cassava ethanol in Thailand have been analysed.

GHG-emissions take place in every step of the production chain. The main steps are summarized in Table 6.

Table 6: GHG-emissions in the production of ethanol from cassava

	Main GHG-emissions
Cassava farming	Use of fertilizers (N_2O-emissions) and herbicides Use of fossil fuels (farming equipment)
Cassava transport	Fossil diesel for trucks
Cassava processing	Electricity (generated with fossil fuels) and fossil fuels like natural gas
Ethanol transport	Fossil diesel for trucks

The Nguyen study has made a comparison with several other ethanol production processes based on different crops. The main results are shown in Table 7.

Table 7: GHG-emission reduction (compared to gasoline) of ethanol from different crops (adapted from Nguyen, 2007)

GHG-reduction compared to fossil gasoline	**%**
Cassava in China	23.3
Cassava in Thailand	62.9
Corn in the USA	48.4
Sugar cane in Brazil	90.9

[6] This assumes a rather optimistic yield of 40 tonnes/ha. Currently, in most subsistence farming systems an avergae yield of 10-15 tones/ha is achieved.

From Table 7 can be derived that the GHG-performance of cassava ethanol shows a rather wide range (23.3 – 62.9% reduction). Similar ranges were found in many other studies on more common crops such as corn en wheat. Table 7 suggests that cassava ethanol can compete with corn ethanol produced in the USA in terms of GHG emission reduction. To optimize GHG reduction, strict regulations are required (see Chapter 7 on sustainability).

4 Cassava ethanol waste to biogas

This chapter explores the possibilities of using cassava ethanol waste streams for biogas production. Two options are assessed: biogas from ethanol stillage and biogas from root cake (cassava pulp).

4.1 Characteristics of waste streams

The production of ethanol from biomass, whether from sugar crops (sugar beets, sugar cane, molasses, etc.), starch crops (corn, wheat, rice, cassava, etc.), dairy products (whey) or cellulosic materials (crop residues, herbaceous energy crops, bagasse, wood, or municipal solid waste) causes the concurrent production of stillage that shows a considerable pollution potential (Sheehan and Greenfield, 1980; Wilkie et al., 2000). Stillage (also termed distillery waste water, distillery pot ale, distillery spent wash, dunder, mosto, vinasse and thin stillage), is the aqueous by-product from the distillation of ethanol following fermentation of carbo-hydrates.

A mass balance for cassave shows the following results with respect to available organic material from the processing of cassava roots: 1 ton of fresh root contains 400 kg dry matter. During processing about half of this amount is recovered as starch. Root fiber represents 30% of the organic matter and 20% ends up in the wastewater (stillage).

When assuming a COD[7] to dry matter ratio of about 1:1, per ton raw cassava root theoretically 42 m^3 methane (1.5 GJ) can be extracted and 28 m^3 from the wastewater (1.0 GJ). Of course, we have to take into consideration that the root fiber is more ‘digestible’ than the wastewater, with COD conversion efficiencies ranging from 60-90% for the stillage (depending on composition and other factors) and up to 95% for the root fiber.

For each liter of ethanol produced, up to 20 liters of stillage may be generated (Wilkie et al., 2000). The characteristics of the stillage vary considerably according to the fermentation feedstock and to location. In addition to this, wash water used to clean the fermenters, cooling water blow down might contribute as well to stillage variability (Wilkie et al., 2000; Sheehan and Greenfield, 1980; Pant and Adholeya, 2007).
In general, stillage has low pH, high temperature, dark brown colour, high ash content and high percentage of dissolved organic and inorganic matter (Beltran et al., 2001). The biochemical oxygen demand (BOD) and chemical oxygen demand (COD) range between 35,000 – 50,000 and 100,000-150,000 mg/L, respectively (Nandy et al., 2002). Table 8 shows the distillery wastewater characteristics for cassava.

Table 8 Characteristics of distillery waste water for cassava feedstock

Characteristics	**Cassava**	
	(Jackman, 1977; Sheehan and Greenfield, 1980)	(de Menezes, 1989; Wilkie et al., 2000)
Stillage Yield (L/L EtOH)	-	16 - 20
BOD (mg/L)	-	31,400
COD (mg/L)	-	81,100
pH	-	3.5
Organic Matter (g/L)	21,800	-

[7] COD= cemical oxigen demand; BOD = bio-chemican oxigen demand

Total Nitrogen (mg/L)	400	650
Sulphate (SO_4^{2-}) (mg/L)	100	-
Calcium (CaO) (mg/L)	100	-
Phosphorus (P_2O_5) (mg/L)	200	-
Total Phosphorus (mg/L)	-	124
Magnesium (MgO) (mg/L)	100	
Potassium (K_2O) (mg/L)	1,100	-

Observations in the cassava-to-ethanol industry in South East Asia have highlighted the variability in the strength of the stillage, with COD ranging from 40,000 to over 200,000 mg/L, total organic content ranging from 100,000 to 150,000 mg/L, suspended solids concentrations from about 6,000 to 30,000. In most cases sulphate levels in the stillage are high, ranging from 2,000 to 7,000 mg/L, as a result of the use of sulphuric acid during the manufacturing process.

4.2 Biogas production from stillage

Anaerobic treatment is the first treatment step for distillery wastewater. A significant portion of COD can be converted to biogas by anaerobic digestion. According to recent studies, anaerobic biological treatment is widely applied as an effective step in removing of up to 90% of the COD in the distillery effluent stream (Wolmarans and de Villiers, 2002). Similarly, 80-90% BOD removal can be obtained. Biochemical energy recovered is 85-90% as biogas (Pant and Adholeya, 2007).

Because of the high organic content of stillage, anaerobic digestion has a prospect of financial return from methane production. By operating the digester with adequate residence time, up to 90 % of the BOD can be removed. The produced gas could supply 30% of the fuel requirements of distilleries operating on cassava (Willingthon and Marten, 1982).

Wilkie et al. (2000) has made a comprehensive review for anaerobic treatment of different kind of feedstock (Table 9).

Table 9 Mesophilic anaerobic treatment of stillage from conventional feedstocks

Feedstock	**Reactor Type**	**Influent COD** (g/L)	**HRT** (days)	**ORL** (g COD/ L/day)	**Treatment Efficiency % Removed COD**	**Methane Yield** (L/g COD)
Barley and sweet potato	2-UASB	29.5	1.2	25	90	0.28
Corn (thin stillage)	ACR	16	5	3.2	97.3	nd
Mixed (potato, beets, wheat, and corn)	UFF	20-55	5	10	75-95	0.3
Potato and beet	UFF	40	4	10	90	nd
Cane Molasses Stillage	DFF	57	4	15	85	0.22

nd: no data; ACR: Anaerobic contact reactor; CSTR: Continuously stirred recator; DFF: Downflow fixed film; UASB: Upflow anaerobic sludge blanket; UFF: Upflow fixed film; 2-UASB: 2 stage UASB

Table 89, summarizes mesophilic anaerobic treatments of several feedstocks in different kinds of reactor types are shown. Because in the literature no specific data is found on cassava ethanol stillage, the results of ethanol stillage for similar feedstocks is used for the assessment of treatment efficiency, suitable reactor type and methane yield.

In

Table 10 mesophilic and thermophilic anaerobic treatments are compared with respect to treatment efficiencies and methane yields.

Table 10 Summary of anaerobic treatment of stillage from conventional feedstocks (Modified data from Wilkie et al., 2000)

Temperature/Feedstock	OLR (g COD/L/day)	Treatment Efficiency % removed BOD	Treatment efficiency % removed COD	Methane Yield (L/ g COD)	Methane Productivity (L/L/day)
Mesophilic/molasses	12.25	79.33	71.20	0.26	3.84
Mesophilic/other	12.16	nd	87.25	0.25	2.90
Thermophilic/molasses	23.50	89.20	60.73	0.17	3.37
Mixed/cellulosic	9.48	93.73	83.56	0.30	2.37

nd: no data

Literature study indicates that the treatment efficiency and organic loading rate are dependent on the feedstocks as well as reactor types. According to the research done by Pant and Adholeya (2007), the highest BOD removal is possible in open lagoon whereas the most methane is produced in an upflow anaerobic sludge blanket (UASB) type reactor. On the other hand, the research done by Wilkie et al. (2000) shows that the highest BOD/COD removal can be obtained by using an anaerobic contact reactor, while the highest methane yield is reached by using an upflow fixed film reactor.

The methane yield of the stillage ranges between 0.22 and 0.30 for mesophilic anaerobic treatment. The methane yield and treatment efficiency for thermophilic anaerobic treatment is lower than mesophilic ones.

4.3 Biogas production from cassava pulp

Cassava pulp (also called root cake) is a residue which remains after the extraction of starch from the grinded root. The material consists of fine particles and can be easily digested. Root cake has a dry matter content of about 20%. Own research has shown that the COD equivalent of pulp ranges between 1.0 and 1.3 kg per kg dry matter. This would translate in about 350-450 m^3 methane per ton dry matter or 580-750 m^3 biogas. In other words, the calculation suggests that 70 m^3 methane can be extracted from one ton cassava pulp.

Based on a literature study and practical experience of Ecofys, the potential of biogas production from cassava with respect to the cassava growing region has been analysed. The biogas potential is estimated by taking the share of cassava production that goes to 'other purposes' (see Chapter 6), which is mostly for industrial uses. In the future these amounts of cassava could become available for ethanol production. In this way ethanol can compete with other industrial uses (e.g. starch production) and will not compete with uses for food and feed, which would have consequence for the sustainability (see Chapter 7). Countries have been selected that show large cassava-ethanol potential. With these numbers the potential production of biogas from stillage and pulp can be calculated. Table 11 summarizes the potential biogas production which can be obtained from ethanol stillage and from cassava pulp, respectively.

Table 11 Potential Biogas Production world-wide based on ethanol industry capacity

Region	Annual Cassava production for ethanol industry (10^6 tonnes/year)[a]	Biogas from Ethanol Stillage (10^6 m^3 CH_4/year)[b]	Biogas from Pulp (10^6 m^3 CH_4/year)[b]	Total Biogas Potential (10^6 m^3 CH_4/year)[b]
Angola	2.7	76	113	189
Benin	1.3	36	55	91
Brazil	5.2	146	218	364

China	4.4	123	185	308
Congo, The	0.6	17	25	42
Ghana	3.7	104	155	259
Indonesia	6.5	182	273	455
Mozambique	6	168	252	420
Nigeria	14.8	414	622	1,036
Thailand	2.1	59	88	147
World	46.3	1,296	1,945	3,241

a The annual cassava production for ethanol industry is based on the data from Chapter 4 (Table 1). The data listed as "other uses" is assumed to be used entirely for ethanol production.

b The conversion efficiencies are not considered in this calculation.

