BIOMASS, HOT ISSUE

SMART CHOICES IN DIFFICULT TIMES

Creative Energy
Energy Transition

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Smart choices in difficult times

FOREWORD

In the last half year an international social and political debate has arisen about biomass. That debate is often pursued in a furious tone. Understandably so, because at stake are key themes such as world food and energy provisions. It is therefore a complex and emotionally charged debate.

It is important to carry out the debate on the basis of a clear oversight of the relevant facts and a reliable analysis. These however are often missing. That is of course because of the theme's complexity and the interests at stake. Furthermore I would like to emphasize that biomass can and must contribute to make the Dutch energy household more sustainable, a task to which the Taskforce Energy Transition is dedicated.

I am therefore grateful to the Biobased Raw Materials Platform for successfully making such a clear analysis in this publication. The Platform has created oversight and space. It analyses the potential of biobased raw materials in contributing to world food provisions and the demand for industrial raw materials and energy, but then within the well-indicated and acceptable preconditions. It also indicates the potential of biobased raw materials to give agriculture a new impulse to renew itself all over the world and thereby offer many people in developing countries a new perspective.

Although, of course, the last word has not been spoken in this publication. New facts and progressive insight will continue to restore the discussion. But it is indisputable that the Biobased Raw Materials Platform has laid a thorough base for the debate with this publication, as well as with the Biobased Book from 2007. A global debate, that is nevertheless of great importance to the Netherlands, with their strong agricultural and chemical sectors and internationally important position as trading country.

Theo Walthie,
Chairman of the Taskforce Energy Transition

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SUMMARY

The use of biobased raw materials for energy and material has been brought into discredit in the past years. The use of bio-energy is repeatedly held responsible for the recent food crisis and for the deforestation of rainforest, and questions are being asked about the advantages to the climate. As a result of this discussion, the joint Platforms in Energy Transition have once again considered their position in respect to biomass. Along with the Biobased Raw Materials Platform, these are the Chain Efficiency Platform, the New Gas Platform, the Sustainable Mobility Platform and the Sustainable Electricity Supply Platform.

The Platforms share the concerns existing in wider circles. Bio-energy must not be produced at the cost of food provisions. At the same time the Platforms are of the opinion that biomass is essential for achieving a sustainable energy system. The Platforms will maintain ambitious objectives in this field, on condition that application of biobased raw materials takes place in a sustainable and intelligent fashion, where agriculture can still produce enough to feed the world. The discussion about the sustainability of bio-energy is essential and the Platforms seek a balance in this discussion. It appears from scientific research that agriculture can produce sufficient food and energy and materials. The productivity of agriculture continues to increase, even though the efforts required have not come up to mark in large parts of the world during the last decade. Limits for retaining biodiversity are respected in the intelligent use of biomass: no damage to natural areas for new production. Care is taken of improved performance in crops: less artificial fertilizer, higher yields. Types of agriculture that are beneficial to the environment, labour conditions and local economy are stimulated in the production countries. The efficiency of the entire chain, from plant to food and use of biofuels, is increasing continually which in turn decreases the emission of greenhouse gases. Waste products are used usefully. New crops with high yields are being developed. And new products are being made and new applications are being opened up with the new technologies.

Clever crops and clever technologies form an essential part of the intelligent use of biomass. Plenty of such crops and technologies are being developed. The first step is to make use of the whole crop. Important parts of the harvest, such as straw and foliage, often remain unused. They could be used for energy and materials. Wood-like crops and grasses with a high yield (often higher that that of food crops) can be planted on fallow land, on marginal and degraded soils and – if the food situation permits – also on arable land.
Innovation in these areas is happening at high speed. Boundaries that appear now can be shifted with sufficient effort far away in ten years time. The efficiency can be increased with clever technologies, not only for the energy and material chains, but also for the food chain.

It goes without saying that world food production, local as well, must not suffer from the production of bio-energy. Clear criteria must be set out to achieve this and there should be some type of monitoring to check whether it is upheld. The EC has formulated criteria, the Netherlands and the United Kingdom preceded the EC in this. Round Tables of producers and users of food crops such as palm oil, sugar and soy are currently certifying their products. Monitoring the indirect effects, such as the displacement of crops or arable land which indirectly promotes the exploitation of tropical rainforest for example, is more difficult. But this is also feasible in principle.

The Platforms have arrived at the following conclusions:

- Biomass has the potential to play an important role in sustainable energy provision for society with energy and materials.
- There are no reasons why bio-energy should either be rejected or received with open arms. In view of the risks of the use of biomass, careful and intelligent use is recommended.
- According to the latest insights, sufficient potential can be developed in biobased raw materials (if the productivity increase in agriculture across the world remains at the top of the list) to cover the growing demand for bio-energy and biomaterials without endangering the production of food.
- Use must be made of chains with a good greenhouse gas balance and little environmental impact.
- It is imperative to increase the efficiency in all chains (food, cattle feed, energy) constantly by using the whole crop and by integrating the chains.
- Biobased materials offer new chances for economic activity, in the Netherlands as well as in developing countries, and a new source of income for farmers all over the world.
- Certification of biomass, monitoring the food situation and the macro-effects such as land usage are the key variables for the successful application of biobased raw materials.
- Speedy development of technologies which enable more efficiency in the chain (particularly biorefining, biocascading and second generation technologies) are necessary to counterbalance the tension between the ambition of the current (European) policy and the (current and future) world agricultural production.

A large potential of biomass can be developed in a responsible fashion with intelligent use and consideration to the conditions in force.

1 CONTROVERSY AROUND BIOMASS

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In April 2007 the Platform Groene Grondstoffen (the Biobased Raw Materials Platform) published the Groenboek (the Biobased book), a vision of the use of bio-based raw materials (biomass) in the Dutch economy. It states that 30% of the fossil fuels used (petroleum, natural gas, coal) will be replaced by biomass by 2030. The Groenboek contends that biobased raw materials should first be sourced in waste products and in the more efficient use of biomass in current applications (10% of fossil fuels in the Netherlands could already be replaced using this method), subsequently in reliable import and finally in energy cultivation (the cultivation of plants which supply food as well as raw materials).

The use of biobased raw materials for energy and materials has fallen fast into discredit, particularly due to the competition with food production. As a result of this discussion, the joint Platforms in Energy Transition have once again considered this attitude. Along with the Biobased Raw Materials Platform, these are the Chain Efficiency Platform, the New Gas Platform, the Sustainable Mobility Platform and the Sustainable Electricity Supply Platform. The Platforms confirm that biomass is essential for achieving a sustainable energy supply. The Platforms want to uphold ambitious objectives in this field, but with condition biobased raw materials are used in a sustainable and intelligent way, whereby agriculture produces enough to feed the world and sustainability is guaranteed.

The intelligent way implies, among other things, the use of the whole crop including the waste products – with biorefining, biocascading and the use of second generation technology as keywords. Biorefining means that the harvest is separated into a part that is used for food and a part for energy and materials. Biocascading is the use of biomass for the most high-grade applications and the waste products used for a more low-grade application. In this manner the value and the energy content of biomass are utilized to a maximum. Second generation technologies utilize the value of fibrous materials not suitable for food. Furthermore intelligent use of biobased raw materials assumes a constant growth in the productivity of agriculture through yield increase and new crops, with the use of resources (artificial fertilizer, water) as low and the efficiency of user chains as high as possible. These points will be elaborated further in this publication.

The driving forces behind the use of biobased raw materials, as contended by the Platform Groene Grondstoffen in the Groenboek, lie in the field of the environment as well as economy. Fossil fuels give off CO_2 when used, the most important greenhouse gas. Other types of pollution, namely nitrogen oxides (NOx) and fine particles, also go hand in hand with the use of petroleum, natural gas and coal. Biobased raw materials in particular score much better on CO_2 emissions when used cleverly. Furthermore the world is slowly becoming convinced that fossil fuel use must be reduced because it is very expensive and the reserves are limited. The reserves are spread unevenly around the globe, resulting in the supply to industrial countries such as the Netherlands being vulnerable to disruptions. And finally, the Platform foresees new chances for the Netherlands because of its unique location and the advancement in the economy, imports, processing and the transit of biobased raw materials.

The debate about biobased fuels has gained momentum since 2007. One application in particular is being discussed: the use of food crops for making transport fuels. Palm oil and Cole seed oil for example are processed into biodiesel. Sugar cane and corn are used for bio-ethanol. This use of biofuels has been going on for some time, particularly in Brazil, who made the decision to be less dependent on imported petroleum thirty years ago and set up their own industry for the production of bio-ethanol. In Europe and the US the use of biofuels began around 2000 – and it is now starting to take off just at the moment world food prices are rising and access to food by the poorer parts of the world's population is threatened .
The relationship between hunger for energy and the actual hunger of people is easily made and that has not helped biofuels. People are more important that cars, three Latin American presidents agreed this in April 2008, thereby distancing themselves from Brazil. "Converting food into fuel is a monstrous activity," stated Fidel Castro on 7 May 2007. Jean Ziegler, food rapporteur from the UN, says: "The right to live goes before a full tank." He calls the European guideline that 10% of all transport fuels must be of biobased origin by 2020 "a crime against humanity." More criticism comes from conservationists, who watch helplessly as jungle is cut down in countries such as Brazil, Indonesia and Malaysia, and who make a (in) direct link with the establishment of sugar cane and palm oil plantations for the production of bio-energy.

There are reactions to the attacks on biofuels.
The Brazilian President Lula defends his country's policy: "The price of food is increasing because the poor are eating more, not because of biofuel production." He argues further that the supply of food is inadequate not because of biofuels but because the rich West is protecting their agriculture with subsidies and trade barriers. For that reason other countries will not increase their food production because they cannot export the surplus, according to Lula. And Professor and former Deputy Director of the FAO, Louise Fresco, wrote in her column in the NRC Handelsblad on 18 March 2008: "Are we standing at the eve of mass famine now that the price of food is increasing? Is world peace in danger? The short answer is no. Food is not oil. Food stocks fluctuate but the whole line is never exhausted unless a planetary disaster occurs. Food is after all a sustainable resource: (...) the stocks are replenished after each growing season."

A couple of comments are necessary about the current food/fuel discussion, and in particularly, on the way they are conducted. The first reaction is that the discussion about the allocation of land and harvests is of all time. Agriculture is not only for producing food. Land is also used for the production of fibres for clothing (cotton, linen), timber and paper. Much land is used for pasture and the production of cattle feed. The preservation of natural areas is essential for maintaining biodiversity, and also for tourism. More and more land is used for urbanization, and that is often the most fertile land in the river deltas. The use of arable land for perfumes and flowers is greatly appreciated. No-one has ever resented the rose or tobacco cultivator for using land that could have been used to feed hungry mouths. There will be no objections to using arable land for the production of energy and materials, as long as bio-energy is made from waste products and the production of food remains level.

The second reaction is that the current developments even have positive aspects when seen from other perspectives. The increasing demand for biomass creates a new source of income for farmers over the whole world. For many decades European farmers have needed subsidies for an adequate income. Suddenly, because of the increased agricultural prices, their income can come from the market. The rising agricultural prices offer third world farmers new chances and provide an alternative to migration to the towns. Rising prices offer the opportunity of bringing the undersized investments in the agricultural sector world-wide up to the required standard again and therefore increasing production.

The third reaction is that the food/fuel controversy concerns the production of biofuels in particular, in other words: biodiesel and bio-ethanol that are used as a substitute for diesel oil and petroleum. Nevertheless the majority of the current use of biomass relates to the wood and other fibres that are used for the production of heat and electricity. This definitely applies to the poorer countries where wood is the most important source of energy. Competition with food is only indirect here: land that is used for fibre production could potentially be used for food. This indirect competition is not unimportant: there could be important points of conflict here, certainly if the use of biomass increases greatly.

It is notable in the present discussions that the parties do not agree on many points. We are going to look at a number of these points.

Controversies

Biomass and famine, now and in the future

The world anno 2008 is on the eve of a great food problem. Food riots are taking place in many countries. In Pakistan, where the flour price has doubled, the army has had to protect storage depots and transports from attacks. In Egypt long queues have formed in front of the subsidised bakeries and fighting has broken out. In Yemen and Cameroon there have been dozens of deaths during food riots. Other countries where riots have occurred are Ethiopia, Haiti, Indonesia, Mexico, the Philippines and Senegal. In Thailand rice is stolen at night from the fields so that armed villagers are forced to defend their fields.

Lester R. Brown from the Earth Policy Institute, who provided this data, is of the opinion that we are contending with a situation without precedent in modern history. World food production is increasing, but less and less, while there are 70 million more mouths to feed every year. The increase in agricultural productivity is levelling off: while between 1950 and 1990 the production of grain per hectare rose by 2.1 % per year, calculated over the whole world, these increases amounted to 1.2% per year between 1990 and 2007. Climate change also applies here. In Australia continual drought has led to crop failure. In Asia the glaciers are melting resulting in too little water in the in the rivers during the dry season. Water provisions for agriculture are becoming acute in increasingly more areas.

Up until now no actual food shortages have been reported. The acute food problem comes from price increases as a result of which the poor can buy less food. World food programmes, in Darfur for example, are confronted with sudden shortages. The question is: can the world produce enough food? Quite apart from the question of whether agriculture can also produce large quantities of biomass for energy! In how far is Louise Fresco's optimism that the world food stocks will be replenished when there is sufficient (with purchasing power) demand justified?

There is an enormous gulf between potential and factual food production. If all the signals are positive the world can amply feed the expected 9.5 billion people in 2050. "There is enough food to feed twice the world population," says UN rapporteur Jean Ziegler. Improvement programmes must reach all the farmers in the world to substantiate this in the future. The so-called green revolution, started in the fifties of the last century, was only partly successful in this. Why should it now work in the future?

The IAASTD (International Assessment of Agricultural Knowledge, Science and Technology for Development) report from April 2008 indicates the necessity for improvements to markets rather than to technology. The best incentives for increasing production are sufficient demand for agricultural products and that farmers can earn a reasonable income. The IAASTD also points out, just as President Lula from Brazil does, the trade barriers and subsidies in the industrial countries. But

Food distribution in Kenia by the Netherlands Red Cross

the recent food crisis has further disrupted action on the world market because the food exporting countries curbed exports to combat home price increases. This includes Russia, Ukraine and Argentine (grain), and Vietnam, Cambodia and Egypt (rice). It has also become painfully clear that speculation in the agricultural markets pushes up the prices. 60% of the wheat market is in the hands of an index fund (De Volkskrant, 25 April 2008). But still many analysts hope that the increased food prices will give rise to farmers all over the world increasing production.