Table 11 indicates that potential biogas production from cassava pulp is higher than biogas from stillage due to the higher methane yield from the pulp fraction. The global potential of biogas which can be obtained from cassava ethanol production facilities is approximately 3,000 million m^3. Nigeria has the highest relative contribution with 1,000 million m^3 /a of biogas potential, which is followed by Indonesia and Mozambique with a 455 and 420 million m^3 /a of biogas potential, respectively.

5 Economics

5.1 Cassava ethanol production costs

Economic analyses on cassava ethanol production are scarce. The core part of this section is based on one study, by Nguyen et al. (2006) for Thailand.

For the African context, we assume that the industrial parts of the supply chain will eventually have similar efficiencies and costs, since the technology could be imported from other countries. On the agricultural part of the supply chain, initially lower yields can be expected, but it is not clear how this will impact the feedstock costs. Therefore, we assume that the Thailand analysis can be used as an example for cassava ethanol production in Africa, but that the results should be used with care. Additional research would be needed to judge the viability of cassava ethanol in Africa.

The cost of cassava ethanol is the sum of the following process costs:

- Cassava cultivation. This involves land preparation, planting, crop maintenance (fertilization, weed control), and harvesting
- Cassava processing into dried chips.
- Ethanol conversion, milling, mixing and liquefaction, saccharification and fermentation, and distillation/dehydration.

The supply chain is schematically represented in Figure 4.

The costs of cultivation, processing and ethanol production are summarized in Table 12.

Table 12. Cost analysis of cassava ethanol; all data stem from Nguyen et al (2006).	**Specific costs and conversion efficiencies**		**Ethanol production cost (€/litre ethanol)**
Production costs of cassava roots[1)]	20.1 – 23.5	€/tonne roots	0.164
Profit for farmers[2)]	3.8 – 8.8	€/tonne roots	0.047
Cassava chips yield[3)]	0.4	tonne chips/tonne roots	
Processing costs[3)]	3.4	€/tonne chips	0.010
Profits, margins, transportation[4)]	12.4– 18.5	€/tonne chips	0.046
Ethanol yield[5)]	333	l ethanol/tonne chips	
Processing costs[5)]	0.131	€/l ethanol	0.131
Margin[5)]	0.075	€/l ethanol	0.075
Ethanol ex distillery			**0.473**

1) The production costs of cassava roots are estimated to range 980 – 1,140 THB/tonne. 1 Thai Baht_{2006} = 0.0206 Euro_{2006} (X-rates 2007).
2) Farmers get an average profit of about 183 to 427 THB/tonne depending on product market price
3) The total production cost of cassava chips is 3,300 THB/tonne; 95% of this cost is due to the cost of 2.5 tonne of cassava roots, whereas processing cost makes just 5%.
4) The price of cassava chips ranges 3,700 - 4,000 THB/tonne on the open market, after adding profit margin, taxes, etc. When including transportation cost, the feedstock at plant gate costs 3,900 - 4,200 THB/tonne chips.
5) Conversion rate is 333 litres of ethanol per tonne of cassava chips according to Ngyuen et al. USDA mentions 155 liter of anhydrous ethanol per tonne (USDA 2007), but considering that Cassava is one of the starch-richest crops, we assume that the estimation of Ngyuen et al. is correct.

A detailed breakdown of the feedstock cultivation cost is shown in Figure 5. It demonstrates that fertiliser contributes significantly (i.e 25%) to the overall costs.

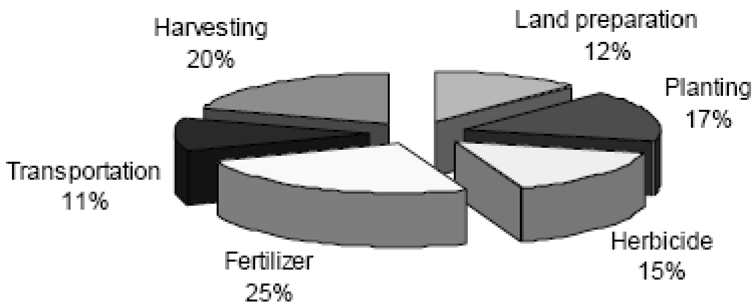

Figure 5 Breakdown of the cassava roots production costs (Nguyen, et al. 2006).

A detailed break-down of the distillery costs is given in Figure 6. The feedstock, including margins, transportation costs and market effects, accounts for 54% of the ethanol production costs.

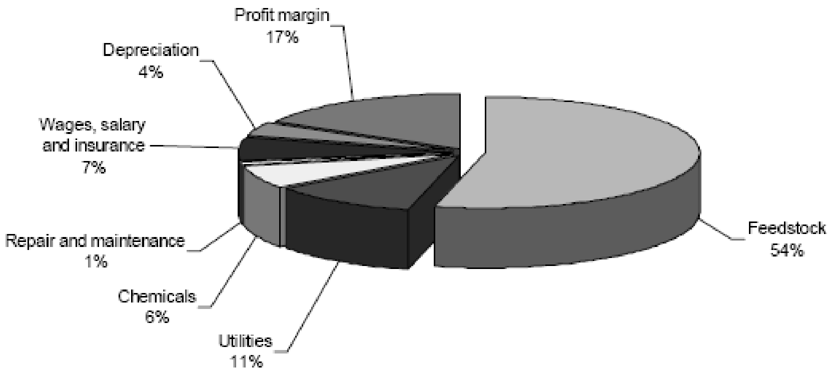

Figure 6 Breakdown of the ethanol production costs (ex distillery) related to a feedstock price of 80.3 €/tonne chips (Nguyen, et al. 2006).

There are several options that slightly improve the economics of the ethanol production from cassava:

- The ethanol conversion produces a sludge residue, which, in principle, is a good soil conditioner and which could be sold to cassava farmers. To realize this option it is necessary to dewater the sludge, which implies a small additional cost to the distillery.
- Fuel oil, used for heat and electricity generation for the distillery could be replaced by much cheaper rice husk.

These options could decrease the production costs of cassava ethanol by about 5 eurocent/litre.

5.2 Comparison with ethanol from other feedstock

Table 13 shows the production costs of ethanol from other feedstock. Both ethanol from maize in the United States and ethanol from sugar cane in e.g. Brazil can be produced at lower costs than ethanol from cassava, i.e 0.47€/l. However, cassava ethanol has a favourable pricing position in comparison with wheat and sugar beet ethanol in Europe.

Table 13. Ethanol production costs, both calculated and market reported.

	Calculated costs[1] (€/l)	**Market price (€/l)**
Ethanol from sugar beet	0.54	
Ethanol from wheat	0.47	
Ethanol from cassava	0.47	
Ethanol from maize	0.40	0.37 €/l
Ethanol from sugar cane	0.21	0.24 €/l

[1] Hamelinck (2007) calculated the production costs on basis of wheat ethanol in Europe 22 €/GJ_{LHV}, sugar beet ethanol in Europe 26 €/GJ_{LHV}, maize ethanol in USA 19 €/GJ_{LHV} and sugar cane ethanol in Brazil 10 €/GJ_{LHV}. Energy content is 26.4 GJ_{LHV}/tonne, density 791 kg/m^3.

[2] Sugar cane ethanol (FOB Port of Santos) and maize ethanol (US national rack average) market prices August 2007 from ethanolmarket.com.

5.3 Ethanol import to the EU from ACP countries

Generally, ethanol imports to Europe are subject to import tariffs. Depending on the nature of the ethanol, denatured (undrinkable) or undenatured (still drinkable), a low or high tariff is applied. Imports from some countries are subject to a lower or even a zero-tariff. E.g. ethanol imports from the so-called ACP countries (Africa, Caribbean and Pacific Ocean) face no import tariffs (see Table 14).

Table 14. Import tariffs for ethanol.

	Taric code	Imports erga omnes	ACP countries[1)]
Ethanol, undenatured	2207 10 00 10	19.20 EUR / hl	0%
Ethanol, denatured	2207 20 00 10	10.20 EUR / hl	0%

1) A list of ACP countries can be found at www.europarl.europa.eu/intcoop/acp/

Imports from Brazil are applicable to the all-in import tariff. Depending on the form of the ethanol the costs are increased with 0.102 or 0.192 €/l. Depending on the biofuels regulation in the destination country, it could be necessary to import ethanol in undenaturated form, in order to receive excise exemptions or to count for biofuels obligations.

From table 14 it can be deduced that ethanol imports from ACP countries are favourable. Ethanol produced from cassava in these countries is likely to be sold in Europe at a competitive price.

6 Current status and markets

6.1 Cassava markets and countries

Production

World cassava production amounted 208 million tons in 2005 (FAO, 2007). Since the late 1990's production has grown steadily by 4 to 6%. Nigeria is by far the largest producer of cassava, responsible for 18% of the world production (42 million tons). Second is Brazil with 26 million tons, followed by Indonesia which has passed Thailand as third producer in 2005. In general, over the last years cassava production has mostly increased in Nigeria, Brazil and Mozambique. Production declined mostly in Thailand and China. Figure 7 shows cassava production for selected countries.

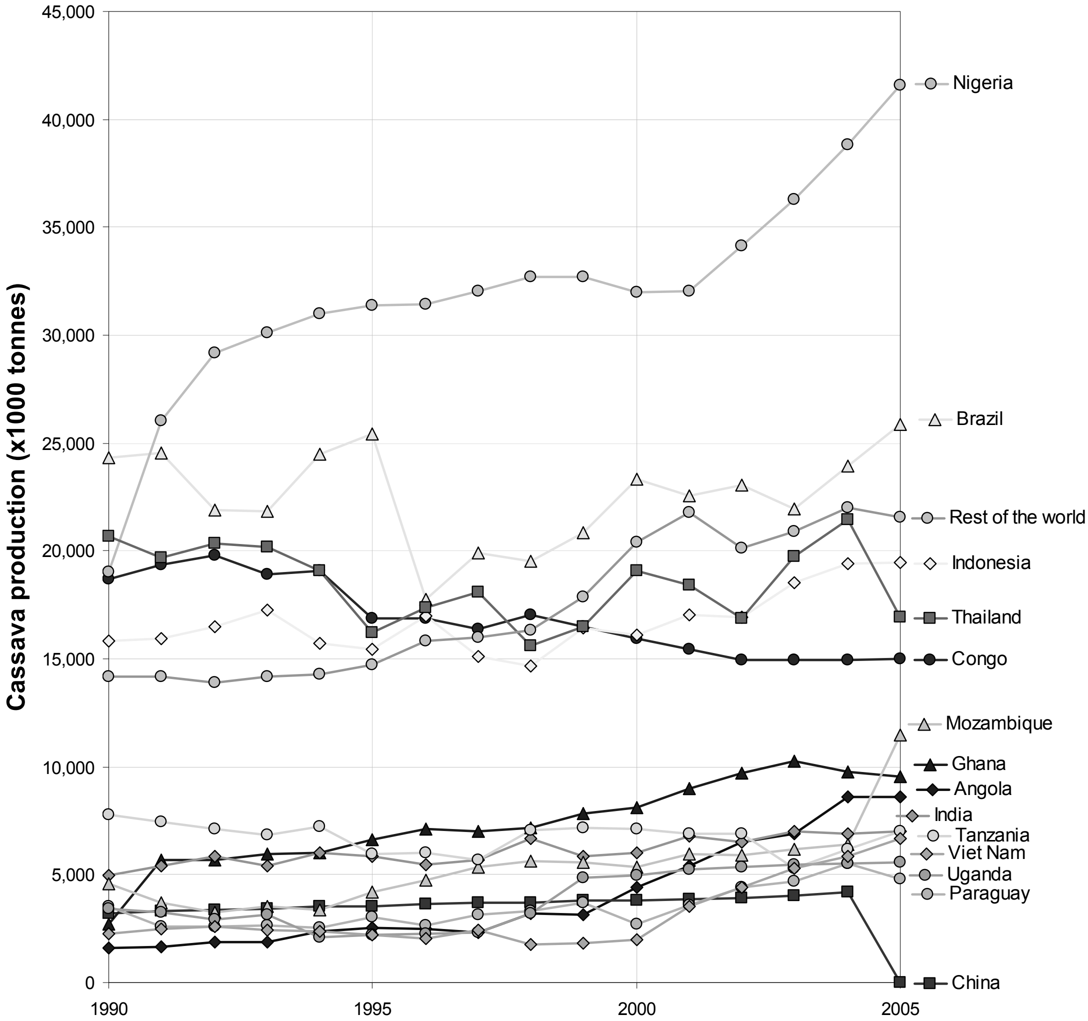

Figure 7 Cassava production in selected countries 1990-2005 (FAO, 2007).

Import and export
Approximately 2% of world cassava production is being traded. Exports have decreased rapidly in the late 1990's and have remained fairly constant since than. Major exporting countries are (in absolute numbers): Thailand, Vietnam and Indonesia. The Netherlands and Germany also export (or rather through-port) significant volumes of cassava (after first having imported it). China is the largest importer (3.3 million tons in 2005), followed by The Netherlands (0.9 million tons). Other European countries have much lower trade volumes. Trade in cassava consists of the following product categories:

- Fresh cassava roots: International trade in fresh cassava roots is mostly confined to transactions between neighbouring countries and is not usually recorded in the official statistics. Some demand exists in developed countries caused by an increasing population that originates from 'cassava producing countries'.
- Dry cassava chips and pellets: Cassava can be chipped or pelletised in order to increase shelf life and to make export available for animal feed uses. The EU is the main market for cassava feed products, as it accounts for about 80% of global imports. The other 20% of trade find their way to China, Indonesia, Japan, the Republic of Korea, the United States, Australia, New Zealand, Malaysia and the Philippines. EU demand for feed cassava products was met mainly by Asian countries, in particular Thailand. Thailand is the most dynamic in meeting the requirements for trade expansion. In recent years, however, falling grain prices following the 1992

CAP reform have decreased demand for cassava feed products in the EU and stalled much of the growth of production in Thailand, where the sector was highly dependent on external markets as its main outlet.

- Starches and flours: Trade in cassava flour and starch, which represents some 15% of overall cassava products trade, expanded in recent years. The major cassava starch and flour importers are, by order of importance, Japan, the Chinese Province of Taiwan, Hong Kong, China, Indonesia, Malaysia, Singapore, the United States and the Philippines.

Cassava pellets have been sold to other destinations at prices much lower than those obtained in the EU. This pattern reflects the export policies implemented by Thailand and Indonesia since the mid-1980s to encourage a diversification of markets. Both countries introduced a "bonus scheme", under which traders were awarded a given amount of the profitable export quota to the EU for each tonne sold elsewhere. Such a scheme encouraged traders to offer very cheap prices to non-EU customers as they endeavoured to increase their entitlements for sale to high-price markets in the EU. As a result, the international cassava pellet market was characterized by a two-tier pricing system that contributed to the expansion of cassava exports to non-EU destinations in the 1980s and early 1990s. (FAO, 2003)

Uses

Worldwide cassava is mostly used for food: 53% of world cassava production was used for food in 2005. Secondly, feed uses amounted to 24%. 22% was used for other purposes. The latter include post-harvest losses and industrial uses. The share of cassava losses was much smaller for Latin America and the Caribbean and for Asia, at 10% and 8% respectively, while it was of the order of 29% in Africa (FAO, 2000). Industrial uses of cassava include utilisation in the manufacturing of paper, cardboard, glues, textile, resins, composite woods, pharmaceuticals and ethanol production. Some large-scale, integrated, cassava starch plants have been reported in Venezuela, whereas in Brazil the scale is generally small. A major constraint of the industry is the unavailability of a regular flow of roots for processing. In Brazil, for instance, cassava starch industries had to stop working for more than four months a year, because of a lack of fresh cassava roots (FAO, 2003).

Table 15. Cassava production and consumption (2005) data for selected countries. Grey shadings indicate countries that have been studied further in detail.

Country [10^6 tonnes]	Production	Consumption (food)	Import	Export	Feed and seed	Other uses
Angola	8.6	4.6			1.30	2.7
Belgium			(2004) 0.27	(2004) 0.08	0.16	
Benin	2.9	1.0			0.56	1.3
Brazil	25.9	7.1			13.40	5.2
Cameroon	2.1	1.5			0.16	0.5
China	(2004) 4.2	1.9	3.30		8.80	(2004) 4.4
Colombia		1.6			0.14	0.3
Congo, The	15.0	14.0			0.39	0.6
Costa Rica				0.08		
Côte d'Ivoire	2.2	1.6				0.5
Germany			(2004) 0.03	(2004) 0.13		
Ghana	9.6	4.5			1.40	3.7
Guinea		1.2				0.1
India	7.0	6.5				0.5
Indonesia	19.5	12.0		0.25	0.40	6.5
Italy			(2004) 0.04			
Japan			(2004) 0.03			
Korea, rep. of			(2004) 0.40		0.50	
Madagascar	2.1	1.7				0.3
Malawi	2.1	1.4			0.58	0.1
Malaysia						0.4
Mozambique	11.5	5.1			0.40	6.0
Netherlands			(2004) 0.90	(2004) 0.11	(2004) 1.40	(2004) 0.2
Nigeria	42.6	15.2			11.60	14.8
Paraguay	4.8	0.7			3.90	0.2
Philippines		1.6				0.2
Portugal			(2004) 0.14		(2004) 0.29	
Spain			(2004) 0.81		(2004) 1.73	
Tanzania	7.0	5.2				1.7
Thailand	16.9	8.8		3.0	0.29	(2004) 2.1
Uganda	5.6	3.5			1.40	0.7
U.S.A.			0.07		0.20	
Vietnam	6.6			0.48	2.58	2.0
World	**208.1**	**111.8**	**6.1/3.9**	**6.1/3.9**	**49.9**	**46.3**
Criterion	*>2*	*>1*	*>0.01*	*>0.01*	*>0.10*	*>0.10*

Notes:

a) Differences might occur in summations due to rounding and differences in years (stock levels etc).

b) Most import numbers have been taken for year 2004, since import/export in 2005 was considerably different from previous years due to a large drop of exports in Thailand and Vietnam.

Potential

Table 15 summarises production numbers and cassava uses within the most important cassava growing countries[8]. Based on the cassava production numbers Nigeria, Brazil, Indonesia, Thailand and Congo are definitely the most important countries. These countries inherently have high (food) consumption rates of cassava. By looking at the consumption rate (food consumption divided by production + imports), the relative importance of cassava for food is indicated. From the largest cassava producing countries, Indonesia, Thailand and The Congo have highest food consumption shares; resp. 62%, 52% and 93%. Lowest shares are observed in Mozambique (45%), Nigeria (36%) and Brazil (28%). Furthermore, the share of 'other uses' is important, mostly because this indicatedsthe share of industrial uses that could become available for ethanol production in the near future. Countries with high shares of other uses are Mozambique (52%), Benin (45%), Ghana (38%), Nigeria (36%) and Indonesia (34%)[9]. The countries which have a large potential for ethanol from cassava, are described in detail in the next paragraphs.

[8] Firstly based on annual production (larger than 2 million ton per year), secondly by the height of cassava consumption (>1 million ton), and finally on volumes of import and export (>10,000 tonnes), feed and seed use (>100,000 tons) and other uses (>100,000 tons).

[9] The uncertainties in data for small producing countries have to be taken into account as well.

6.2 Status of ethanol production from cassava

No consistent data have been found on production volumes of ethanol from cassava. Some initiatives have been announced and small volumes are being production in mainly Asia (Thailand) and small scale local production in some African countries. In this section the cassava market in relevant countries is described. If applicable, information on ethanol production is provided. It appears that currently approximately 100 kton of cassava ethanol is being produced. In the short term this could increase up to 2000 kton if large production facilities in Thailand and China start operating and if Nigeria implements its ambitious plans for future ethanol production. This informationis based on information publicly available on the internet. At the end of this section the potential cassava ethanol production is calculated.

Table 16 Key information on cassava growing countries.