Farmers over the whole world will have to work harder to produce enough on the available arable ground so that the production of large amounts bio-energy will become possible. World population is growing and prosperity is increasing causing the food demand per head of the population to also increase and food patterns to change. The traditional growth percentage of world food production cannot keep pace with the growing demand. Extra growth of agricultural production will be necessary to enable reliable exploitation of bio-energy, combined with improved utilization of the harvest by biorefining and biocascading. We will have to consider whether the right crops are been cultivated in the right places. An optimisation battle is possible resulting in the use of artificial fertilizer and water also being limited and the production growth sustainable.

Biomass and price increases

The growing demand for biofuels coincides with the explosive price increase of food. That can hardly be a coincidence... Or can it?

Firstly we must note that the price of nearly all raw materials has exploded in the last ten years.
The dollar price of aluminium has doubled, nickel quadrupled, copper has increased fivefold and lead has increased six fold. The price of raw materials is generally stated in dollars. The price increase in Euros amounts to about half the dollar increase because the value of the Euro has almost doubled in respect to the dollar in this period.

Secondly it is noticeable that the prices of most important foods, such as grain, rice and edible oils, has in fact dropped in the period immediately before 2001 (see 4.8). Roughly speaking the prices only started to increase in 2001 resulting in them reaching the 1996 price in 2007 and only going higher in 2008. The price drop in 1996-2001 is not unique, on the contrary. It is the continuation of a long existing trend: since about 1900 the prices for agricultural products have dropped constantly. The actual price of agricultural products (worldwide) in 2000 was only 45% of the 1973 price.

There are many factors besides biofuels that have affected the price increases. FAO, World Bank etc. state the following influences:

- The price of fossil fuel affects the cost price of agricultural products via diesel oil, fertiliser and pesticides.
- The cost price is also increased by the growing scarcity of resources such as fertile land and water.
- Speculation as a result of less stock pushes the price up. Financial markets have also become interested in agricultural products promoting extra speculation.
- In 2006 a large number of harvests failed through drought and other natural disasters.
- Income growth translates directly to increased consumption of food in many developing countries.

It is expected that the demand for some crops will increase greatly resulting in the pressure on prices remaining. An example is soya, its consumption will grow due to increasing prosperity and more consumption of meat (soya is an important constituent of cattle feed). But there is still a link between the use of biofuels and the price of agricultural products such as sugar cane and palm oil. We will follow Schmidhuber’s argument (FAO) and take the cultivation of sugar cane as an example.

Ethanol from Brazilian sugar cane competes with petroleum upwards from a price of about $ 35 a barrel. From this price upwards the ethanol price fluctuates with the oil price because of the integrated markets. More and more producers in Brazil have sugar factories which can produce sugar for consumption or for ethanol. The price of sugar for consumption has to keep pace with the price of sugar for ethanol, otherwise the producers would all choose to produce ethanol. However the oil price does not only indicate a minimum for the price of the crop concerned but also a maximum. If the crops become too expensive they will price themselves out of the fuel production market, which will result in a drop in demand and the price.

Agricultural products not considered for bio-energy can increase in price through the market for bio-energy. Farmers could decide to transfer from sugar or corn to such a crop because of the higher price. Other agricultural products could be negatively affected by this. The advance of the palm oil plantations in Malaysia (NB. largely for markets other than energy production) was at the cost of the production of rubber and cacao, as a result of which the price of these products could be pushed up; the price of corn in the US increased by 23% in 2006, largely due to the government's bio-ethanol programme. But the impact of biofuels on food prices is limited at the moment by the fact that no more than about 1% of the world's arable land is used for biofuel production. The price increases for rice, a crop that is not used for bio-energy, cannot therefore be explained by these factors.

Predictions about further price development differ greatly. The most authoritative body, the FAO, arrives, on the grounds of extensive analysis, at the conclusion that production will adapt to increased demand. Prices for most crops will then stabilize, but at a higher level than at the beginning of this century (see 4.8).

To summarise we can suppose that many factors have contributed to the recent price increases, including the high oil price. Use of agricultural crops for biofuels plays a certain role, not particularly because shortages occur but because the prices are linked in an already tight market for agricultural and natural oil products. These increases must be contrasted with the constant drop in prices for agricultural products in the last century.

Biomass and deforestation of tropical rain forest

Palm oil and bio-ethanol have been put in a bad light by the suspicion that tropical rain forest has been cut down for their production. The Western hunger for energy would be at the cost of irreplaceable natural areas. In reality it is more subtle. The most important driving force behind cutting down tropical rain forest, in Brazil as well as in Indonesia and Malaysia, is the acquisition of tropical hardwood. The WNF and the FAO have monitored the situation in Indonesia and Malaysia in the past years. From this it appears that in the period from 1990-2005 about 30 million hectares have been deforested, an area ten times the size of the Netherlands. Over the years the size of oil palm plantations has grown by 6.5 million hectares, of which about 50% was already cleared ground. Overall therefore, 10 to 15% was deforested for the sake of building oil palm plantations in the period. And no more than 1.5% is intended for biofuels in the palm oil market.

A very large area of deforested land lies in Indonesia (20 million hectares, it is said). There is not much incentive to build oil palm plantations: new infrastructure has to be created and the big money-maker (tropical hardwood) has already disappeared. But that area does have the potential for additional production of palm oil, without cutting down anymore rain forest. Suppose half that area, 10 million hectares, could be successfully planted with oil palms, a yield of 4 tons of oil per hectare would supply 40 million tons of palm oil per year, while the current world market amounts to 37 million tons. Expansion of palm oil

Rainforest destroyed for creating oil palm plantations (Borneo)

production (strictly regulated) does not have to be at the cost of tropical rain forest. Indonesia has announced these regulations but enforcement is a problem.

In Brazil there is also hardly any *direct* relationship between ethanol production for sugar cane and cutting down jungle in the Amazon. The pressure of sugar cane in this area is notably less than that from soya. This has economic reasons. Soya yields much more per ton (peas; $ 400/ton, oil; $ 1,200/ton) than sugar cane ($ 100/ton). On the other hand the sugar harvest is much bigger, around 14 tons/ha, as opposed to 3 tons/ha for soya beans. Cultivation of sugar cane for export in the deepest interior is not profitable because transport to the ports costs $ 70-80/tons (but cultivation for local consumption and use might be profitable). Moreover the Amazon area with its daily rainfall is not the right climate for sugar cane, which only forms sugar under drought stress. There is an important side-effect: the increased growth of corn in the US and sugar cane in Brazil for ethanol is at the soya area's expense and the additional production of soya comes partly from the Amazon area.

The Brazilians view cutting down tropical rain forest from a different perspective. The Brazilian large land owner (of soya plantations) and governor of the Mato Grosso province, Blairo Maggi urges the West to adopt a less arrogant tone with this question. Brazil simply has the same ambitions for their population as the western countries had earlier, he states. And the latter have done nothing in the last century other than expanding to 'uncultivated' areas, so where does the West get the right to read Brazil the Riot Act?

Biomass and the greenhouse gas balance
At the beginning of 2008 two articles appeared in the scientific magazine Science which attracted much publicity. It was calculated in these articles that using biofuels in traffic would hardly make any contribution to combating the greenhouse gas impact. When rain forest is cut down, large quantities of CO_2 are released from the felled trees and from the oxidation of humus, which take decades to redress by CO_2 return when biofuels are produced from biomass cultivated on the cleared ground.

Converting corn into bio-ethanol can have a bad greenhouse gas balance, particularly when prairie is first converted into arable ground. Another potentially disruptive factor to the greenhouse balance of biofuels is the release of the strong greenhouse gas N2O from artificial fertilizer, during production as well as during its stay in the ground.

We now arrive at one of the main reasons why *intelligent* use of biomass is so important. Biomass chains prove to differ strongly in the greenhouse gas balance and for that reason must be carefully selected when choosing methods of cultivation and processes. We will give a couple of examples.

- The direct CO_2 impact when natural forests or grasslands are cleared for cultivating biofuels is negative – a reason to not do it.
- Ethanol from corn does indeed often have a less good greenhouse gas balance especially when it is distilled in ovens fuelled by coal (which is often the case in the US). But in the US they are more interested in an independent energy supply than in greenhouse gas impact.
- The greenhouse gas balance is often worsened by the use of artificial fertilizer: the strong greenhouse gas N2O is created in the soil as well as during production. Limiting the use of artificial fertilizers is possible, guided by plant needs, and there are affordable methods to decrease N2O during the production of artificial fertilizers by more than 90%. Decreasing the use of artificial fertilizers in agriculture as much as possible is desirable for other reasons as well. The emission of nitrogen compounds during the cultivation of

crops and intensive cattle farming leads to eutrophication, acidification and adverse impacts on human health and bio-diversity. Biofuels from food crops often have a bad greenhouse gas balance (except for ethanol from sugar cane). The so-called second generation biofuels (including ethanol and biodiesel produced from wood-like material and waste products), as well as biogas from manure or sludge fermentation, have a much better greenhouse gas balance. The greenhouse gas balance is also improved when the whole plant is used, as happens in biorefining and biocascading.

All the fossil energy input (in the form of energy consumption during the production of artificial fertilizer, transport and the use of tractors), plus further greenhouse gas emissions in the chain from cutting down rain forest, for example, are compared with the output of biofuels and other products, to calculate the greenhouse balance in a biomass application. Besides CO_2 emissions, the other greenhouse gases such as N_{20} and CH_4 are included to calculate the impact to the climate by the production and use of biofuels. The recent design guidelines from the EC state that the limit for allowing biofuels is that they generate at least 35% less CO_2 emissions, compared to an equivalent quantity of fossil fuel. it is proposed that this percentage is raised to 50% by 2015. In this discussion, the Netherlands suggests employing stronger criteria: 50% and 60% later. Bio-ethanol from sugar cane complies amply with these limits: typically 74% decrease. Bio-ethanol from corn and biodiesel from palm oil perform less well: typically 56% resp. 57% decrease. Another measure for the useful yield of biomass cultivation is the net energy yield per hectare, calculated as the energetic value of the harvest in its various forms and decreased by the direct and indirect input of (fossil) energy.

Useful by-products of biofuel production from food crops do not appear in the greenhouse gas balance. About a third of the wheat used for bio-ethanol is returned to the various animal food chains in the form of Dried Distiller's Grains with Solubles (DDGS), a protein-rich co-product. Cake that is produced during the production of biodiesel from Cole seed also has these properties. For that matter the greenhouse gas balance does not form the ultimate benchmark for the intelligent use of biomass. The fact is that biomass is hardly ever wasted in the greenhouse gas balance. In Brazil the (manual) harvesting of sugar cane is still preceded by setting fire to the crop in the field in more than half the cases. Snakes and scorpions are chased away and the harvest is made easier. Only the dry foliage is burnt (with a lot of environmental pollution), not the moist sugar-holding stalk. This is an inefficient use of biomass because the energy content from the foliage could also have been used usefully. Furthermore the distillation of ethanol often takes place in obsolete, inefficient appliances. One of the criteria for the intelligent use of biomass is that the plant's energy content must be utilized as much as possible. Biorefining and biocascading aim at this useful use of the whole plant.

Field of rape seed

Biomass and the use of transgene plants
There are differing ideas about the application of genetically modified crops (transgene plants or GM crops) in the world. While Europe is opposed, they are used on a large scale in the US, Argentine and Brazil and to a lesser extent in Canada, India, China, Paraguay and South Africa. Soya, corn and cotton form the majority of the GM crops.

Genetic modification of plants can serve various purposes, such as increasing the yield, resistance to plagues or harmful insects or to pesticides, increasing the share of useful components or decreasing the need for artificial fertilizers or water. Supporters of GM technology point out the speed that desired properties can be built in and the effect this technology has on safeguarding crops. Opponents are worried that the modified properties will spread to natural sorts and that the natural balance will be disrupted. In countries where GM crops are permitted, extensive procedures for approval are enforced which are intended to minimise such risks. In Europe there is concern for the impacts on public health in particular when GM crops are consumed. Transgene plants are not essential for the successful use of biobased raw materials. They can contribute to larger harvests and a smaller chances of crop failure, reduction of the environmental impact of cultivation or increase the useful yield through the stimulation of production of worth-while substances. The Platform Groene Grondstoffen is of the opinion that GM crops could have great advantages but that broad debates would have to reveal whether the advantages outweigh the possible disadvantages. Up until now the discussions have been mainly about the application in food crops. The balance of pros and cons in the EC public debates will possibly be different if this technology is applied to non-food crops in protected environments (for example when algae is cultivated) or with the specific cultivation of energy crops.

Shared visions

Now that we have discussed the most important controversies, it should also be noted that the verdicts in a number of fields differ much less:

- The use of organic residues is in general judged positive. It scores positively on the greenhouse gas balance. The problems are therefore mainly economical: how can waste products be collected at low cost? Waste products are often wet, which restricts their use in most processing methods. Moisture has to be evaporated at the cost of much energy. Extracting all the waste products from the land must be avoided because this could disturb the mineral and carbon balance in the soil.
- There is hardly any objection to burning waste wood or other fibres to produce electricity and/or heat. A point for attention is whether or not indirect competition exists (through the use of the land) with the production of food and other consumer goods (paper, furniture etc.), or that the wood is not extracted at the cost of biodiversity, and whether conversion into useful energy can take place with sufficient profit and without pollution.
- Concordance with the desirability for the fast development of technologies of second generation fuels exists in wide circles. This is the general name for liquid and gas fuels made from fibrous material and the parts of plants which are not suitable for food. Many companies are working hard to commercialise these second generation technologies at the moment. Biomass is converted more efficiently into biofuel by second generation technologies, resulting in the land use being reduced and the greenhouse gas balance improved. It is even possible to catch the CO_2 when producing biogas from biomass, resulting in net CO_2 profit. Moreover there is no direct competition between second generation biofuels and the production of food. Through biocascading for that matter, including the production of first generation bio-fuels, the total energy yield from one hectare can be just as high as when producing second generation biofuels. Wide approval exists for the idea of dual-purpose agriculture, in other words cultivation where part is destined for food and the other part for the production of energy and/or minerals. But disruption of the carbon and nitrogen balance in the soil is warned against. Carbon (in the form of humus) and nitrogen (as general nutrient) are essential for plant growth. If the whole plant is harvested and minerals, carbon and nitrogen are not replaced, the soil will deteriorate quickly. We will

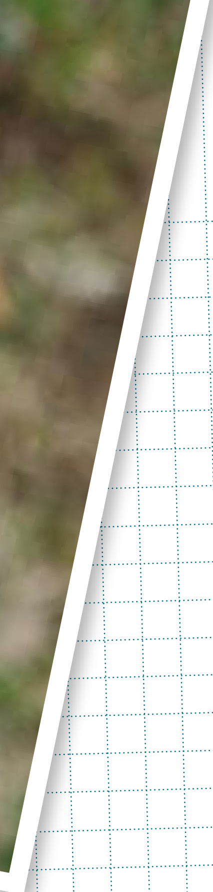
discuss examples of dual-purpose agriculture in Chapter 3 (sugar cane and wheat).