Country	**Cassava yield [ton /ha]**		**Cassava price [USD/ton]**		**Ethanol production [kton/year]**	
	2004	**2005**	**2004**	**2005**	**Production**	**Announced/planned**
Benin	13.0	12.9	n.a.	n.a.		*n.a.*
Brazil	13.6	13.6	22	27		*Initiatives*
China	16.8	19.6	547	547		*310 kton announced*
Congo	9.7	9.4	76	68		*Initiatives*
Ghana	12.4	12.8	90	93		*10 kton*
Indonesia	15.5	15.9	75	83		*50 kton announced*
Mozambique	6	10.4	107	113		*Initiatives*
Nigeria	11	11	439	548		*450 kton planned*
Thailand	20.3	17.2	22	34	*23 kton,*	*1000 kton announced*

Cassava prices are quoted from the FAO database, indicating the producers price in US$ per tonne fresh or dried cassava. Large differences in cassava prices have been observed. Especially China and Nigeria show high prices, even if all prices are corrected for purchasing power according to the PPP (purchasing power parity). This could be caused by differences in the definition of cassava (fresh or dried, the latter probably having a premium price). Time was too limited to identify the reasons behind the differences.

The following countries have been identified as having a high potential for future cassava based ethanol production. As stated before, no large scale cassava ethanol production is currently existing, but countries having high shares of industrial cassava use and relative low feed use have been studied in detail. Countries which have ethanol initiatives or ambitious governmental plans, have also been included.

- *Benin*

Between 1996 and 2003, cassava production doubled to reach a total output of 2.9 million tonnes, while the per-ha yield increased by 25%. This strong performance was largely the result of the government scheme “a billion for cassava” which offered credits, fertiliser and cuttings of improved varieties to producers to encourage them to increase production. However, not much was done to improve marketing at the same time (The Bahama Journal, 2007).

- *Brazil*

Cassava is grown in the regions of Sao Paulo (6%), Mata Grosso do Sul (17%), Parana (75%) and Goias (2%). These regions are also know for their large sugarcane and ethanol production. Cassava is mostly used for starch production; 36% is cassava derived starch. However, corn is still the most important feedstock for starch production (63.8%) (Henry and Cardoso, 2003). In Brazil cassava is currently not being used for ethanol production. Negative experiences with cassava in Brazil have been quoted by FAS: Large-scale farming of cassava failed because of pests and diseases and manual harvesting appeared very labour intensive and time consuming. High ethanol demand could increase interest in cassava as possible feedstock. However, this seems unlikely due to the fact that Brazil is mainly focussing on sugarcane and there appears to be no need for alternative feedstocks (besides soy for biodiesel).

- *China*

China's current cassava production is estimated at 7.5 million tons per year. Increasing land area planted to cassava (it can grow on marginal land) and technological advances could eventually add 21 million tons to cassava production. In the meantime, cassava imports from Thailand, Vietnam, and Indonesia are surging, up from 257,000 tons in 2000 to more than 3.3 million tons in 2005. Semi-tropical Guangxi region offers an ideal mix of climate and soil conditions for growing cassava (FAS/China, 2006).

A subsidiary of China National Cereals, Oils & Foodstuffs Corporation recently reached a deal with the government of southern Guangxi Zhuang Autonomous Region to construct a 200,000-ton cassava ethanol plant in the capital Nanning. The Nanning plant, the first phase of the project, will be finished by mid-2007. Another ethanol plant in southern China, which is a joint venture of the provincial and national governments, will open in October 2007 with production capacity of 110,000 tons of ethanol per year. With cassava as the main input, the plant is expected to supply much of southern China when it reaches production of 1 million tons per year in 2010 (Worldwatch Institute, 2007).

- *Congo*

Cassava is a very important food crop in Congo, with 93% of total production being used for food consumption. Also the leaves are used as a vegetable. As of October 2007, Brazil has signed two agreements to help Congo with training, technology and financing to produce ethanol (Reuters). Drawbacks for small scale cassava/ethanol production in Congo are the civil stability, poor road access and the existence of import subsidies on rice and wheat.

- *Ghana*

In Ghana, the cassava transformation has lagged behind Nigeria by about a decade. For example, the dramatic increase in cassava production occurred in Nigeria from 1984 to 1992 and in Ghana from 1990 to 2001. In Ghana, until the drought which occurred in the early 1980s and resulted in the failure of most food crops except cassava, government agricultural policies emphasized on stimulating large scale production of grains by the public sector and neglected cassava as an inferior food whose consumption was destined to decline as incomes increased.

Caltech Ventures Ghana Limited, a biofuel company founded by members of the Ghanese diaspora, will begin the production of ethanol from cassava at Hodzo, near the city of Ho, in 2007 when its $6.5 million production plant will be ready. The company's total investment in the venture is $10 million. Caltech Ventures Ghana Limited has established a 162 hectare cassava seed plantation with plans to expand it to 486 hectares next year. 60 percent of the six million litres of ethanol to be produced yearly will be exported. It has also organised a corps of cassava out-growers to provide the needed raw material for take-off. The project has the potential to provide 600 jobs, when its ethanol plant comes to full production (Biopact 2007).

- *Indonesia*

Relative small amounts of Indonesia's cassava production are used for food consumption. In Indonesia two ethanol plants are currently operating, both using molasses as raw material. The industry is also looking at cassava as a feedstock. Since molasses is also used to produce monosodium glutamate, cassava may be an attractive alternative. At least two companies are currently making plans to use cassava as an feedstock (FAS/Indonesia, 2007). Indonesia's largest-listed energy firm, PT Medco Energi Internasional, plans to spend $135-$144 million on three ethanol plants. Each ethanol plant needing an investment of $45 million. One plant in Sumatra's Lampung will have a capacity of 60 million litres of cassava-based ethanol a year, which is going to be exported to India, Korea, Taiwan and China (Reuters).

- *Mozambique*

Compared to other African countries Mozambique uses only 45% of the cassava supply for food consumption, whereas 52% is being used for other purposes. Recently, a panel of scientists has put efforts in the development of using cassava for ethanol production. A cassava-based ethanol industry will be adding value to the crop and provide major opportunities for poverty reduction amongst the country's small subsistence farmers. The Mozambique Bio-Fuels Industries is also promoting the use of cassava (and jatropha) for biofuel production (Biopact, 2007).

- *Nigeria*

Yields were boosted when high yielding 'TMS' varieties were introduced and supported by the government. In 2002, cassava suddenly gained national prominence following the pronouncement of a Presidential Initiative. The intent of the initiative was to use cassava as the engine of growth in Nigeria. To put Nigeria in the global context for competition the country needs to upgrade the use of cassava into primary industries such as starch, ethanol, chips and flour in order to provide an industrial base for further diversification of its national economy (Knowledge for Development, 2007). This initiative aimed to produce 107 million tons of cassava in 2007 with 78% destinated for export. The majority of cassava will be used for animal feed (85%) and 3% will be dedicated for ethanol production (FAO, 2004). Highest potential for future increased cassava production and processing facilities is in the southwest of Nigeria. FAO (2004) has made the following recommendations in order to enable Nigeria to exploit its large cassava potential. The cassava industry throughout Nigeria has long been neglected as a valued and respected contributor to modern agriculture. Yet cassava production is greater than the 'more respected' and 'more organized' agricultural commodities in Nigeria. For the cassava industry to mature in Nigeria it must organize itself. Competitive funding in support of excellence and innovation within the cassava industry should be given priority.

In 1994, NIYAMCO (Nigerian Yeast and Alcohol Manufacturing Company) began looking for an alternative source of raw material. Dried cassava chips was selected as a suitable raw material for the production of ethanol. The production facility of NIYAMCO required about 30 tons of dried cassava roots per day. Because of problems in organizing the collection of dried cassava chips from scattered smallholders, NIYAMCO had to close its ethanol plant. If the 88 million liters of alcohol currently imported each year for the liquor industry were produced with cassava roots in Nigeria, it would open up a market for about 600,000 tons of cassava roots, or about two percent of national cassava production (Nweke, 2003).

- *Thailand*

Production and export of cassava has dropped significantly in 2005, whereas more cassava was used for food production. Most cassava in Thailand was exported as cassava chips and pellets to Europe, to be used in the animal feeding industry. During the late 1980s, Thailand's cassava-production area covered 1.6 million ha. Almost all of this was destined for the lucrative export market for cassava pellets in Europe. However, changes in the EU's agricultural policies in 1993 lowered the support price of their own grain crops, and made Thailand's cassava pellets no longer competitive as a cheap source of animal-feed. Thus, the amount of cassava pellets Thailand exported to the EU began to drop. Foreseeing the problem of overproduction, the Thai government tried to decrease the cassava-growing area by encouraging farmers to plant other crops. However, none of these were as well adapted to the climatic conditions in the Northeast as cassava. As a result, farmers continued to grow cassava, albeit on a reduced area of about 1 million ha. While the area was reduced, cassava yields started to increase substantially from about 14t/ha in 1995 to 22t/ha in 2006/2007. The result was that total cassava production decreased only marginally from a peak of 24 million tons in 1989 to about 16 million tons in 1998/1999 and back up to 25 million tons in 2006/2007. The Thai cassava industry changed from making mainly cassava pellets for export to making more and more cassava starch for both the domestic and export markets. Currently, cassava starch and modified starch industry absorbs over 50% of all cassava roots produced in the country. Chinese neighbours to the north have also built more and more starch factories, to the point that domestic production could not keep up with demand. Thus, in 2001, they started importing dry cassava chips from Thailand, firstly in very modest amounts, but increasing every year to four million tonnes in 2006.

Presently there is only one ethanol factory in the country using cassava as its raw material and producing about 80,000 litres per day. However, two additional factories are ready to start operation and another 12 factories should be completed by the end of 2008, producing a total of 3.4 million litres of ethanol per day. This will require an additional six million tons of fresh roots, on top of the 25 million tons currently being produced. Since the cassava growing area cannot increase substantially due to competition from other crops, the increased supply can only be met through increases in yield (Biopact, 2007).

In Thailand, ethanol production from cassava will not necessarily cause an over-demand to the existing cassava industries, since the starch industry is not expected to grow much further and the pellets industry will decline somewhat. At an annual production of 20 million tonnes of fresh roots in 2005, there was 4 million tonnes of roots available as a surplus to the feed industry and to make ethanol from. The Thai agricultural policy strives to increase yields without increasing the area planted with cassava (which is now restricted to 1 million ha). Due to continuous research and development on cassava variety improvement and cropping efficiency, Thailand has been able to increase cassava yields from 13 tonnes/ha in 1995 to an average of 17.2 tons/ha in 2005.