– Biorefining is another development of this concept. Vegetable matter is divided into a number of components in biorefining which increases the economic value and the greenhouse gas balance is often improved. Grass, for example, provides fibres (for combustion, building applications or second generation biofuels), proteins (for cattle feed) and polysaccharides (for the production of chemicals). Chemical production from biobased raw materials has a strong positive indirect impact on the greenhouse gas balance of the crop because the chemicals would otherwise be synthesised (using much energy) from fossil fuels.

Conclusion

Objections to biomass must be taken seriously but while respecting them, the objectives of the Platform must be upheld. In the best case scenario, the use of biomass can provide a win-win situation (economic, social and ecological). Less favourable side-effects can occur even then (for example repression of other crops). But there is no reason to reject the use of biomass entirely or even to accept it with open arms. Biomass could make an important contribution to forcing back the greenhouse impact and decreasing the dependence on fossil energy reserves, but it must be used intelligently: see the following chapters.
When used intelligently, biomass could mean a new, valuable source of income for farmers all over the world.

2 THE USE AND REGULARIZATION OF BIOMASS



2 THE USE AND REGULARIZATION OF BIOMASS

Biomass is the most important sustainable source of energy. Biomass accounts for about 10% (46 EJ) of the world energy usage of 489 EJ. This contribution is larger than that of hydropower (26 EJ) or nuclear energy (26 EJ). The lion's share of consumption of biomass (37 EJ) is non-commercial, mostly by the poorer population of developing countries. At the moment modern consumption of biomass (for industry, generation of electricity or transport) comprises 9 EJ and this is growing fast.

The consumption differs greatly from country to country. The proportion of biomass does not exceed 5 % anywhere in the industrial countries (OESO countries). In non-OESO countries it averages19% but the amount differs greatly between the countries. Countries that have their own oil and/or gas, such as the North African countries, use little biomass. South of the Sahara the share is very large (more than 90% in Mozambique, Ethiopia, Tanzania and the Democratic Republic of the Congo).

The consumption in OESO countries is dictated by high oil prices, the aim to lessen the dependence on suppliers and climate concerns. But for many people in developing countries biomass is the only accessible source of energy. Biomass is used for cooking and heating in the form of products from the forests (charcoal, firewood), by-products of agriculture (peelings and shells) or manure. Traditional use is often inefficient and also leads to health problems from the smoke, for example.

The Dutch ports have great ambitions in the field of biomass. The largest portion of the international trade in biomass will be concentrated around the harbours, in combination with the storage and processing of raw materials and marketable products (biocommodities). There are already five factories being built in the Rijnmond for biodiesel and two for bio-ethanol. Delfzijl has been named as the place of business for the first commercial factory in the world for torrefaction (converting organic raw materials into granules by heating). Nedalco in Sas van Gent wants to build a factory for the production of second generation bio-ethanol from wheat waste.

Rotterdam's ambition is to become the centre for processing and storage of bio-commodities for the whole of North West Europe. Storage of biofuels in the Rotterdam harbour doubled in 2007 compared to 2006. Storage of bio-ethanol increased by a half million ton to 1.6 million tons (was only 0.2 million tons in 2002). The largest increase was in the storage of biodiesel: from 50,000 tons in 2005 to 250,000 tons in 2006 and 1.2 million tons in 2007. The Port of Rotterdam expects a continued increase for 2008. The biggest customers are the oil companies who use it to mix with petrol and diesel.

A small amount is used in pure form (high blends). Pure biodiesel (B100) can be used in older diesel engines, but a warranty would as a rule elapse if used in new engines. In Germany B100 is available at 2,000 filling stations, but subsidy cutbacks have caused the collapse of this market. An automobile has to have a modified (flexifuel) engine for almost pure bio-ethanol (E85). Favourable financial and other incentives policies ensure a growing market share for E85 in countries such as Sweden, Germany and France. However the Netherlands does little or nothing on the consumer side to stimulate the use of biodiesel en bio-ethanol in high blends. The Netherlands implements the EC guidelines in the most minimal form.

These EC guidelines mean that 5.75% of the volume of engine fuels must consist of biofuels by 2010, with the prospect of this proportion growing to 10% by 2020. The simplest manner of acting on this is by blending. Car and truck engines do not need to be modified with these percentages.

The most important range of application for biomass is however electricity and heat production from wood and other fibres. There are four main routes:

- The co-firing of wood chips and other fibrous material in coal-fired power stations. These power stations can cope with a blend of up to 30% biomass, but this will be limited to 20% in practice because of the extra air pollution from incinerating biomass. The production of electricity and heat from waste incineration (a large part of the energy content of household waste comes from biomass).
- The fermentation of manure and the waste products from agriculture into biogas (a mixture of CH_4 and CO_2), followed by the generation of electricity and heat form this gas. An alternative is to upgrade biogas into a replacement for natural gas (biogas).
- The gasification of biomass, a still experimental technique whereby synthesis gas or syngas is created, principally consisting of CO and H_2, or a mixture with CH_4, from which synthetic natural gas (SNG, biogas) can be made.

Biorefining or biocascading and the production of biomaterials (biobased materials) can be included as other important ranges of application.

These applications are not stimulated by volume demands, such as for biofuels for haulage, but by means of subsidies. In the Netherlands, the subsidy for sustainable energy was stopped in August 2006, but the SDE (Stimulering Duurzame Energieproductie [Sustainable Energy Incentive Scheme]) has been in force since 1 April 2008. Of all the routes mentioned fermentation (by 7 ct/m^3 gas), further small scale co-firing of biomass and the (limited) production of biogas are recompensated in the SDE. Large scale co-firing of biomass is not recompensated in the new regulations, but there are still long-term contracts that fall under the old regulations.

From Chapter 1 it emerges that the use of biomass is accompanied by many stumbling blocks. When the SDE was

One of the sustainability criteria of the Round Tables is the right to education (photo: Indonesia)

appointed, there were extensive debates in the Lower House about the sustainability of biomass. It was decided that only certified sustainable biomass would be eligible for subsidy. However there are not yet enough certification systems: certified biomass for the generation of electricity is still hardly available. The new subsidy regulation has not yet been opened to liquid biofuels such as palm oil because the greatest doubts about the sustainability occur here. This could change as certification gets going (see next paragraph).

Criteria for sustainable biomass

In the Netherlands the debate about the sustainability of biomass got going early, urged on by the environmental movements. Concern about the sustainability of biomass exists in a number of fields:

- Impact of cultivation and harvest of biomass on the natural environment, especially on biodiversity (abundance of types), water level and water quality.
- Labour conditions on energy plantations in developing countries.
- Contribution to local economy.
- Impact on food markets, in the production countries as well as worldwide.
- Indirect change in use of land, with damaging consequences to the provision of food or biodiversity.

The first three problems can be dealt with by a system of certification. Initiatives for this date back to the seventies in the last century when environmental and third-world movements raised the question of environmental quality and labour conditions in developing countries. Fair trade coffee and bananas preceded sustainable palm oil. A well-functioning system for wood for the paper and pulp industry has existed for years. And now the criticism of biofuels provides an important impulse to raise the question of further certification.

Manual harvest of sugar cane

Under the influence of these movements a system of self-regulation is gradually being created for important markets such as palm oil and soya. In other words: Criteria will be drawn up by so-called Round Tables for the sustainable production of these raw materials and, by raising the pressure of public opinion, an effort will be made to have these regulations endorsed by more and more producers and customers. Not only non-governmental organisations such as Solidaridad and WNF have earned their spurs in this field, Dutch companies such as Essent and Unilever are linking themselves more and more to the use of sustainability criteria. For example, Essent has developed the Brazilian coffee husk project, together with Solidaridad. And Unilever, a member of the RSPO (Round Table on Sustainable Palm Oil) since its foundation in 2004, announced in May 2008 that they want to draw all their palm oil from certified sustainable sources by 2015. The first certified palm oil is expected to reach the market at the end of 2008. Similar Round Tables exist for sugar (Better Sugarcane Initiative) and soy (Round Table on Responsible Soy). And on 15 April 2008, the English system Renewable Transport Fuel Obligation (RTFO) went into force.

Governments have also recognised the importance of biomass certification. The Netherlands and the United Kingdom were the first countries to develop policy for this purpose. In Netherlands this was accomplished by appointing a commission chaired by Prof. Jacqueline Cramer, the current (2008) Minister of Housing, Spatial Planning and the Environment. The commission formulated a list of minimum criteria and attuned as much as possible to the existing conventions and quality marks. For example the commission refers to guidelines from the international organisation ILO for labour conditions. As sustainability criteria the commission has formulated:

- A sufficiently positive greenhouse gas balance.
- No competition with foodstuff or other local uses such as medicines or building materials.
- No adverse effects to the vulnerable biodiversity.
- No adverse effects to the environment.

- Contribution to local prosperity.
- Contribution to the welfare of the employees and the local population.

Besides these the commission also sees that direct effects could occur through the changes in land usage. Such effects cannot be covered by the sustainability criteria which have to be complied with at company level. Indirect effects appear for example if a new plantation for biomass causes primary forest to be cut down. The biomass in question may be sustainably cultivated but the indirect effect is that non-sustainable production takes place elsewhere. The Cramer Commission therefore states that it is important to start monitoring of these macro-effects and that adequate steering mechanisms should be found to combat such undesirable indirect effects.
On 23 January 2008, the European Commission published a proposal for a Guideline for renewable energy. It included the confirmation of the objectives in the field of biofuels. The guideline also determined that biofuels must be sustainably cultivated. For the time being these demands only mean that the biofuels must comply with a minimum reduction percentage of 35% of emissions of greenhouse gases (calculated across the whole production chain). Furthermore areas with high biodiversity or with high carbon content are named that may not be used for cultivating crops (certain types of forest, wet peat bogs and grasslands with high biodiversity, for example). The European Commission proposal states that they will report on these indirect effects periodically.
The EC proposal does not go as far as the Cramer criteria. Moreover the EC proposal says that member states may not set additional criteria. Along with the minimum demands there is however room for additional voluntary sustainability criteria. The Dutch position in the current (at the time of writing) negotiations is that a case should be made for heavier criteria.

Reward mechanisms

The promotion of sustainability can take place by setting demands, such as sustainability criteria, but an alternative is to reward sustainable production. This is the mechanism that lead to the rise of fair trade coffee and bananas and which can be extended to biomass cultivation for energy. We can take the labour conditions for biomass cultivation in third world countries as an example. These are not included the European Commission's sustainability criteria, but are included in the Cramer Commission criteria and also in those from the Round Tables. Labour conditions differ greatly: child labour is normal in some countries and also (concealed) slavery. One of the concerns of the development organisations is that biomass cultivation will take place on large scale plantations. The strong growth of sugarcane cultivation in Guatemala, Brazil and Mozambique almost takes place on huge capital-intensive plantations with mono-culture. Side-effects are conflicts about land, expropriation of land (often heavy-handedly), migration and an exodus from rural areas. The new plantations are often highly mechanised, which after all is better for the environment as the sugarcane harvest when cut is not set alight is an example. On the hand the need for labour is much smaller. In the case in Brazil, the redundancy of labourers can be absorbed reasonably easily in a relatively prosperous province such as São Paulo. But in older sugar areas such as Recife and Pernambuco, the social effects of mechanisation are perhaps so great that an argument can be made for the temporary continuation of manual cultivation and harvesting, including the adverse environmental impact.

Certification by Round Tables is beginning to get going and can be supported by governments. In the United Kingdom for example the criteria in the Better Sugarcane Initiative were indicated as the formal benchmark on 15 April 2008 in the report obligation for transport fuels (the RTFO).

Certification brings extra costs in the form of arranging administrative procedures, investment in the infrastructure (roads, waste water purification, wildlife corridors), and the costs of the certification. If the starting situation is good then the additional costs are limited. The proceeds should consist of a higher price for the certified product. User countries can influence this price by demanding certification. The incentive for sustainable work would be counteracted if there was a too low a premium for certified palm oil for example.

Certified palm oil can be traded in various ways. If the certificates are traded separately from the physical product, their expected price is $ 10-20 per ton on the market, in itself an attractive price but only 1 to 2% of the market price for the oil. On the other hand the margins are now very large (production price $ 150-300 per ton, market price more than $ 1,000 per ton), so that a slightly smaller margin for sustainable oil would not be a drawback at the moment.

Sustainable production can also be encouraged by financial compensation for the conservation of the quality of the environmental by the production countries, as in debt-for-nature swaps. A developing country would receive remission of debt in exchange for his pledge to conserve an indicated nature area. The result of this could be that new palm oil or soy plantations are established on undeveloped land and that virgin forest is not chopped down. Another possibility goes through the Clean Development Mechanism, put in place by the Kyoto Protocol, in which industrial countries invest in a project abroad whereby the emission of greenhouse gases is restricted.

Severity and tempo of objectives

Setting severe environmental demands appears to be a good way of obtaining environmental advantages within economic boundaries. The idea is that by setting severe demands (which in the course of time become valid, after ten years for example) innovation will be encouraged, resulting in the measure becoming affordable and perhaps even yielding an economic advantage. For years the model has been the demands set by the State of California on the emissions from cars, a measure protested against by the automotive industry, but which has lead to accelerated innovation in the fields of hybrid and fuel cell power.