6.3 Potential volumes of cassava ethanol

The potential of cassava ethanol can be estimated by taking the production share of ‘other uses’ in a selected country. Within the category “other uses” a large share is used for industrial purposes. Industrial parties may have to compete with future ethanol production. This avoids direct competition with cassava used in food and feed (see next chapter on sustainability). Table 17 summarises the cassava-ethanol production potential for various countries. It appears that in total 6.6 million tonnes of ethanol can be produced from cassava annually. This represents a share of 16% in current world fuel ethanol production. Nigeria and Indonesia show the largest potential of cassava ethanol production, which is e.g. reflected in the ambitious ethanol policy plans in Nigeria. Also in Indonesia, several initiatives have been identified and three ethanol plants have been announced. Thailand shows a smaller potential, due to the large volume of cassava chip exports.

Table 17 Top-10 cassava ethanol potential (based on cassava available for ‘other uses’)

Country	**Cassava used for ‘other uses’ [million ton / year]**	**Potential cassava ethanol production [kton / year]***
Benin	1.3	185
Brazil	5.2	739
China	4.4	625
Congo, The	0.6	85
Ghana	3.7	525
Indonesia	6.5	923
Mozambique	6.0	852
Nigeria	14.8	2,102
Thailand	2.1	298
World	(17%) 46.3	6,576

**Assuming that from 1 ton of fresh cassava 180 litres ethanol can be produced;*
And ethanol density : 0.789 kg/l.

7 Sustainability issues

7.1 Competition between food and ethanol

Cassava is a staple food for 500 million people in the humid tropics. Thus, cassava price increases caused by a rising cassava demand for ethanol production are likely to have effects on the food access of poor people which do not produce cassava themselves.

However, cassava price increase on the existing cassava market are not to be expected, if:

- The demand for cassava within other industry sectors (e.g. the fodder market) is diminishing by the same volume needed for ethanol production. To our knowledge, however, there are no indications that such a development is currently taking place or is to be expected in the near future.
- According to Horizonte (2003) a substantial proportion of the cassava harvest in tropical regions is lost. By using heat produced out of cassava residues, cassava losses can be reduced considerably. Thus, using improved conservation processes could make cassava available for ethanol production that would have been lost otherwise.
- The increasing demand for ethanol production is covered exclusively by cassava which has been produced in addition to the current cassava production. This can be achieved without severe negative ecological consequences by increasing the yields of existing plantations using sustainable production methods or by setting up new cassava plantations on "idle" land (see textbox). Cassava could be especially appropriate for the cultivation on idle lands, as these lands often do not have the best soil qualities and cassava still has reasonable yield on land where other crops cannot be produced.

Doing so, a new market for cassava from additional production is set up. The increasing demand from the ethanol industry will only become effective on this market. Thus, the existing market for cassava will not be influenced by the increasing cassava demand of the ethanol industry. However, if the cassava demand for the food sector would increase in the future, additional cassava will have to be supplied by the new ethanol market for cassava from additional production.

Textbox: Idle land
Several authors have indicated the large potential of energy crops on degraded land. The challenge with realising production on idle land is that there is no internationally agreed definition of “idle land”. Not having clarity about which land can be considered to be ‘idle’ forms a major barrier to realising production on idle land. Therefore it is advised that stakeholders (market players, NGO’s, governments) set up a programme to identify areas which can be classified as idle land. Such a programme should build upon existing knowledge to protect biodiversity such as in the Convention on Biological Diversity.

Furthermore, such a programme should include active consultations with:
• local and national governments of the relevant areas;
• biodiversity experts with relevant local experience;
• local communities (assisted by NGO’s with local representation);
• industry representatives.

Guidelines for designating land as idle land are given below. Idle land for sustainable biomass production should meet the following conditions:
• Compliance with the criteria of the RTFO Sustainable Biomass Meta-Standard (a biofuel certification system which is currently being set up in the UK) on carbon stock conservation.
• Compliance with all criteria of the RTFO Sustainable Biomass Meta-Standard on Biodiversity, i.e. no conversion in or near areas with one or more High Conservation Values.
• Compliance with all criteria of the RTFO Sustainable Biomass Meta-Standard on land rights and community relations).
• In a reference year (e.g. 30-11-2005), the land was not used for any other significant productive function, unless a viable alternative for this function existed and has been applied which does not cause land-use change which is in violation with any of these criteria for “idle land” .

The criteria on biodiversity refer to High Conservation Values, a concept introduced by the Forest Stewardship Council. Guidelines have already been drafted and applied on how to identify such High Conservation Values. It could be an interesting option to expand the process of identifying High Conservation Values to also include the identification of idle land.

To improve the food access of people in regions where cassava for ethanol production is cultivated according to the criteria of additional production described above, it would be possible to either intercrop other food crops on biofuel plantations or to sell a part of the produced additional cassava supply to the food market.

7.2 Ecological and social sustainability aspects

At least the following ecological and social aspects have to be considered to assess the sustainability of producing feedstock for the biofuel industry, no matter what agricultural crop is used:

Ecological Criteria

1. Carbon storage: Carbon losses can be caused by the conversion of high carbon storage land (e.g. forests) into biofuel plantations.

2. Biodiversity: Biodiversity losses can be caused by the conversion of high carbon storage land (e.g. forests) into biofuel plantations.

3. Soil quality: The soil quality of biofuel plantations may decrease, e.g. in the case that no measures are taken to prevent erosion, an excess application of pesticides and fertilizers (an overuse of nitrogen decreases the cassava crop quality for food consumption as well) and a decrease of soil fertility due to an excessive export of nutrients (especially potassium in the case of cassava)

4. Water use: The water quality in the production regions might deteriorate in the case of an overuse of pesticides and fertilizers. A sustainable water use has to take the natural ground water level regeneration rates into account.

5. Air quality: The air quality in the production regions might deteriorate in the case of burning of residues or the use of fires to burn forest with the aim of setting up new biofuel plantations

Social Criteria

6. Labour conditions: Proper labour conditions on the biofuel plantations include e.g. the prohibition of child labour and forced labour as well as the workers right to organize themselves.

7. Land rights: Taking existing land rights into account is especially problematic in countries where companies set up large scale biofuel crop plantations and do not comply with the existing legislation.

Currently, a number of European countries (United Kingdom, The Netherlands and Germany) and the European Commission are setting up certifications systems to assure a sustainable production of biofuels. These certification systems are mostly based on existing, voluntary certification system for different agricultural crops and forest products. However, there is currently no certification system for cassava production in place.

Sustainable cassava production for the ethanol industry may be guaranteed by setting up a sustainability certification system for cassava. In addition to the ecological and social sustainability criteria mentioned above, it is recommended to add a criterion on “additional production” in the certification system. Thus, increasing prices on the existing market for cassava could be prevented. Doing so, the displacement of current agricultural production with possible negative ecological consequences could be prevented as well.

Although certification would be desirable also for the cassava food market from an ecological point of view, it is not recommended to include the food sector in the certification system, as the costs of certification would be imposed on the users of cassava food who often have a very low income.

8 Conclusions

1. About 54% of the world's cassava is produced in Africa, 29% in Asia and only 14% in Latin America (FAO, 2007).
2. Growing and harvesting cassava is a manually intensive activity and thus lends itself to small scale production units.
3. Post harvesting activities are not very capital intensive either and can therefore be conducted at the farm level.
4. Other activities in the supply chain (e.g. refining, extracting, marketing and packaging) tend to be more capital and knowledge intensive and thus benefit from economies of scale.
5. The supply chain provides possibilities for small-scale farmers on marginal lands to become involved in producing a cash crop.
6. According to TIPS (2007), on the long-term, cassava best potential growth market is its application in starch and starch-based products.
7. Countries that have the greatest potential for future ethanol production are countries such as Thailand, Nigeria and Ghana, which produce cassava for higher value added products, such as for animal feed or for industrial starch production. This avoids a direct competition with food uses of cassava.
8. Possible drawbacks could be the limitations of Thai exports, and political instability in Nigeria and Ghana.
9. The worldwide growth in ethanol production has resulted in increased awareness of the possibilities of African cassava.
10. More developed countries such as Thailand have made the step towards higher added value uses of cassava in the past and have become leading exporter of cassava chips and pellets. This development could very well indicate the future direction of selected African countries.
11. Cassava could be especially be appropriate for the cultivation on idle lands, as these land often do not have the best soil qualities and cassava still has reasonable yield on land where other crops cannot be produced.
12. Large opportunities exist for cassava ethanol production. Due to its high availability, its large potential to optimise yields and due to its integration in small scale communities, ethanol can be produced in a viable way.
13. Drawbacks may result from the competitive pressure that co-markets of ethanol, such as the starch market, could exercise.
14. Also, the application of cassava in African animal feed market could potentially interfere with large scale ethanol production.
15. The current development of sustainability criteria will most likely also be extended to cassava ethanol.
16. To avoid food or fuel debates, it has to be assured that additional cassava is grown for ethanol, preferably on idle land. This enhancess cassava's potential, due to its cultivation potential on low fertility soils.
17. Beneficial export conditions and relative low production costs will enhance cassava's potential.
18. In order to develop a market and infrastructure for cassava the following aspects should be addressed:
    - Increase stable cassava yields. Use high yielding root material and optimise harvesting methods in order to make large volumes of additional cassava available.

- Explore the possibilities for integrating small scale ethanol production facilities with opportunities for biogas production.
- Define domestic ethanol markets and possibilities for exporting ethanol.
- Address sustainability issues from the start.