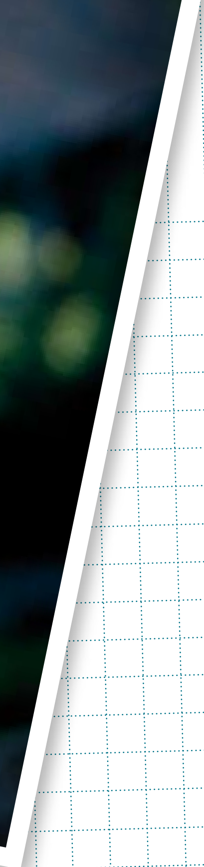
Such ideas also lay at the foundation of the European Commission's volume demands in the field of biofuels. But the measure has many possible negative side-effects resulting in the feasibility being doubted and the appeal for mitigation becoming stronger. To start with five years ago nobody could foresee that feedstuff and fuel would become so greatly intertwined. Even if biofuels were not actually at the cost of foodstuff, the current public image that such conflicts do exist would undermine the legitimacy of biobased raw materials. Politicians react to that. But also the cry to not push bio-fuels to hard in the short term can be heard increasingly more often from scientific circles.

For example, the Netherlands Environmental Assessment Agency (MNP) suggests in a report in February 2008 that the European objectives of 10% of transport fuels being biobased by 2020 should be 'reconsidered'. MNP, with new calculations, has arrived at the conclusion that biofuels fail all the criteria or threaten to do that if they are used in great quantities. The Platforms formulate the conditions under which this objective is still admissible in Chapter 3.

In this situation many parties call especially for the use of second generation biofuels. The first pilot plants are being built at the moment. It will take at least five years before second generation biofuels in small quantities comes onto the market. Large scale production will take an estimated ten years.

Parties such as environmental movements and the food processing industry plead for the quota for biofuels to be made more flexible until the second generation becomes available. This is a hefty intervention because the investments encouraged by the policy in the factories for biofuels are just starting up and the credibility of the (European) policy could be damaged. However the proposal by the European Commission also contains a measure which encourages second generation biofuels: doubling the contribution of second generation fuels for blending. This would increase the premium for the fast development of the second generation. Other possibilities are an exemption from excise tax or a separate objective for second generation bio-fuels such as in the US.

3 TOWARDS INTELLIGENT USE OF BIOMASS



3 TOWARDS INTELLIGENT USE OF BIOMASS

From the previous chapters we can draw the conclusion that everything must be bet on the intelligent use of biomass.
This means:

- Implementation of a good system of certification.
- Increasing agricultural production over the whole world, within the environmental preconditions.
- Improved application of biomass with new production technologies for energy and materials.
- Increasing efficiency in the chain.
- Improving the greenhouse gas balance.
- Decreasing the need for water and nutrients.
- Care for the local economy in biomass producing countries.
- New crops.
- Constant innovation.

The Platform's opinion that sufficient bio-energy exists in the world (without competition from food provision) is based on the recent WAB study. A number of prominent Dutch institutes have participated in this study: The Copernicus Institute, WUR, MNP and ECN. On the basis of a comparison between various potential studies, this study shows a range for exploitable biomass in 2050 of 200-500 EJ per year worldwide built up as follows:

- Waste products from forestry and agriculture: 40-170 EJ.
- Surplus forestry: 60-100 EJ.
- Energy crops from possible surpluses from arable and pasture ground: 120 EJ.
- Energy crops from areas with a shortage of water, marginal and degraded soil: 70 EJ.
- Potential additional production through learning effects in agricultural technology: 140 EJ.

The estimated annual demand for biomass will amount to 50-250 EJ in 2050 and will therefore be lower that the potential. The total world energy demand is estimated at 600-1040 EJ in 2050.

Intelligent use of biomass and sufficient support from public opinion is necessary to enable the potential utilization in an economical, social and environmentally responsible manner. The most important criteria for this sort of intelligent use are specified in this chapter and illustrated with examples.

Certification

The Platforms applaud certification of biomass because it will remove any doubts about the sustainability of the biomass production. Certification of agriculture means that an independent body will authenticate the production in accordance with clear stipulations relating to local economy, social circumstances and the environment. This certificate is seen by the Platforms as the minimum requirement for utilizing agricultural products in energy supply.

But indirect effects such as competition with food supply are not highlighted by certification. At the same time and because of this, monitoring the food situation, regionally and worldwide, is necessary to prevent the use of biomass causing food shortages. The same applies to effects such as indirect deterioration of the greenhouse gas balance or indirect damage to biodiversity caused by moving crops to natural areas.

Increasing agricultural production

The productivity of agriculture over the whole world is increasing every year (see 4.6). Only because of this the agricultural sector remains capable of feeding the world. This growth will have to continue if bio-energy is to be obtained from agriculture. The belief that this growth will continue for the time being is partially based on the large differences between the average yields and the yields of experimental farms in many countries. Much can be achieved with good agricultural information, as long as the markets work well and farmers can expect their products being sold. There are also opportunities to increase the yield in countries with a well-developed agricultural sector, for example by precision farming. The use of subsidies for increasing agriculture will have to be aimed at stimulating the cultivation of the right crop at the right place within the environmental preconditions.

New crops can contribute to this production increase. Among the candidates for biomass production are crops with very high yields, such as miscanthus, switch grass and willow. These are crops that are typically suitable for the production of second generation biofuels. Biorefining existing crops can also considerably increase the yield in energy terms.

Fallow ground in the EC appears to be very suitable for growing energy crops. Policy to decrease food production while maintaining the farmer's income has been carried out in the EC for decades. One of the measures was awarding fallow land premiums to farmers who took part of their land out of production. As a consequence there is a large amount of fallow ground, especially in France, Germany, Spain and the United Kingdom. In 2005 this area amounted to 5.6 million hectares over the whole EC. The European Commission thinks that 5 million hectares of this could be used for the production of biofuels; in 2005 approx. 1 million hectare of this was in use, more than half in Germany. Use of fallow land for new crops will incite discussion, particularly in the United Kingdom, because some fallow land has in the meantime been developed into valuable natural areas.

Marginal and degraded soil can also be considered for energy crops. Perennial energy crops could be planted in areas that have been damaged by erosion. This serves a dual purpose: water retention (the ability to hold onto rainwater) is increased and use is made of ground that would otherwise be left fallow. The policy of energy production from biomass not competing with food production is being implemented by giving priority to fallow, marginal and degraded soil.

Proces installation Nedalco

Enlargement of the world agricultural production is of common importance. Previously it was stated that the IAASTD and President Lula of Brazil pointed out the trade restrictions and subsidies from industrial countries which disrupt this market and which result in the demand for agricultural products not reaching many farmers in developing countries. Improvement of operations in the food market is therefore an important policy objective when the use of biobased raw materials for energy supply is increased.

Improved utilization of biomass: biorefining and en biocascading

Intelligent use of biomass is further characterised by the increase of efficiency in the chain through the utilization of alternative products in existing griculture. Products such as straw, foliage and (rice) stalks are often left behind on the land or burned pointlessly. As a rule, only a little is needed for conserving the nitrogen content in the soil. Good examples of the potency of chain efficiency and biocascading are the new processing methods for sugar beet (see 4.14).

The foliage and the tops and tails of sugar beet are removed in the existing process. They are then washed and milled and the pulp is treated with water to dissolve the sugars. Crystal sugar is made by evaporating this solution. The by-product molasses is processed into ethanol or yeast at a fermentation company. With the help of large investments and a lot of energy, by-products are processed into products which can be returned to the land as minerals.

In the new process the harvest is separated into a number of components that are each processed and marketed. Ethanol and biogas are also created, along with crystal sugar. Sugar production is slightly lower (this can be absorbed by a small increase to the surface area) to optimise the process, but in energy terms the yield is 50% higher. The beet foliage is also used in a further improvement to the process, mostly for cattle feed. The yield from this route in energy terms is 75% higher than with the existing process. Watch out: these results were achieved with a first generation ethanol production method. Biorefining is still being developed. One of the possibilities is further division of the plant's components whereby proteins and other chemicals can be extracted, so that the value of the harvest and the (indirect) energy yield increase further. A considerable energy yield can be booked by extracting chemicals from biobased raw materials: energy-intensive production of these materials from petroleum and natural gas is avoided.

Another example is the biorefining of wheat, for which the British company Ensus is now building a large factory. Ensus say they will make use of the surplus wheat on the European market. As well as 400 million litres of bio-ethanol (first generation), this factory will also produce a protein-rich product for animal feed which will take the place of soy as an additive. Furthermore CO_2 will be removed for use in greenhouses and Ensus will produce electricity and heat from waste products (straw). The company says they will achieve a greenhouse gas balance that is comparable to that of ethanol production from sugar cane. This balance is even better when the decrease in the necessary surface area for soy is taken into account. The company sees opportunities of increasing wheat production in the enlarged EC (by making up for the backlog in East Europe and with continual crop improvement) so that the EC can reach its goal of 10% biofuels and at the same time produce enough wheat for their own food supply.

Sugar beets

Improved utilization of biomass: second generation biofuels

Better applications for biomass must be continually sought. One of the possibilities is the development of second generation biofuels. This means generally: biofuels with high energy efficiency and improved greenhouse gas balance that are made from wood and other fibrous material without direct competition to the food supply.

The relationship between first and second generation biofuels is discussed in the European Refuel report from March 2008 made by ECN (see 4.13). Second generation biofuels clearly deserve preference, it emerges from this report. For second generation technologies, use can be made of the waste products from agriculture farming and forestry which do not lay extra claims to the soil. Furthermore the production of second generation biofuels per hectare is double to quadruple the first generation because the whole plant is used whereas only the grain is used in first generation. Moreover there is more ground suitable for second generation fuel, especially grassland and marginal soil. In short, according to the Refuel report, second generation biofuels scores better on all criteria.

But there are strong arguments against constructing an energy provision on the basis of the second generation. The first is the price composition of the product. Second generation fuel requires capital-intensive installations. Capital costs form only 10% of the total amount for first generation biodiesel but this proportion can reach 50% for second generation biodiesel. That is why second generation factories are vulnerable to price decreases on the fuel market and more dependent on subsidies. The second argument is that farmers will have to grow perennial crops. With annual crops the farmer is free each year to sow the crop that has the best expectations on the market. When growing wood he has to commit himself to a choice for ten to twenty years. Moreover farmers know little about these crops.

The last argument is that there are no guaranteed sales channels for the products for the time being. There are no second generation factories yet. The most flexible solution is gassification of biomass because there are more opportunities with the gas product: production of electricity, biodiesel or nitrogen, or synthesis of chemicals. However, gasification of biomass is also still in an experimental stage.

The suggestion that second generation fuels are better than first generation does not apply generally to third world countries. This is because the relationship there between labour and investment capital is different. Second generation technology is usually accompanied by high capital costs which, divided over production, can soon amount to $ 50-80 per barrel oil equivalent. The raw materials are relatively cheap and need little labour. The attached capital is considerably lower for first generation fuels: $ 35 a barrel.
The raw materials are more expensive but often produced in the vicinity which contributes to the economic development of the countryside. Moreover there is then money for artificial fertilizers and this also stimulates food production. The use of sugar cane for bio-ethanol for first generation technologies can be regarded as positive as long as no deforestation occurs (not even by replacement by other crops), the food situation permits and the entire plant is used efficiently.

In conclusion the suggestion that second generation fuels are better than the first generation does not have to apply to Europe, as the example of biorefining sugar beet (with ethanol production) has shown.

Improved utilization of biomass: chemicals

The Biobased Raw Materials Platform foresees chemicals developing into an important sales area for biomass in 2030: 25% of the fossil fuels that are now used in the chemical sector in the Netherlands could be replaced by biobased raw materials.

Chemicals are a premium market for biobased raw materials. Biorefining is necessary to divide the biobased raw materials into useful components. Use is made of enzymes and (modified) micro-organisms in further processing; these processes are called by the collective name of white biotechnology.

The first big steps towards applying biomass in chemicals are being set at this moment. The polyactic acid, or PLA factory for short, from NatureWorks (part of Cargill) was the trendsetter. But now other factories have announced that they are going to make large quantities of 'biobased' polyethylene (PE), together more than a half million tons per year. These are DOW Chemicals (jointly with Crystalsev, a large Brazilian player in the field of ethanol) and Braskem, an important Brazilian producer of petro-chemical polymers. Dupont is making propaandiol from corn starch; polyurethane foam is made from this in Canada. Solvay in France produces epichlorohydrine from bioglycerol; methanol is made from this by BioMCN in Delfzijl. And DSM, Dutch leader in sustainable chemicals, has announced they will be making succinic acid in France and polyhydroxyalkanoates in China. And these are only a few examples.

The economical and environmental impact of this use of biobased raw materials in chemicals was investigated in a large-scale study (BREW) lead by the Copernicus Institute from the University of Utrecht in 2006. The possibility of making 21 substances from biomass using white technology was looked at in detail. The conclusion was that white technology can offer many opportunities for fabricating new and existing biobased bulk chemicals and that, in view of the early stage of development, great progress could be achieved in this field.

According to BREW, many interesting opportunities and breakthroughs can be expected in the long term. But in the first place the challenge is economic, partly because the necessary enzymes and fermentation processes are too expensive and partly because the raw materials are still too expensive after conversion to be able to compete with bulk chemicals from the petro-chemical industry. Because of the great differences in the prices (the lowest sugar price is in Brazil, for example), the first generation factories will probably be built in countries where the prices for raw materials are low. Opportunities for Europe are mainly expected when lignocellulose can be unlocked (second generation technologies).
The environmental and climate impacts of these developments are assessed by BREW as very favourable. Conversions using white biotechnology often need much less energy than those in the petro-chemical industry and the waste products are generally much less poisonous. The emission of greenhouse gases can be reduced considerably (for some substances and

technologies perhaps by 100% in the future, according to BREW). This is both from using less energy and from not using fossil fuels. Breakthroughs can be expected, according to BREW, as the price of fossil fuel remains high and that of sugars is low.

Increasing efficiency in the chain

The previous paragraphs show how the efficiency of the chain can be increased on the production side. Considerable improvements are also possible on the usage side. One of these possibilities is adapting the consumption of meat.The efficiency of converting vegetable food into meat is low. Roughly 8 kilos of soy is needed to produce 1 kilo of beef. That is 5 kilo for pork, 2.5 kilo for chicken and 1.3 kilo for the tilapia fish. Intelligent use of biomass means that we must ponder the efficiency of using biobased raw materials in the food chain.

A clever way to handle this is to biorefine pasture grass which could lead to the more efficient production of beef: the cow gets what she needs and the other components go towards other applications. There are plans in Rotterdam to set up a pilot factory to separate protein for pigs and chickens from the waste products of food and biofuel industries (soy and turnip waste). Minerals and lignocellulose, components that cause the manure problem to an important degree, will no longer go to the compound feed industry. Minerals can be recycled via the artificial fertilizer industry while the lignocellulose can be converted into electricity for the time being, and later into ethanol with second generation technology.

Due to the low efficiency of meat production, potential estimates of the proportion of biomass in the provision of energy and materials depend strongly on the anticipated meat consumption. As more and more biomass is needed for feeding stock for slaughtering, less remains for energy and materials. Calculations indicate that if people in developing countries take over the food pattern of the Americans, for example, (hamburgers!), the potential for biomass in the provision of energy will be greatly limited.

There are various solutions for this dilemma. Shifts in the food pattern to less consumption, or from red meat to chicken or (farmed) fish would make quite a difference. Besides, research into making artificial meat is underway. It cannot be foreseen at the moment whether consumers would wish for such a change in their lifestyle.

Improving the greenhouse gas balance

The greenhouse gas balance of a biomass chain depends strongly on local circumstances, such as the question of whether forest has been cut down for the crop or for processing biomass. Improving the greenhouse gas balance is often only possible with crops that score well in decreasing CO_2 emissions. When growing sugar cane for example, the energy content of the plant is often badly utilized on old plantations: by setting fire to the foliage before harvesting and by the inefficient exploitation of bagasse, a waste product of sugar production. These are considerable quantities: one hectare supplies roughly 12 tons of sugar, 12 ton bagasse and 12 tons of foliage. A problem when assessing the various processing routes is that the CO_2 criteria score negatively for the use of fossil fuels and not positively for the efficient exploitation of biomass. Therefore reuse of biobased products does not recur in the greenhouse gas balance and we cannot find wasteful use of foliage and bagasse in the scores either while much can be won here. Brazil as well as the users of bio-ethanol score well with a 1/8 energy content of fossil fuels in bio-ethanol, while they could do much better. In the short term improvements can achieved by condensing bagasse, for example by torrefaction. But there is no incentive in the existing criteria for improvement. The Brazilian government has a policy whereby burning the harvest on the land is being permitted less and less, with a view to a total ban in 15 years.

It will be even better with biorefining and second generation conversion technology, when it becomes available. The plant can be harvested earlier (no maximum sugar production, just like sugar beet). After splitting into components the protein can be used for cattle feed. The foliage and bagasse can be used for second generation bio-ethanol.

Decreasing the need for water and food

Water shortage is increasingly more important as the limiting factor when boosting world agricultural production. Will further boosting of this production, needed for energy and materials, meet with a shortage of water or even encroach on food production by using the water?

Agriculture is the largest consumer of fresh water in the world (about 70%). The opportunities for expanding or intensifying agriculture often go hand in hand with access to water (rain or irrigation) for many crops. In large parts of the world there is already a shortage of water. The need for water is growing almost everywhere because of the growing population in combination with the increase in welfare, expansion of agriculture and further industrialisation. Generally speaking there is no shortage of water in the temperate climate zones (see 4.10). In dry climates it is also possible that there is enough water because water is carried in by rivers. But large areas do suffer from a shortage of water or will meet this situation in the near future. There are some areas with no physical shortages, but where the locals lack the buying power or the infrastructure for good provision of water (especially in Africa).

Crops balance precariously with natural water provisions in the form of rainwater. All moisture in the atmosphere comes from evaporation, partly from soil and surface water (evaporation), partly from trees and plants (transpiration) – known jointly as evapotranspiration. Thoughtless cutting down of natural areas can cause dehydration because not enough water can evaporate for rain.

Irrigation of a rice field (at Da Nang, Vietnam)

Water-saving methods for agriculture are urgently needed and are being developed in many places in the world. Drip irrigation is often required, in combination with decreasing evaporation by growing methods without needing to plough (zero tillage). Some GM crops are specifically developed for decreasing the need for irrigation.

It is essential that artificial fertilizer is used to enlarge biomass and food production. Every kilo of nitrogen supplies a factor 5-10 more energy per hectare of biomass by stimulated growth. However the existing systems of cultivation do not use the added artificial fertilizer efficiently, in the best case 50% is used by the plants. In the production of meat nitrogen use is less. A large part of the added nitrogen gets into the environment. Consequences include damage to human health by the formation of nitrogen oxides, fine particles and ozone, damage to nature, decline in biodiversity, acidification of eco-systems, damage to the quality of the groundwater, algae in the sea, climate changes and damage to the ozone layer.

Artificial nitrogen fertilizers have been made up until now synthetically using much energy whereby the nitrogen component ultimately comes from the air. Artificial phosphate fertilizers however come from the soil and the sources are endless. Both types of artificial fertilizers must be handled as efficiently as possible; leakage into the environment must be avoided as much as possible. Some GM crops are specifically developed for decreasing the need for artificial fertilizers.

Care for the local economy in developing countries

Increased prices for agricultural crops improve the farmer's income, in developing countries as well. This can revive local economies, potentially resulting in a halt to the migration to large towns. Home production of transport fuels can also play an important role in development. It could be favourable to national economy and even for the provision of food, in countries such as the Sahel and in East Africa for example. These economies suffer greatly from the price increase of fossil fuels. Transport costs are an important part of the cost of food for urban dwellers in these countries. The development of a home source of biodiesel is then a knife that cuts both ways. That also applies to villages that plant an energy crop for their own use: by producing energy

locally, they can save the money for diesel oil and reinvest it in the community.
There are various candidates for such small-scale projects with biodiesel. The most well-known is the jatropha plant, a tropical plant with great potential. The berries from the jatropha bush contain much oil and are not edible. Therefore there is no direct competition with the provision of food. Jatropha oil in pure form can be used as a fuel in older diesel engines.

Jatropha can cope with drought: the plant will not grow further, but will not die. Cultivation of this crop is pre-eminently suitable for marginal soil in areas that are regularly subjected to drought, in the Sahel and East Africa. It can be planted in plantations, but also in hedges around arable fields so that the use of ground does not compete with food production. Marginal soil in east Africa for instance could be the residential areas of the poorest groups of the population. Large scale planting would be at the cost of their way of life. Consideration must be given here to the lay-out of plantations.

Cultivating jatropha is recent and it is not clear whether the crop can substantiate the high expectations. Although the bush can cope with drought, it is clear that the yield improves considerably with rainfall or irrigation. This means that competition with food provision from jatropha is more than only theoretical. Certification of jatropha is also useful, partly to check whether the local economy is indeed positively affected.

Jatropha nuts

Another example is the sugar palm, stimulated on Kalimantan by forester Willie Smits, who is committed to the orang-utan, and by the World Bank in Africa. The sugar palm is a labour-intensive crop, suitable for small-scale companies. The sugary sap is very suitable for processing into bio-ethanol. Smits wants to plant 680,000 hectares of sugar palm on Kalimantan.

New crops

New crops can encourage the acquisition of bio-energy. A special category of new crops are the micro-algae.
Micro-algae are vegetable micro-organisms that use sunlight and inorganic nutrients for their growth, in particularly CO_2, nitrogen compounds and phosphate. The algae are grown in open or closed ponds and cultivation is very productive in terms of

the amount biomass per hectare. In the Netherlands 30 ton per hectare per year is possible at the moment, and probably 50 ton per hectare is possible in the future (compared with corn at 20 ton/ha maximum).

Biomass from micro-algae is a versatile raw material for the acquisition of energy sources and chemicals. There are more than 30,000 types of micro-algae. The choice of algae type, method of cultivation and processing method, depending partly on the climate and the product demand, is still in development.

Constant innovation

The opportunities from biomass are new and the demands made by these opportunities are advancing fast, just as the problems they cause. Technologies to open up these new opportunities or avoid problems are been developed feverishly. Research relates to the agricultural product as well as the technology needed to process biomass. The social necessity to find new solutions is great and the past has taught us that in such circumstances new routes can be opened quickly. The Platforms are dedicated to the intelligent use of biomass and that also means that they will keep an eye open for new chances and will not be bound by problems which appear to be insurmountable at present.
Innovation must be provoked and stimulated. Society must produce enough flexibility to stimulate promising developments when they occur.

Conclusions from the Platforms

The Platforms from Energy Transition have tried to develop directions for the intelligent use of biomass in this publication. The Platforms are of the opinion that the acute problems in the development opportunities sketched out which dictate the agenda at the moment could loose their power.
The Platforms conclude:

- Biomass has the potential to play an important role in a sustainable provision for society with energy and materials.
- There are no reasons why bio-energy should either be rejected or received with open arms. In view of the risks in the use of biomass, careful and intelligent use is recommended.
- According to the latest insights, sufficient potential in biobased raw materials can be developed (if the productivity increase in agriculture across the world remains at the top of the list) to cover the growing demand for bio-energy and biomaterials without endangering the production of food.
- Use must be made of chains with a good greenhouse gas balance and little environmental impact.
- Increasing efficiency even higher in all chains (food, cattle feed, energy) by using the whole crop and by integrating chains is imperative.
- Biobased materials offer new chances for economic activity, in the Netherlands as well as in developing countries, and a new source of income for farmers all over the world.
- Certification of biomass, monitoring the food situation and macro-effects such as land usage are the key variables for

the successful application of biobased raw materials.

- Quick development of technologies which enable high efficiency in the chain (particularly biorefining, biocascading and second generation technologies) are necessary to counterbalance the tension between the ambition of the current (European) policy and the (current and future) world agricultural production.

A large potential of biomass can be developed in a responsible fashion with intelligent use and consideration to the conditions in force.

TEN CRITICAL QUESTIONS AND ANSWERS

TEN CRITICAL QUESTIONS AND ANSWERS

1 Is the use of biomass for energy responsible for the current increase of food prices?

There are many reasons for the recent increase of food prices and the development of bio-energy is one of them.

- For many years the governments of industrial countries have tried to stabilise the food market. Stopping surpluses and regulating production were the most important remedies. This policy was abandoned not so long ago. Consequently food stocks have decreased. And now the demand is increasing; not only from bio-energy but particularly through increasing prosperity and population size in emerging economies such as China and India.
- Rising prices lead to reactions which increase the prices even more. Food exporting countries are closing their borders in an attempt to prevent further national price increases. This leads to shortages on the world markets and further price increases.
- Rising prices also lead to speculation. Farmers and traders are holding on to their stocks in the hope that prices will rise even further which also leads to shortages. Furthermore speculators, frightened by the unrest on the financial markets, have begun to invest their money in raw materials, including food. This leads to new price increases.
- And alongside all this, the prevailing opinion of analysts is that there are no physical shortages on the market. That is why the recent price rise seems to be an extreme reaction.
- Bio-energy does indeed need food crops such as corn, palm oil and rape seed. But the amount needed is limited at the moment. The proportion of the world production of palm oil used for energy generation at the moment amounts to 1.5%. Larger percentages are reached regionally. At the moment 20% of corn production in the US goes to bio-ethanol, but the American corn farmers report that in spite of this export and surpluses are increasing. Two thirds of the European production of rape seed goes to biodiesel but part of this rape seed is grown on land that was set aside by mandatory European regulations to prevent overproduction.
- An indirect effect is displacement of land usage. An example is the increase of the corn surface area in the US at the cost of other crops, in particular soy. This could influence the price of soy.
- A more profound reason for the influence of bio-energy on the price of food is that some food, namely sugar, can be used for two markets now. Brazilian farmers often have the opportunity to dispose of their product as sugar or as ethanol, as they have processing installations for both of these. The sugar price must then follow the price of fossil fuels if they go above a certain level, otherwise all the sugar would be converted to ethanol. The two markets have become linked. However at the same time the oil price also defines the maximum sugar price.

- Finally an important factor: the increasing oil prices. The price of diesel oil for tractors, artificial fertilisers and pesticides affects the agricultural costs.
- The increasing price of food should be put into perspective even though it threatens the poorest in the world: the price has increased for many raw materials, such as lead, copper and nickel, in the last years and exceed the price increases of food many times over.

2 Is the deforestation of tropical rainforests in Indonesia and Malaysia caused by planting palm oil plantations for biodiesel?

Large scale deforestation of tropical rainforest has taken place for many years. Palm oil plantations are being planted on an important proportion of the cleared land. This started before palm oil was used for the production of biodiesel. The majority of palm oil production is still for human consumption.

The big profits made during large-scale deforestation are from tropical hardwood. Moreover it is not easy to assess whether oil palm cultivation is the driving force behind (small-scale) deforestation.

A very large area of tropical rainforest has been cut down in Indonesia. The expansion of palm oil production is feasible on this land in principle. Deforestation of tropical rain forest is officially forbidden in Indonesia now, but there are indications it still occurs, sometimes under the pretext of establishing palm oil plantations.

3 Is the deforestation of tropical rainforests In Brazil caused by planting sugar cane plantations for bio-ethanol?

The Amazon area is actually too wet for cultivating sugar cane. Even so sugar cane is grown in this area, but due to the high transport costs to the coast it is probably mostly for local use. There is an indirect influence: expansion of the sugar cane surface area is at the cost of cattle farming and the cultivation of soy, resulting in them being driven even further into the Amazon area. The Brazilian government is trying to counteract this partly by more intensive grazing, whereby more cattle are being kept per hectare and the expansion of pastures is no longer necessary.

Other areas in Brazil are also under threat. An example of such a threat is sugar cultivation in the Pantanal wetlands on the border with Paraguay (large impact on nature). The same is happening in the Mata Atlantica where only 8% of the tropical forest remains. Indians are recruited to harvest in very poor conditions: for example they are paid with food and alcohol.

But there are better initiatives. The investment company, AdecoAgro, which includes George Soros as a participant, wants to prove that large-scale production and modern sustainability (people, planet, profit) can go hand in hand with sugar cane. The enterprise cultivates sugar cane on a large-scale on 120,000 hectares in the Mata Atlantica biome which was cut down forty years ago. The sugar cane is cultivated on marginal soil which the cattle have left and which is gradually being restored by modern techniques. For the cultivation of sugar cane, AdecoAgro uses sustainable technology with high productivity. The company is completely mechanised. So-called zero tillage is used for the cultivation, the vegetable material remains on the land, with nitrogen fixation in the soil. Artificial fertilizer is used. A matrix system is used for crop rotation, optimising short, medium and long cycle crop rotation. This can intensify production from 80 to 140 ton/ha.