References

- Abera, S. and Rakshit, S.K.; Effect of Dry Cassava Chip Storage on Yield and Functional Properties of Extracted Starch; *Starch*; Volume 56, Issue 6, page 232 – 240; 2004
- Bassam, N.el 1998. Energy plants species. Their use and impact on environment and development. James & james Science Publishers, London
- Beltran F. J., Alvarez P. M., Rodriquez E.M., Garcia-Araya J. F., Rivas J., 2001. Treatment of high strength distillery wastewater (cherry stillage) by integrated aerobic biological oxidation and ozonation. Biotechnology Progress. 17, 462-467.
- Biopact, 2007. Available at http://biopact.com/2007/10/caltech-ventures-to-produce-ethanol.html.
- FAO, 2003. The world cassava economy: facts, trends and outlook. FAO & IFAD 2000.
- FAO, 2004. A cassava industrial revolution in Nigeria: The potential for a new industrial crop.
- FAO, 2007. FAOSTAT
- FAS/China, 2006. Biofuels. An alternative future for agriculture.
- FAS/Indonesia, 2007. Indonesia. Biofuels Annual 2007. USDA/FAS.
- FAS/Thailand, 2007. Thailand. Biofuels Annual 2007. USDA/FAS
- Hamelinck CN and Hoogwijk M, 2007, Future Scenarios for Biofuels, Ecofys / Netherlands Environmental Assessment Agency, Utrecht the Netherlands.
- Henry, G. and Cardoso, C.E.L., 2003. Cassava products and biotech: Brazilian trends and implications. Presentation CIRAD Argentina and EMBRAPA Brazil.
- Knowledge for Development, CTA, 2007. Available at: http://knowledge.cta.int/en/content/view/full/2567.
- Nandy T., Shastry S., Kaul S. N., 2002. Wastewater management in a cane molasses distilery involving bioresource recovery. Journal Environmental Management. 65, 25-38
- New crop factsheet Cassava. www.hort.purdue.edu/newcrop/CropFactSheet/cassava.html
- Nguyen TLT, Gheewala SH and Garivait S, 2006, Life Cycle Cost Analysis of Fuel Ethanol Produced from Cassava in Thailand, Institution, City.
- Nguyen, T.L.T. et al.; Energy balance and GHG-abatement cost of cassava utilization for fuel ethanol in Thailand; *Energy Policy*; Volume 35, Issue 9, page 4585 – 4596; 2007
- Nweke, F., 2003. New challenges in the cassava transformation in Nigeria and Ghana. http://www.ifpri.org/events/conferences/2003/120103/papers/paper8.pdf
- Pant P., Adholeya A., 2007. Biological approaches for treatment of distillery wastewater: A review. Bioresource Technology. 98, 2321-2334
- Sheehan G. J., Greenfield P. F., 1980. Utilisation, treatment and disposal of distillery wastewater. Water Research. 14, 257-277
- Sriroth, K. et al 2004. A study of directions for the development of ethanol industry in Thailand.
- Sriroth, K. Lamchaiyaphum, B and Piayachomkwan, K. 2006. Present situation and future potential of cassava in Thailand.
- The Bahama Journal, 2007. Available at http://www.jonesbahamas.com/?c=47&a=7415
- TIPS, unknown. Trade Information Brief: Cassava. Australian Government, Trade and Industrial Policy Strategies (TIPS).
- Wang, W. 2002; Cassava production for industrial utilization in China – Present and future perspectives; *Proceedings of the 7th regional cassava workshop*; Bangkok, Thailand;

- Wilkie A, C., Riedesel K. J., Owens J. M., 2000. Stillage characterization and anaerobic treatment of ethanol stillage from conventional and cellulosic feedstock. Biomass and Bioenergy. 19, 63-102
- Willingthon I.P., Marten G.G., 1982. Options for handling stillage waste from sugar-based fuel ethanol production. Resources and Conservation. 8, 111-129
- Worldwatch Institute, 2007. Available at http://www.worldwatch.org/node/4351
- X-rates, 2007, Historic exhange rates, www.x-rates.com

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Viability of local productive arrangements for biodiesel in brazil: field assessment of sustainability in oil palm farm[1]

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Context of Embrapa's biofuels sustainability study

Socio-environmental impact assessments have been carried out on oleaginous crops production under the context of expanding demand for biofuels in Brazil, under the auspices of Embrapa's Network Project on Oleaginous Crops for Biofuels. The study brought together the main stakeholders of the biofuels production chains in five regions of the country, in Delphi-type workshops (Monteiro & Rodrigues, 2006). Major impacts expected or observed were related to increases in demand for inputs, resources, and energy, with potential risks on water quality and habitat conservation. In some instances, management practices have been improving soil quality, favoring habitats recovery. Crop intensification has been expected to bring important contributions for farmers training, income generation and income sources diversity, as well as improved management and administration capacities. Especially designed local productive arrangements, involving Institutional Integration have been shown to offer the best policy options for fostering sustainable development and avoiding environmental degradation risks, under the current scenario of expanding demand on oleaginous crops for biodiesel production in the studied regions.

Building upon the results of these Regional Workshops and given the aforementioned expected and observed impacts (for more details on this Regional context, refer to Rodrigues et al., 2007), a field assessment was carried out in an oil palm farm in the region of Belém (Pará State, Brazil), corroborating the importance of local productive arrangements, to promote the sustainability of the production chains of biofuels in the country.

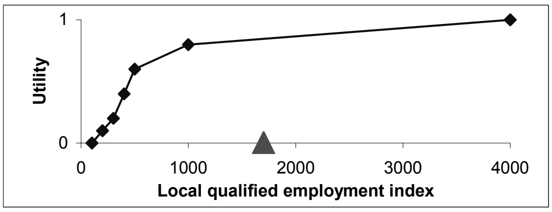
Integrated sustainability indicators system

The "System for Weighed Environmental Assessment of New Rural Activities" (APOIA-NovoRural - Rodrigues & Campanhola, 2003) has been proposed as an adequate method for promoting the environmental management of rural establishments. The APOIA-NovoRural System consists of a set of 62 indicators weighing matrices, formulated towards the systemic assessment of a rural activity at the rural establishment scale, according to five sustainability dimensions: i) Landscape Ecology, ii) Environmental Quality (Atmosphere, Water and Soil), iii) Socio-cultural Values, iv) Economic Values, and v) Management and Administration. The sustainability assessment is performed by quantitatively and analytically assessing the effects of the rural activity on each and every indicator constructed for these five dimensions, and automatically calculating the impact indices, according to appropriate weighing factors (Figure 1). The impact indices are expressed as utility values (0-1, with the baseline sustainability conformity level defined at 0.7 - Bisset, 1987) in graphs for each indicator, the aggregated dimensions and a final sustainability index.

[1] The results shown in this report were partially presented in the VI International PENSA Conference, held at the School of Business and Economics of the University of São Paulo, Ribeirão Preto – Brazil in October, 24-26th, 2007.

Table of percentage occupied personnel						
Local opportunity for qualified employment			Qualification for the activity			
			Manual work	Specialized manual	Technician	Engineering
Weighing factors			1	2	3	4
Personnel origin	Establishment	10	20	60		
	Village	5			20	
	Region	1				
				Check		100
Local qualified employment index				(sum pi*k1*k2)		1700

IEmpLQ	Utility
100	0
200	0.1
300	0.2
400	0.4
500	0.6
1000	0.8
4000	1



Best fit equation for utility

Exponential model: y=a(1-exp(-bx))
Coeficients:
a = 1.01
b = 1.E-03

U-IEmpLQ= 0.88

Figure 1. Typical weighing matrix of the “System for Weighed Environmental Impact Assessment of New Rural Activities” (APOIA-NovoRural), showing the ‘Local opportunity for qualified employment’ indicator.

Information required for filling out the APOIA-NovoRural weighing matrices were obtained in field surveys (aided by GPS, maps and satellite images) and data on the managerial and administrative history of the rural establishment provided by the farmer / manager, according to a structured questionnaire. Other indicators, related to water and soil quality, were obtained in field and laboratory analyses. Some water quality indicators (O_2, pH, Conductivity, Turbidity) were measured in the field with a Multi-parameter Horiba (U-10) probe. Nitrate was analyzed with a Merck RQFlex field colorimeter. Fecal coliform levels were estimated with Tecnobac (AlphaTecnoquímica) culture strips. Water samples were brought to Embrapa Environment laboratory for phosphate and chlorophyll determinations with a HACH spectrophotometer. Soil samples were sent to Embrapa Oriental Amazon laboratory for routine macronutrients determinations. For further details on the methodology, the full set of indicators, and access to the APOIA-NovoRural operational system, refer to Rodrigues & Moreira-Viñas (2007).

Field study context

The studied rural establishment dedicated to oil palm production was selected by indication of the Association of Palm Oil Producers Dentauá Ltd. The Ishihara Farm is located in the municipality of Santo Antônio do Tauá, in the Geographical Metropolitan Meso-region of Belém, Castanhal Micro-region (Pará State, Brazil), in the ecological domain of the Amazon Equatorial Rain Forest. At 54m altitude and geographical coordinates 01^{o}06'13" S and 48^{o}07'34" W, the 275 ha farm has oil palm in approximately 192 ha; and a diversified agricultural productive base, including black pepper (28 ha), açaí palm (28 ha), lemon (5 ha), papaya (5 ha), cupuaçu (2 ha), pineapple (2 ha), noni (5 ha), and woods (5 ha distributed among neem, teca, mahogany and Gliricidium). Only 2.5 ha correspond to native forests in the establishment, occupying the Permanent Preservation Areas shoring a small stream.

Sustainability Assessment – indicators and dimensions conformity evaluation

The APOIA-NovoRural System shows the assessment results in a synthesis graph for the sustainability dimensions, and an aggregate index for the establishment, according to the spatial and temporal context defined locally (Figure 2). For the case of Ishihara Farm this Sustainability Index reached 0.70, right in agreement with the conformity baseline defined in the method. Among the sustainability dimensions considered, quite favorable mean indicators results were obtained at Ishihara Farm for Water Quality (0.85) and Economic Values (0.78). With mean indicators values very close to the conformity baseline were Landscape Ecology (0.67) and Socio-cultural Values (0.68). On the other hand, mean indicators results for the dimensions Soil Quality (0.51) and Management & Administration (0.61) were below the conformity baseline defined in the APOIA-NovoRural System.