According to Brazilian law, 20% of the surface area in the Mata Atlantica biome must retain a natural function (80% in the Amazon area). AdecoAgro is trying to keep to this by means of a cluster programme with the regional farmers, among other things. An integrated environmental plan will be set up for the most vulnerable areas.
In a nutshell: sugar cane for bio-ethanol is only partly responsible for the deforestation of the tropical rain forest in Brazil.

4 Is it true that the production of bio-ethanol from corn has a negative CO_2 balance? For which biofuels does this also apply?

Various countries, including the Netherlands, are working on a generally acceptable manner of calculating the greenhouse gas balance of bio-energy. Moreover the calculation rules for this method have been established in the EU proposal for the renewable energy guideline. CO_2 emissions as well as emissions of N_2O en CH_4 are included in the greenhouse gas balance.

The greenhouse gas balance depends on many factors:
- The vegetation originally removed from the land for a biomass production plantation.
- In addition a lot of carbon is stored in the soil in the form of humus. When forests are cut down or grassland ploughed up oxidation takes place and much humus escapes in the form of CO_2. This impact can be so great that it would take decades before the increased 'debt' of CO_2 emissions is made up for through the use of the biofuels cultivated on this land.
- Effects to the aboveground and underground storage of carbon, such as described above, can also occur indirectly, namely if a new plantation is planted because of the extra demand for biomass elsewhere.
- This effect was determined in the conclusions of two controversial studies in the February 2008 issue of Science but will not play a role if land is not cleared for biomass cultivation.
- The use of artificial fertilisers has an important impact.
- The greenhouse gas N_2 is created in the soil (definitely when furtilisers have been used in large quantities) and during the production of artificial fertilisers, and affects the greenhouse gas balance negatively. For example MNP calculates that the greenhouse gas balance from the cultivation of rape seed can decrease by more than half when too much artificial fertiliser is used.
- The method of processing raw materials into fuel is important. Is energy from residues used for distillation, for example in co-firing or conversion into biogas? Or does the energy needed come from coal, which emits much CO_2 during combustion?
- What happens to by-products and waste products is also of importance to the greenhouse gas balance. Making some of the waste products into chemicals, as happens in the biorefining of sugar beet, has a positive effect on the CO_2 balance. The chemicals would otherwise have to be made with intensive use of energy by the petrochemical industry.
- Finally, consideration must be given to the fact that the greenhouse gas balance does not form the ultimate criteria for assessing how environmentally friendly biofuels are. This is one of the indicators for the sustainability of biomass. There are many other factors which impact on the environment, humanity and the economy: the impact of cultivation and processing on biodiversity, water and air

quality, social aspects etc. as expressed in the Cramer criteria. Furthermore efficient use of biomass is important. This cannot be been found in the CO_2 score because it only scores negatively for the use of fossil fuels, and not positively for the efficient use of biomass. A sustainability indicator has not yet been set out for this.

In answer to the question above: yes, under American conditions corn, just like soy, scores less well for the CO_2 balance than most of the other crops used. When the coal is replaced by waste heat from a power station as the energy source for distillation, the CO_2 balance for ethanol from corn looks much better. But all the production conditions have to be known to ascertain the precise balance.

5 while visiting the Netherlands on 12 April 2008, the Brazilian president Lula called ethanol from his country a biobased alternative for fossil fuels. He demanded that the debate about sustainability is carried out with technical and rational arguments and objected to ideological prejudices that place ethanol in a bad light. Is he right?

One can do no more than apply rough generalisations when assessing the entire Brazilian production of ethanol. On that condition it can be stated that the Brazilian efforts in a number of fields score relatively well:

- The production of bio-ethanol during the last thirty years was not apparently at the cost of food provisions but has in fact provided extra income for the agricultural sector.
- It is true that many natural areas have been cultivated, partly for the benefit of ethanol production.
- In general, Brazilian ethanol has a very good greenhouse gas balance.
- The ethanol programme has reached its objective: to make the country independent of energy imports to a large extent. Brazil is now so far that it can export energy.
- The biggest problems, seen through Western eyes, are the labour conditions on sugar cane plantations. In many areas the wages are low and the labour conditions bad. This is the result of great contrasts in power and income in Brazilian

society. The richest 10% of the population earn fifty times more than the poorest 10% (in the Netherlands: nine times more). Labour conditions could be greatly improved by mechanisation but this would be accompanied by workers being laid off. The Brazilian cultivation of sugar cane is almost completely in the hands of the large landowners. The proportion of small farmers in this sector is very small.

– Locally there are considerable environmental impacts. 60% of the sugar cane is still being cut by hand (and frequently burnt beforehand). Waste water purification is not always regulated properly.

6 Preferably applying biomass from residues from agriculture and forestry (i.e. straw) and from the food industry (discarded fat, waste from abattoirs etc.) is a wonderful aspiration. But are we anywhere near the quantity needed for the existing Dutch and European objectives?

No, the EC and the Dutch government objectives cannot be reached with waste products alone. Even in the Netherlands, with a sizeable amount of waste from biomass due to the large imports of food (particularly for intensive cattle breeding), the utilization of waste products can only cover a maximum of a third of the Biobased Raw Materials Platform's ambition. The direct yield from biorefining, where unused parts of the harvest are processed, is included.

Crop cultivation will therefore be necessary to obtain the objectives in the field of biomass. Cultivation in the Netherlands will not produce sufficient biomass because of the limited surface area. According to the recent Refuel study, there is however sufficient potential to obtain the formulated objectives in Europe (including the Ukraine) without importing from outside.

7 Is it not so that massive use of bio-energy will always be at the cost of agricultural land and thereby cause hunger or worldwide deforestation – or even both?

No, that is not the case. Malthus's theory, formulated at the beginning of the nineteenth century, states that the growth of agricultural production cannot keep up with the growth of the population and has proved incorrect time and time again. Through the expansion of agricultural surface areas, but particularly due to a large innovation battle, agriculture since that time has continually produced enough to feed the world. Even the current food crisis is not the result of production shortcomings but from a lack of spending power.

There is a deep divide between what agriculture could yield and what it actually does yield, certainly in third world countries. The low food prices of the last years were partly responsible: this slowed down worldwide investments in agriculture. When yields increase, farmers can once again invest, even if only in good seed. Most analysts assume that harvests will increase again with the impulse of higher yields and that the prices will drop or remain stable.

There are also sufficient improvement opportunities in agriculture in the long term, whereby the expansion of the agricultural surface area for producing more food and to be kept as a margin for bio-energy will in principle be unnecessary. But in the past, stimulation of agricultural production has proved to be difficult: better production methods have not reached some farmers or they do not have the means to invest in them. Agricultural potential is estimated high in the recent IAASTD study, which has a non-technological slant. Better functioning of agricultural markets is urged in this study so that farmers are encouraged to increase production.

In conclusion: agriculture has been neglected in the developmental agenda for third world countries for decades. Even ten years ago, when food prices were low, 850 million people went hungry. The suggestion that the hunger problem could be solved for a large part by forbidding biofuels does not cut ice. Even the UN food rapporteur Ziegler does not take this stand, however critical he is about biofuels.

8 If the growth of biomass takes off, will India and China then not monopolize such a large part of the growth that nothing will remain for West Europe?

India and China will definitely monopolize an important part of biomass for energy use. But markets for biomass will be less internationally oriented than those for fossil fuels; a large part of the biomass used in India and China will come from the region. Furthermore the increasing demand from India and China is also included in worldwide studies of potential.

9 Isn't all the fuss around biomass a big hype that will die away when oil prices drop?

Even with the high oil prices at the moment many applications of biomass are not possible without subsidies or a compulsory quota. The growth of biomass in industrial countries is almost entirely moved by policy and hardly by the market at all. That does indeed cause instability in the sector, because the question is will western governments want to invest more and more money in biomass when the oil price drops.

There are factors which could ensure more stability:

- Trade in biomass and biocommodities is starting up. This trade will find its way even when the economic conditions for biomass become more unfavourable. The lack of trade was the central problem in utilizing waste products up until now.
- New technologies are being developed based on biobased raw materials. This leads in niches to considerable investment in products based on biomass. White biotechnology, which will be used to process an important part of biobased raw materials, has developed in completely different sectors of the economy, such as in the production of medicines and enzymes for detergents. This branch of science tackles the production of valuable materials from biomass and will continue for the time being, even if the price of oil drops.
- New technologies can ensure price decreases, resulting in new opportunities becoming available without subsidies.

The vulnerability of bio-energy is more the instability of the agricultural prices than the oil price. Agricultural prices have always fluctuated more than oil prices and depend on natural conditions and can therefore change from year to year. The motorist at the petrol pump is not yet used to this.

10 What alternatives are there for CO_2 reduction in traffic and transport, what is their potential and will biofuels then be superfluous?

Biofuels are not the only way of reducing the CO_2 emissions in traffic and transport. Measures relating to the choice of technology (such as purchase of more economical vehicles and the use of fuels with better greenhouse gas performance), transport choice (such as collective instead of individual transport, more bicycles, more inland shipping for freight) and behaviour (such as a more economic style of driving or less travel from working at home or teleconferencing) are possible. These choices will be influenced by information instruments (such as energy labels), price measures (such as financial greening and distance related road charging) and instructions (such as economic demands on vehicles).

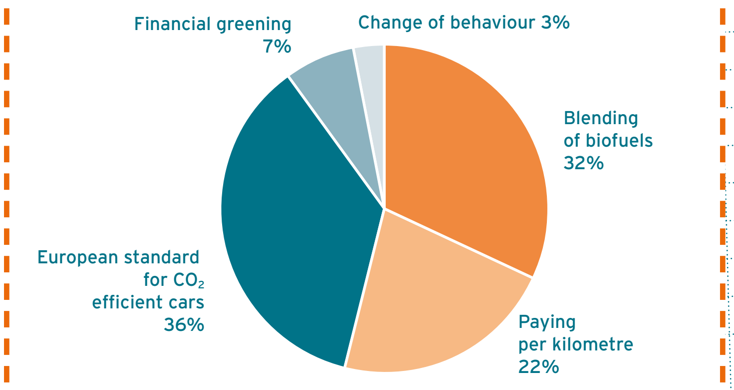
Five measures take a central position in the government policy of attaining a target of 20% CO_2 reduction by 2020 (see figure). The majority are expected from the European standard for more economical cars followed by the use of biofuels and distance related road charging (congestion charges). It is expected that the motorist will then consider more critically whether a journey is really necessary, so that there will be less driving.

The government is not doing well with these measures.

The environmental movement is pleading for even sharper economic demands for vehicles but the automotive industry has successfully lessened the economical standards for private vehicles. Support for distance related road charging is under pressure due to differences in opinion about the reduction of the tax on passenger cars and motorcycles. Controversy about biofuels is handled extensively in this book.

It is obvious that the policy's profit without biofuels will be very small. In the short term (the coming ten years) little CO_2 reduction can be expected from using hydrogen and electricity for driving because large-scale market introduction will only come up for discussion around 2020.

Relative importance of measures from the Dutch Clean and Efficient Programme

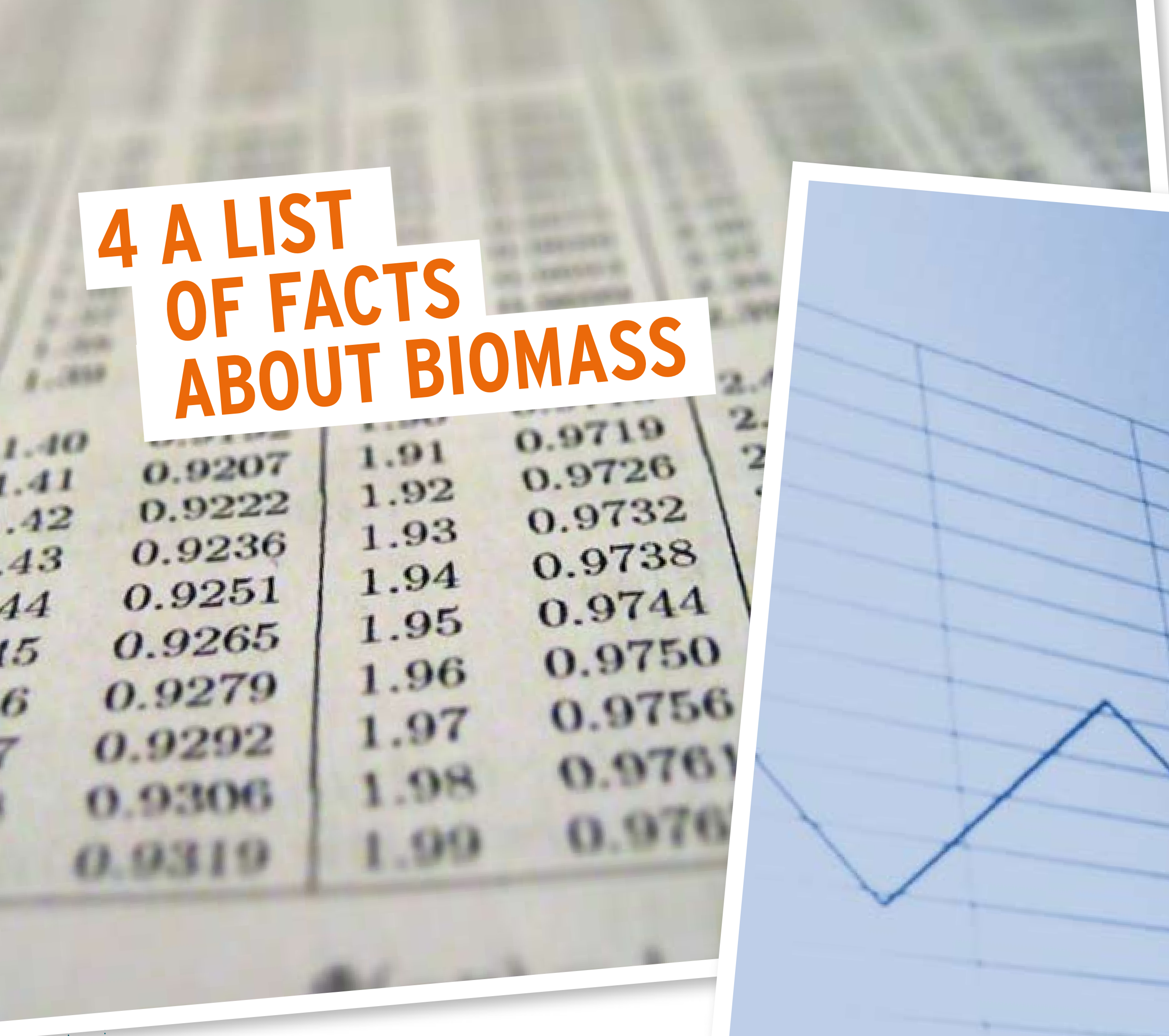


Source: Stichting Natuur en Milieu, 2008

ACCOUNTABILITY

This book came about as an initiative of the Biobased Raw Materials Platform and was led by one of the working groups under this Platform. The members of this working group are Paul Hamm (Chairman of PGG), Johan Sanders (WUR), Jan Maat (Unilever), Mark Woldberg (Nedalco), Jeroen Douglas (Solidaridad), Ella Lammers and Kees Kwant (SenterNovem), Monique van Dongen (SenterNovem, Communication) and Edith Engelen-Smeets (SenterNovem, the secretary of this platform). Research for this book was carried out by CREM BV in Amsterdam in collaboration with the Copernicus Institute from the University of Utrecht. One source used was the WAB study by Dornburg et al., which many Dutch scientific establishments have contributed to (see: Sources). Considerations about prices have been extracted from Schmidhuber, FAO, Von Braun and the World Bank, among others. Background information was gathered through interviews with A. Brinkmann (Biox), J. Vanhemelrijck and C. Burel (EuropaBio), R. Wit (Stichting Natuur en Milieu [Foundation for Nature Conservation and Environmental Protection]) and with the working group members Sanders, Kwant, Douglas and Maat (together with J.K. Vis from Unilever).
The text has been compiled and processed by Diederik van der Hoeven. The publication has been endosed by the Energy Transition Platforms: Sustainable Mobility, New Gas, Chain Efficiency and the Sustainable Electricity Supply Platforms.

4 A LIST OF FACTS ABOUT BIOMASS



4 A LIST OF FACTS ABOUT BIOMASS

This chapter shows a number of key figures relating to biomass.

4.1 Some important biomass sources

Bio-energy is the collective name for energy originating from biobased material (biomass). Bio-energy can be produced from many different biomass sources:

Natural vegetation
such as forests, grasses

Agricultural crops
such as sugar beet, corn, palm oil

Energy cultivation
such as jatropha, grasses, poplar, algae

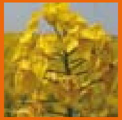
Biomass waste and waste products
such as biogas, straw, household waste, manure

A number of distinguishing properties follow now for each biomass source.

Agricultural crops

RAPE SEED

- Rape seed produces two products: an oil for industrial and edible use and protein-rich cattle feed.
- Rape seed is used in Europe increasingly for the production of biodiesel; Germany is the biggest producer of biodiesel in the world.
- Relatively low net energy yield, partly as a result of the high energy demand during production; fermentation of straw and pulp could increase the energy yield.
- Frequent crop rotation .
- Annual crop.



SOY

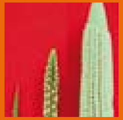
- The most cultivated oil-containing crop.
- In 2006: principally used for the cattle feed industry, besides food (processing).
- Good price/quality ratio due to high yield of protein per hectare in comparison with other protein suppliers.
- Increasingly used for biodiesel, although small biodiesel yield per hectare compared with other oil-containing crops.
- Can grow in temperate and tropical climates.
- Annual crop.

SUGAR BEET

- The largest production takes place in the northern hemisphere; Europe, the United States and Russia are the largest producers.
- An increasing quantity of sugar is fermented into ethanol; less yield per hectare than sugar cane.
- Notable yield of primary and secondary waste products (beet tops, foliage, pulp), fermentation into biogas is possible.
- In Europe, the energy market offers new chances for sugar beet farmers (production was not profitable after subsidies were withdrawn).
- Annual crop.

CORN

- The most important food for many people; contains starch.
- Increasingly used for the production of ethanol (second to sugar cane).
- The United States are leaders in the production of ethanol from corn (are planning to produce even more corn and ethanol in the coming years).
- China also chooses ethanol from corn.
- Net energy from corn and contribution to CO_2 reduction is lower than with sugar cane.
- Annual crop.

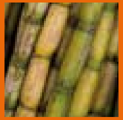


GRAIN

- Farinaceous crops.
- The most important source of food for people worldwide.
- Canada and Europe want to increase their ethanol production from grain in the coming years.
- Ethanol yield per hectare and CO_2 reduction is often less than for corn and sugar cane.
- Energy yield is increased by the use of straw, chaff etc.
- Annual crop.

SUGAR CANE

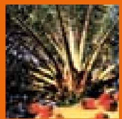
- Sugar cane provides the raw material for sugar; mainly cultivated in tropical climates.
- Increasing use of sugar cane for bio-ethanol (via fermentation); waste products (bagasse) are used to produce electricity.
- Most important crop for ethanol production in order of size anno 2006.
- Brazil is the largest producer of sugar cane and ethanol in the world; 45% of the harvest is for producing ethanol.
- Can realise high CO_2 emissions compared to use of fossil energy.
- Perennial crop.



Energy crops

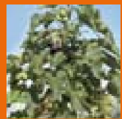
PALM OIL

- Vegetable oil extracted mainly from the fruits of the oil palm.
- Important product in the food market. Also an important raw material for soaps and detergents.
- Used for biodiesel, electricity and biogas.
- Malaysia and Indonesia together produce more that 80% of the market.
- Perennial crop.



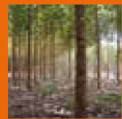
JATROPHA

- Main new oil-containing crop (along with soy and palm oil); waste can be used for the production of electricity.
- Oil is not suitable for food (poisonous).
- Bush grows on poor and very dry soil; fertile soil and water increase the yield.
- Several harvests per year are possible in some areas.
- India especially has chosen jatropha (aim 10 million hectares), but insufficient supply of seeds.
- Perennial crop.



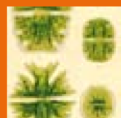
WOOD CULTIVATION

- Examples of fast-growing wood: poplar, willow, eucalyptus, bamboo.
- Harvest every 3 to 10 years.
- Availability partially dependent on other demands for wood, current production of wood is insufficient.
- Worldwide potential through diversity of crops (flexibility for production in various soils and climates).
- Production is also possible on poorer and degraded soil with the potential advantages of soil recovery, carbon storage and more biodiversity value.
- Much marketing experience with the cultivation of wood (such as fibre production for paper).
- Perennial crop.



ALGAE

- Vegetable micro-organisms which are cultivated in open ponds or in so-called photo-bioreactors.
- Productivity of algae is very high: doubling the amount per day minimum.
- Versatile raw material for energy sources. For example, experiments carried out with biodiesel from algae.
- Variety of algae type, cultivation and processing methods are in development.



GRASS CULTIVATION

- Examples: elephant grass, other grasses.
- New crop, almost no market experience.
- Worldwide potential through crop diversity (flexibility for production in various soils and climates).
- Pilots indicate that grasses will possibly reach a higher yield per hectare than trees.
- Production is also possible on poorer and downgraded soil with potential advantages such as soil recovery, carbon storage and higher biodiversity values.
- Perennial crop, harvested at least once a year.

Residues

AGRICULTURAL WASTE PRODUCTS

- Waste from agricultural production.
- Examples: straw from grain, palm kernels, cacao husks, bagasse from sugar production.
- Now used to fuel power stations (also for heat).
- Utilization of waste products for producing biofuels (new technologies, new application opportunities).
- Growth expected due to increasing productivity of agriculture.
- Points for attention: collection and local versus international use, competition with other applications.

WASTE WOOD

- Wood production provides important waste products (solids and dust).
- Wood chips and other wood waste (wood from demolition and building waste for example) are already used for producing energy.
- Most important suppliers: North America, Baltic states, Scandinavia.
- Utilization of wood waste for producing biofuels (new technologies, new application opportunities).
- A point for attention is the infrastructure for collecting.

4.2 What is biomass used for?

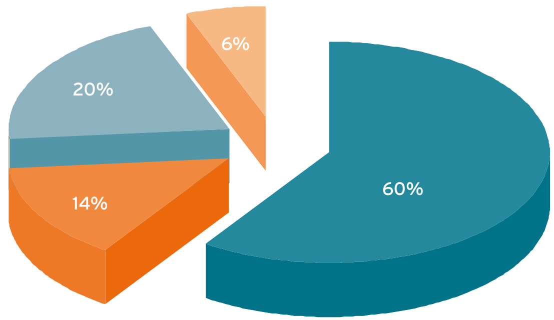
The majority of the biomass produced is for food and cattle feed. In 2006 only 1% of the entire world's arable land was used for producing bio-energy[1]. This portion is growing. Another application is chemicals. Biomass can be used as a raw material for chemicals.

Therefore on average only a small percentage of the world production of arable crops is used as a source of bio-energy. Locally however there are big exceptions.

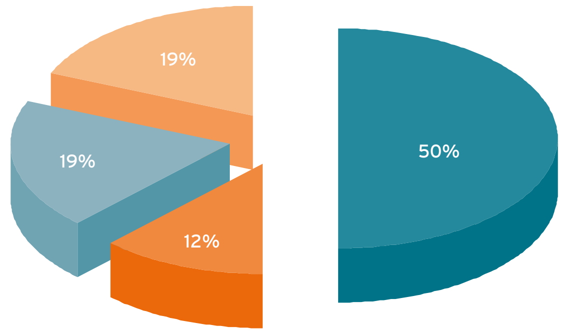
It is unclear how the use of the various sources of bio-mass will look in future. This depends mainly on the results of the fundamental discussions about the use of crops for energy being carried out now and the moment advanced technology breakthroughs happen which could convert the waste products which are more difficult to process into high-quality products.

Example 1: Corn in the US

In the US 19% of the harvest was used for ethanol production in the 2006/2007 production year. This was only 6% in the 1990/1991 production year. The increased ethanol production is covered by the increased corn production[2].



Corn Production Utilization (1990/91 Crop Year U.S.)



Corn Production Utilization (2006/07 Crop Year U.S.)

Feed Use/Residual
Exports
Fuel Alcohol
Food/Seed Industrial (excludes fuel alcohol)

1 International Energy Agency, 2006.
2 Source: Informa Economics, Inc., http://www.informaecon.com

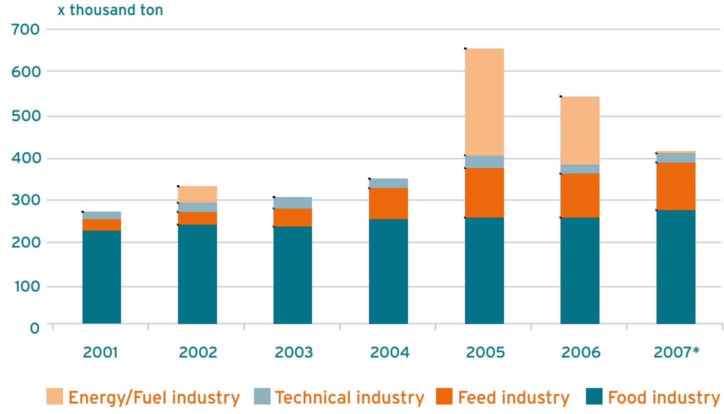
Example 2: Rape seed in the European Community

The increased production of rape seed in the European Community is intended for the biodiesel industry. Germany is world leader in biodiesel production. The European Community has been a net importer of rape seed since 2007; an exporter in the years before that.

	2001/ 2002	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007*	2007/ 2008*
Total	4,00	4,15	4,39	5,38	6,65	7,09	7,82
Food sector	2,88	2,70	2,62	2,67	2,62	2,59	2,82
Non-Food	1,12	1,45	1,77	2,71	4,03	4,50	5,00
- % biodiesel	28	35	40	50	61	63	64

**Estimate*

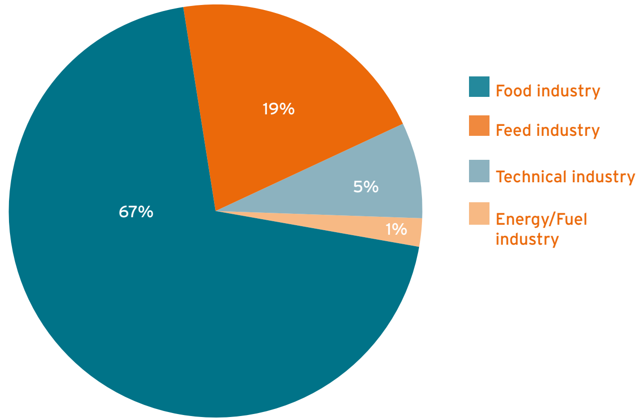
Estimated production utilization of rape seed oil (in million tonnes) 2001-2008 in the European Community[3]



Source: Product Board MVO,2008

Example 3: Palm oil

Palm oil is a product with high energy value per hectare. It is used mainly for co-firing in power stations and for the production of bio-diesel. At the moment about 0.5 million tons of biodiesel are made worldwide from palm oil. This is 1.5% of the world production of 37 million tons. Palm oil is not being used at the moment for energy production because the price is too high. In the Netherlands palm oil was used mainly between 2005 and 2006, but when the relevant subsidy arrangement was withdrawn this sort of use dropped to almost nil.[4]



Use of Palm oil in the Netherlands, 2007*

**estimate*

Source: Product Board MVO, 2007

3 Product Board MVO, 2007.
4 Product Board MVO, www.mvo.nl, 2008.

Example 4: Sugar cane in Brazil

In Brazil about 55% of the sugar cane harvest is intended for sugar production; 45% is used for producing ethanol[5].