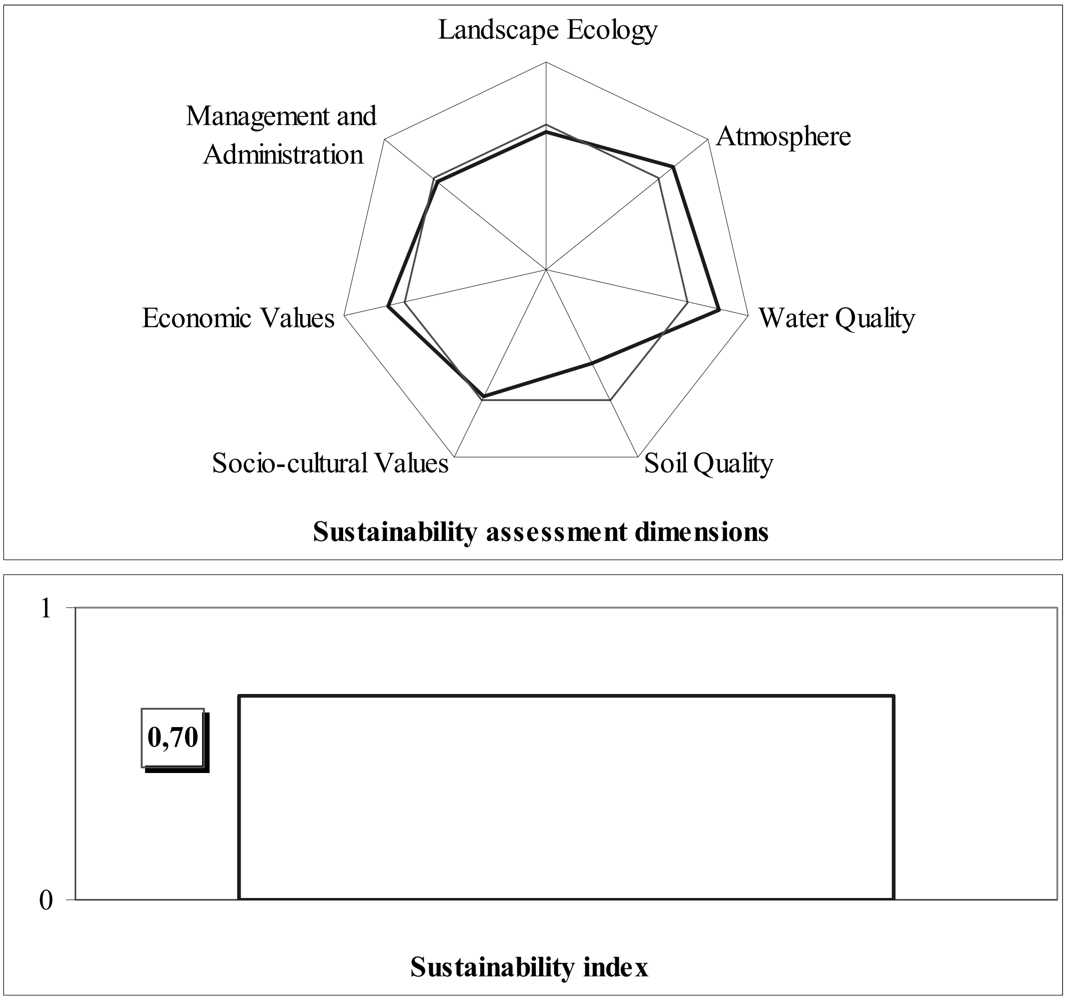


Figure 2. Sustainability assessment for Ishihara Oil Palm Farm, in Santo Antônio do Tauá (PA, Brazil), according to the APOIA-NovoRural System assessment dimensions. March 2007.

The Landscape Ecology dimension (Figure 3) presented the indicators concerned to Natural habitats conservation (0.89), Productive areas management (0.97), and Confined activities/animal husbandry management (0.79) as extremely favorable conditions for the farm's sustainability. The area destined to agricultural production at Ishihara Farm adds to approximately 262 ha, fully taken by perennial crops, mostly oil palm (70%), which is less intensive in terms of inputs and natural resources, comparatively to the other cultures. Natural habitats make up only 3 ha, comprising a paludal forest in pristine condition, and a tract of recovering secondary rain forest, both very important for conforming the legally mandated Permanent Preservation Area indicator (index = 0.82). On the other hand, the mandated Legal Preserve is nonexistent (indicator = 0.0), a passive from the time of implantation of oil palm in the establishment, when the treelike trait of the culture was amenable for Legal Preserve denomination.

The large number of different crops grown at Ishihara Farm resulted in a relatively high Productive diversity indicator (0.67), a positive factor for the farmer's economic security, against eventual market instabilities. Even though below the baseline level defined in the assessment system, the Landscape diversity indicator was also satisfactory (0.59), owing to the perennial aspect of the crops, which contributed moderately for the conformation of Fauna corridors (0.68), and favored the protection of Endangered species (index = 0.80). The oil palm plantation, however, influenced negatively the Fire hazard indicator (0.55), due to the piling up of flammable organic material remaining from harvest operations and brought back from the industry and left under the trees. As in the eventuality of fire the main culture itself would be affected, causing severe losses, the effect on the sustainability index is quite important. This practice, on the other hand, contributes with the organic matter balance in soils, as shown later on in the text.

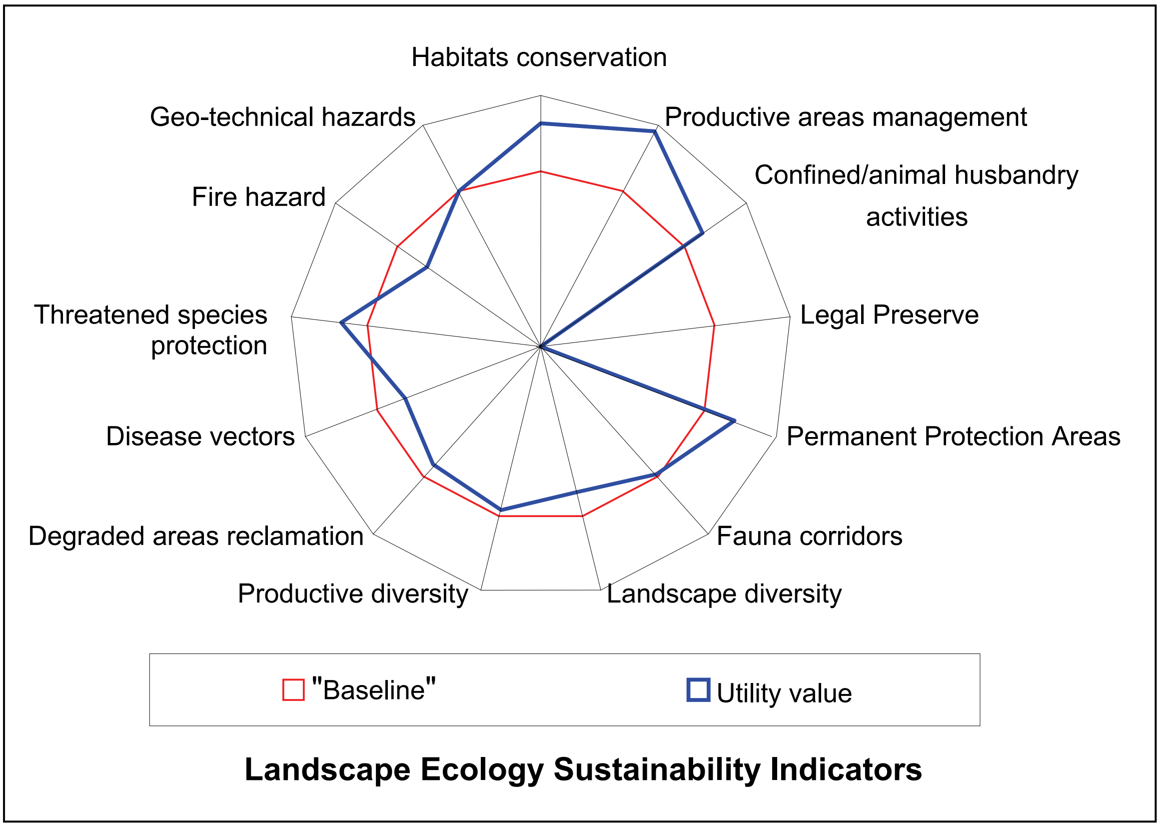


Figure 3. Sustainability indices for the Landscape Ecology indicators, Ishihara Oil Palm Farm, Santo Antônio do Tauá (PA, Brazil), according to the APOIA-NovoRural System. March 2007.

The Environmental Quality dimension resulted well above the baseline conformity level for the indicators of Atmosphere (mean = 0.79) and Water Quality (0.85), whereas the Soil Quality resulted well below that level (mean = 0.51). The Atmosphere indicators pointed out the absence of particulates and smoke emissions (for no burning is allowed in management, index = 0.89), foul odors (1.0) and reduced period and low intensity of noise generation (0.92). Neither were there important sources of sulfur (0.70) or nitrogen oxides (0.70). On the other hand, the intermittent traffic of tractors for harvesting and management imposes some emission of carbon oxides (0.65) and hydrocarbons (0.65) at the local scale, as compared to other crops produced in the farm.

The Water Quality showed positive indices for most indicators, pointing out the favorable influence of the perennial crops, especially oil palm, for water conservation. Surface waters analyzed showed adequate levels and excellent improvement in oxygen saturation (index = 0.97, up 82%), adequate pH (index = 0.89), nitrate (0.80, under 2.0 mg/L), total solids (index = 1.0), chlorophyll (1.0), conductivity (0.95), visual pollution (1.0), and potential pesticide impacts (1.0). Even though showing adequate conductivity (0.95), groundwater (sampled in the farm's well) showed elevated levels of nitrate (up to 8.0 mg/L, index = 0.21), calling for periodic monitoring. This contamination, however, is most likely linked to domestic effluents, not to agricultural practices, and certainly not to oil palm.

The Soil Quality indicators represent the comparison between oil palm areas and orchards/woods soils, areas to be converted into oil palm when plantations eventually expand in the establishment. The less intensive management and smaller input demand observed in the oil palm areas, which nearly excludes hydro-soluble fertilizers in favor of organic matter amendments, has brought strong decreases in soil nutrients levels. Despite the increased soil organic matter (index = 0.77), drastic decreases in phosphate (0.09), potassium (0.46), and magnesium (0.55) were associated to a high potential acidity (0.50), resulting in very low sum of bases (0.12), and bases saturation (0.20), while important reductions on sheet erosion can be attributed to current oil palm plantation management practices (index = 0.75, Figure 4).

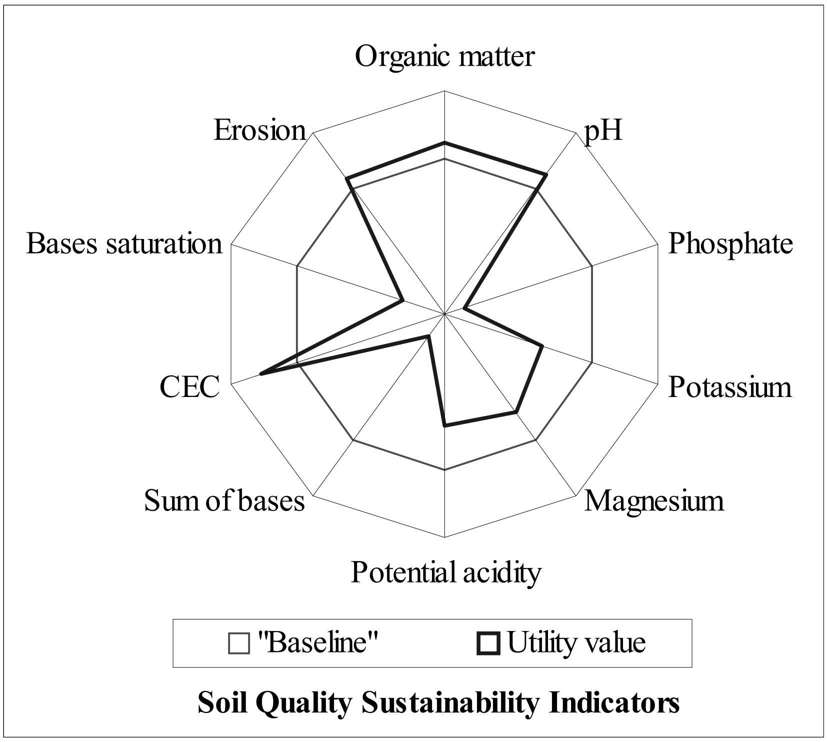


Figure 4. Sustainability indices for the Soil Quality indicators, Ishihara Oil Palm Farm, Santo Antônio do Tauá (PA, Brazil), according to the APOIA-NovoRural System. March 2007.

The mean indicators result for the Socio-cultural Values dimension at the Ishihara Farm (0.68, Figure 5) was very close to the baseline sustainability level of the APOIA-NovoRural

System. The establishment houses the manager and eight family members, one temporary and 16 permanent workers. Regarding the Access to education indicator, only the manager receives regular short training courses (offered by Dentauá Ltd.), with no other contribution accountable to the oil palm activity (index = 0.70). The typically modest Consumption standards of the region, especially referring to the employees, resulted in a lower than baseline index for this indicator (0.64), compared to a relatively good availability of Public services (0.69). The activity shows no influential changes on the Access to sports and leisure (0.70) or the Cultural/historic patrimony (0.70) indicators. The occupational safety and health indicator (0.77) pointed out good working conditions, even though the Local opportunity for qualified employment (0.62) shows essentially manual, low specialization, field labor opportunities only. Most importantly, due to the virtual absence of fringe working benefits, and the uncertain contractual regime of the temporary worker, the quality of employment indicator was lower than the baseline sustainability level (0.61).

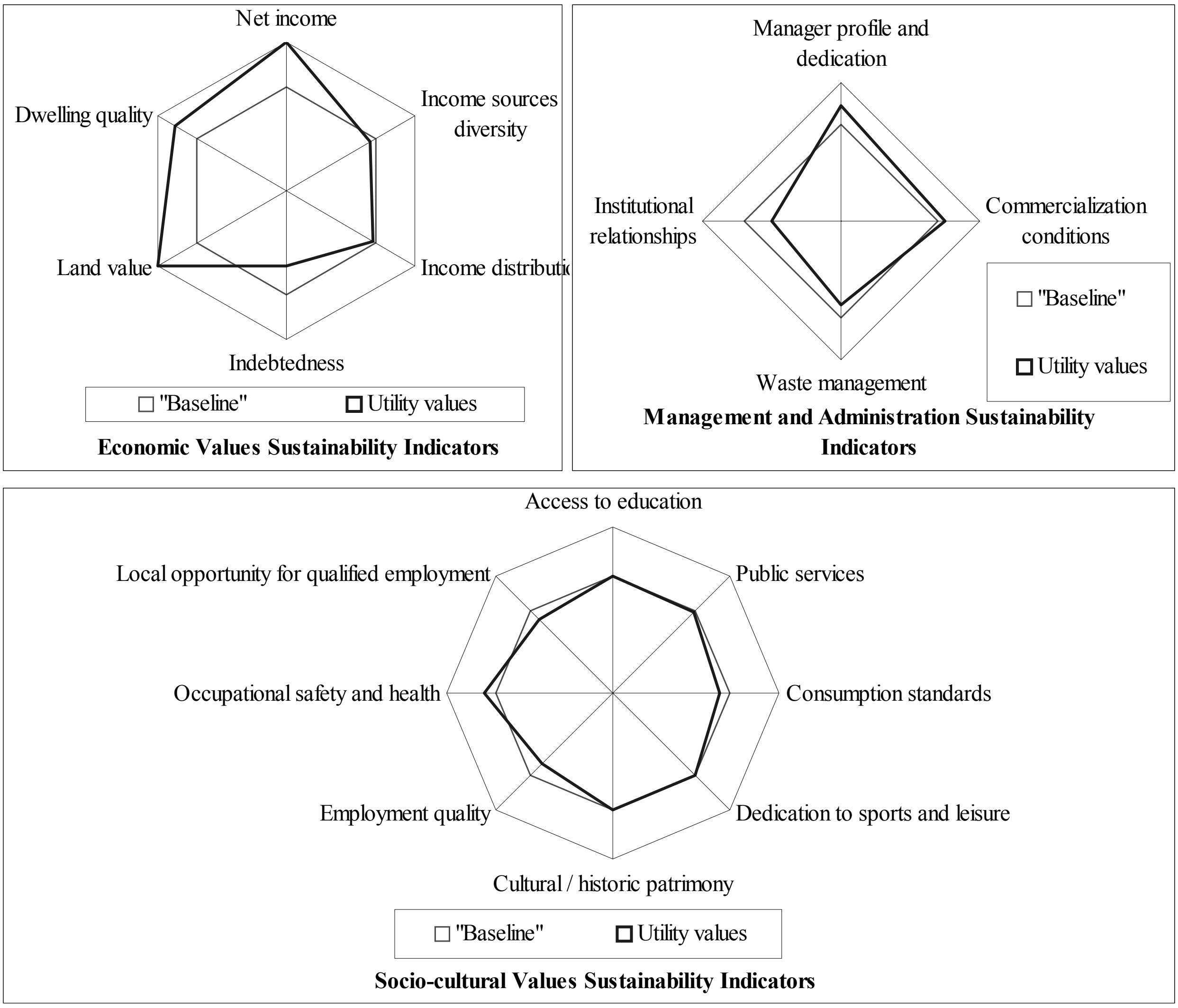


Figure 5. Sustainability index for the Socio-cultural Values, Economic Values and Management and Administration dimensions of the Ishihara Oil Palm Farm, Santo Antônio do Tauá (PA, Brazil), according to the APOIA-NovoRural System. March 2007.

The Economic Values dimension (0.78, Figure 5) showed important indicators with indices well above the baseline sustainability level. Net income improved security, stability and amount (index = 1.0) resulted from the oil palm activity. Reasonably diversified agricultural Income sources (0.65) were associated to a fair pattern of Income distribution (0.67, 1-3 net income / total wages relationship). On the other hand, an increased Level of indebtedness (index = 0.50) was associated to very important Land value improvement (1.0) and good Dwelling conditions (0.86).

The Management & Administration dimension (mean result = 0.67, Figure 5) showed very positive indicators, contrasting with important opportunities for improvement in the sustainability performance of Ishihara Farm, without need for heavy investments. Among the indicators denoting valuable management advantages brought about by the oil palm production activity stand those related to the farmer Profile and dedication (0.83), including local residence, exclusive dedication, specialized training for the activity, family involvement, and formal accountancy system utilization. The only missing component for the indicator was the application of a formal planning system, which may become imperatively valuable for tracking the dynamics presently being imposed onto the agro-energy business. The Commercialization conditions indicator resulted above the baseline level of the APOIA-NovoRural System (0.75), failing to comply only with some components less related to oil palm management, such as Linkage to services/activities and Association to local producers.

Even without regular public service for wastes removal, disposal of domestic residues has been adequately performed, exception to sanitary sewage treatment, that may be impairing groundwater quality with nitrates. Solid domestic residues have been selectively handled, with organic matter being incorporated to soil as amendment. Finally, the Institutional relationship indicator (index = 0,50) denoted availability of Formal technical assistance and Association/Cooperation, both offered by Dentauá Ltd., and also Access to legal consultation, while no Nominal technological affiliation or Continuous training could be referred to.

Conclusion

The sustainability assessment of the Ishihara oil palm farm pointed out important contributions of the main agricultural activity (oil palm plantation) for the socio-environmental performance of the establishment. The Sustainability Index obtained (0.70), which stresses the conformity with the baseline proposed in the APOIA-NovoRural System, figures as a target for continuous improvement and a tool for the farmer’s decision making regarding the adoption of technological innovations, managerial practices, and infra-structural and processes investments for improving the establishment’s performance.

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References

Bisset, R. **Methods for environmental impact assessment: a selective survey with case studies.** In: Biswas, A.K.; Geping, Q., Eds. Environmental Impact Assessment for Developing Countries**.** London: Tycooly International, 1987. p. 3-64.

Monteiro, R.C. & Rodrigues, G.S. A system of integrated indicators for socio-environmental assessment and eco-certification in agriculture – Ambitec-Agro. **Journal of Technology Management and Innovation**. v. 1, n. 3. 2006. pp. 47-59.
http://www.jotmi.org/index.php/GT/article/view/art10;

Rodrigues, G.S.; Campanhola, C. Sistema integrado de avaliação de impacto ambiental aplicado a atividades do novo rural. **Pesquisa Agropecuária Brasileira.** v. 38, n. 4. 2003. pp. 445-451.

Rodrigues, G. S. & Moreira-Viñas, A. An environmental impact assessment system for responsible rural production in Uruguay. **Journal of Technology Management and Innovation.** v. 2. n. 1, 2007. pp. 42-54. http://www.jotmi.org/index.php/GT/article/view/art34.

Rodrigues, G. S.; Rodrigues, I. A.; Buschinelli, C. C. de A.; Ligo, M. A.; Pires, A. M.; Frighetto, R. T., Irias, L. J. M. Socio-environmental impact assessment of oleaginous crops for biodiesel production in Brazil. **Journal of Technology Management and Innovation.** v. 2. n. 2. 2007. pp. 46-66. http://www.jotmi.org/index.php/GT/article/view/art45

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