Million Hectares (2007)			
Brazil	850		
Total preserved areas and other uses*	510 (60%)		
Total Arable Land	340 (40%)	% of total land	% arable land
1. Cultivated Land: All crops	63,1	7,4	18,6
Soybeans	20,6	2,4	6,1
Corn	14,0	1,6	4,1
Sugar cane**	7,8	0,9	2,3
Sugar cane for ethanol***	3,4	0,4	1,0
Oranges	0,9	0,1	0,3
2. Pastures	200	23,5	58,8
3. Available land (ag,livestock)	77	9,1	22,6

* These areas include Amazon Rain Forest, protected areas, conservation areas and reforestation, cities and towns, roads, lakes and rivers

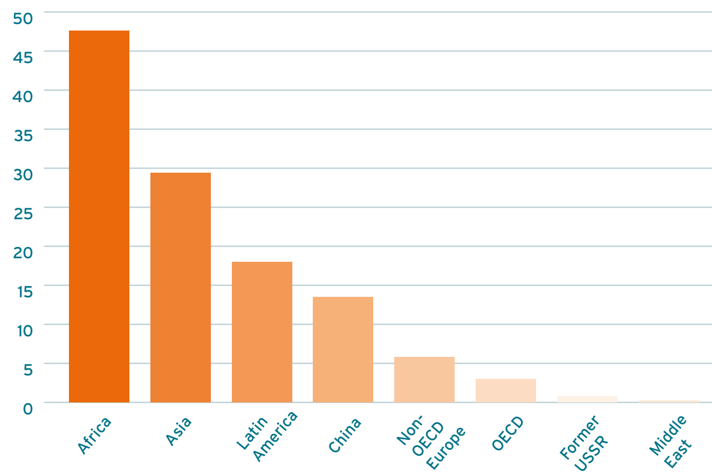
** Cultivated area

*** Harvested area for ethanol production

4.3 Use of bio-energy

Biomass is the most important sustainable source of energy, with a contribution of almost 10% (46 EJ) to the worldwide demand for primary energy of 489 EJ (2005). Bio-energy can be used for heating, electricity or fuel. The lion's share of biomass (37 EJ) is non-commercial and relates to the use of charcoal, wood and manure for cooking and heating, usually by the poorer population of developing countries.

Modern usage of bio-energy (for industry, generation of electricity or for transport) amounted to 9 EJ in 2005 and this amount is growing fast[6].



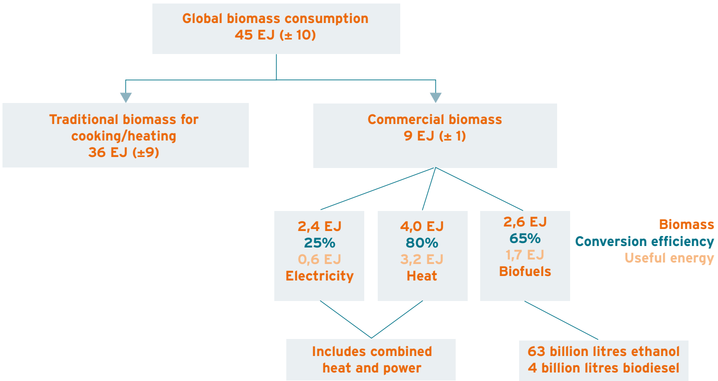
Share of bio-energy in total energy supply in several parts in the world in 2004 (in %).[7]

5 Data presented by Unica (Brazilian Sugarcane Industry Association) in Londen, 14 april 2008. Source: IBGE, Conab en Unica.

6 Dornburg et al., 2008.

7 International Energy Agency, 2006.

World use of biomass for energy can be split up as follows (2007 estimate)[8].



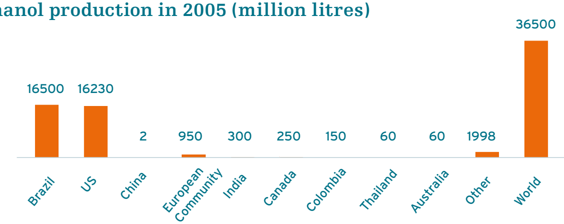
The largest part of commercial biomass is used for heating at the moment. Electricity and biofuels have an equal share. The conversion efficiency is however more with biofuels than for electricity whereby more useful energy can be obtained.

Biofuels

In the transport sector biofuels are one of the few opportunities for replacing fossil fuels (oil). The increased supply of bio-energy is expected to apply to biofuels in the near future – in view of the current policy, for example the policy relating to blending transport fuels (Refuel, 2008).

The world ethanol production for use as fuel more than doubled between 2000 and 2005, while the production of biodiesel almost quadrupled in this period. On the other hand, oil production was 7% higher in the 2000-2005 period (Worldwatch Institute, 2006).

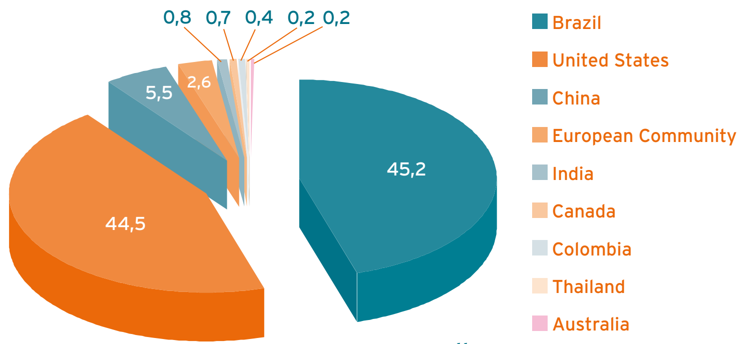
Ethanol production in 2005 (million litres)



NB. About a quarter of the ethanol production is destined for alcoholic beverages or for industrial use (solvents, chemical raw materials, etc.)[9].

Main sources for ethanol production: Brazil - sugar cane, United States - corn, European Community - sugar beet, wheat, sorghum, India - sugar cane.[10]

Ethanol production per country (in %)



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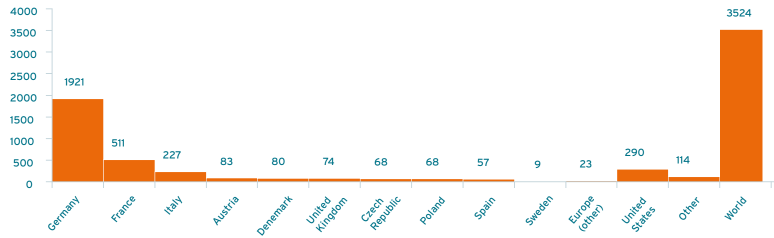
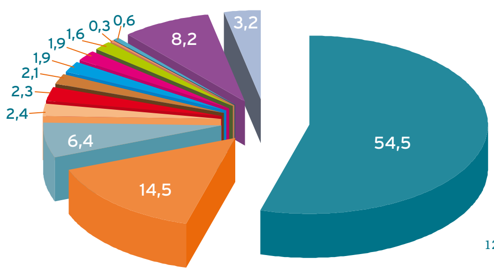
8 Combined information from United Nations Development Programme et al. (2004), International Energy Agency (2006), International Energy Agency (Energy statistics).

Biodiesel production in 2005 (million litres)



N.B. A small percentage of the biodiesel produced is used for heating houses.

Biodiesel production per country (in %)



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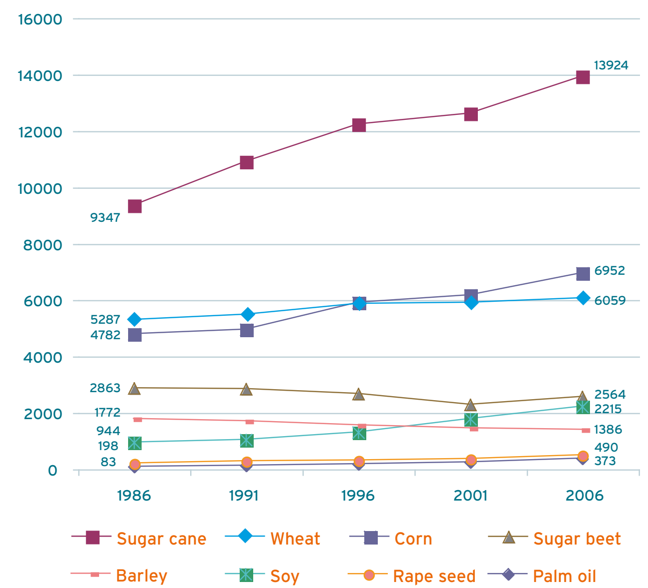
Main sources for biodiesel production: Germany - rape seed, France - soy, United States - rape seed, Italy - rape seed.[13]

4.4 Overview of production figures and development for agricultural crops

The production of many crops has increased greatly in the last twenty years. The reasons for this are various; the most important is the growing world population and altered consumption patterns. The proportion of arable crops used for energy is still limited.[14]

Production growth during the years (in hundred thousand tonnes)[15]



9 Worldwatch Institute, 2006.
10 http://earthtrends.wri.org/updates/node/180.
11 Worldwatch Institute, 2006.
12 Worldwatch Institute, 2006.
13 http://earthtrends.wri.org/updates/node/180.
14 International Energy Agency, 2006.
15 Source: http://faostat.fao.org/site/339/default.aspx, april 2008.

The numbers on the production growth diagram (hundred-thousand ton crops) relate to various units:

- Palm oil: clean, dry seeds; extraction of oil: 17-27% per bunch, 4-10% of the seed.
- Soy/ rape seed: clean, dry seeds.
- Sugar cane/ sugar beet: production data for harvested crop sent to the factory; reasonably clean but still wet. Sugar cane contains 75% water and 10-15% sugar. Sugar beet has a similar moisture content and 10-18% sugar content (sucrose).
- Corn: clean, dry weight.
- Wheat/barley: clean, dry weight (moisture content estimated at only 10%).

They are difficult to compare due to the different units used for the various biomass sources. The quantity of energy yielded by the various crops is the principal in this publication. This will be discussed in paragraph 4.7 (Energy yield per hectare).

The production of many crops has increased substantially in the last twenty years.
Palm oil production has more than quadrupled and sugar cane production has grown by 50%.
Corn production has shown a constant growth totalling 45% in twenty years, while soy production has more than doubled. Rape seed production has increased by 150% and wheat by 15%.
On the other hand the production of barley has fallen by 20%.
The production of sugar beet is 10% less.

4.5 Use of land

The land surface of the world is estimated to be 13,200 million hectares (excluding the large areas of ice). The table below roughly shows how this land is used. The most important categories are forestry and non-productive use (including semi-deserts, mountainous areas and urban areas). About 11% of the surface is used for arable production.

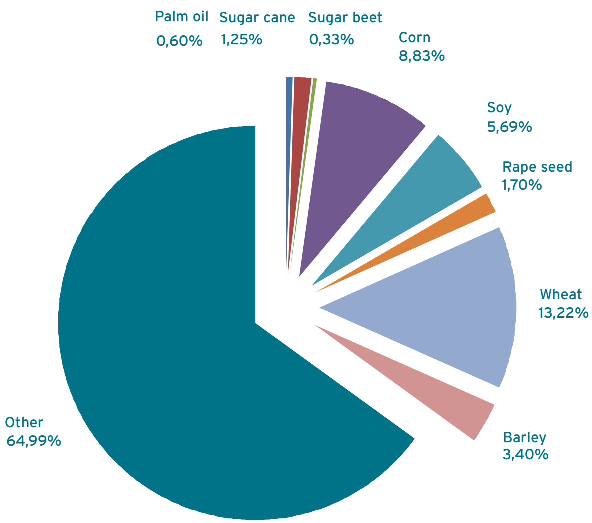
Categories of land use	Million hectares	Remarks
Agriculture	1,500	Includes grassland for intensive cattle farming
Pasture/grassland	3,500	More extensively managed
Forest	4,000	Includes natural production forests
Inproductive	4,200	Includes (semi-)deserts, **mountainous terrain and built-up areas**
Total	**13,200**	**Global land surface (excludes large ice sheets)**

[16]

16 Hoogwijk et al., 2003.

This figure shows how much surface in the world – as a percentage of the total arable area – is used for the arable crop production that is important to bio-energy at this moment [17]. This is land use in 2006. Although in that year only 1% of all the arable land was used for the production of bio-energy. Wheat has the largest surface area of all the arable crops researched with 13.22%, followed far behind by corn with 8.83%.

Land use in the world (%) in 2006



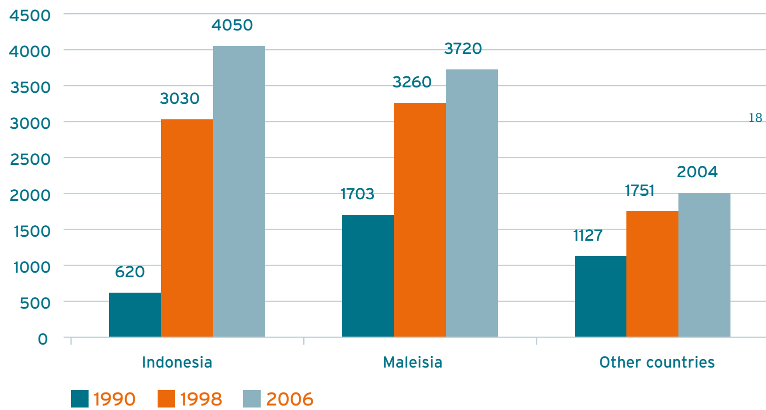
Land use per crop

The tables below show how much land was used in 2006 for certain arable crops.

Palm oil producing countries

The palm oil area increased substantially between 1990 and 2006. In Indonesia by 550%; in Malaysia by 110% and by 75% in the rest of the world. This is mainly because of the increased demand from the food sector and more demand for raw materials for soap and detergents. [18]

Land use palm oil, mature fruit-bearing trees (thousand hectares)

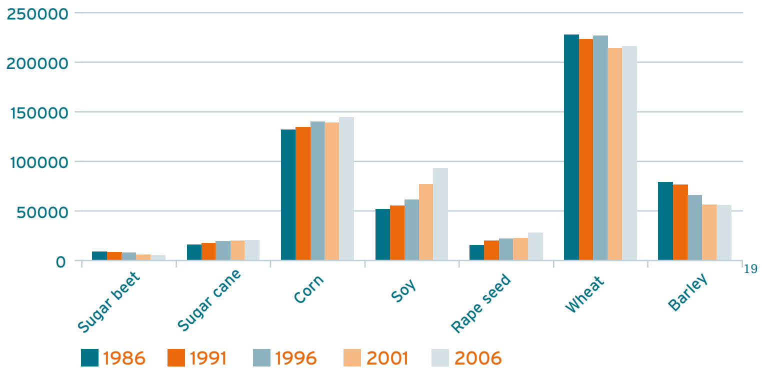


17 Sources: http://faostat.fao.org/site/339/default.aspx and Product Board MVO. The total land use in 2006 is estimated from Dornburg et al., 2008 (p. 49 in the 'Main Report'). In 1999 1.608 million hectares are used for agriculture. For 2015 a total agricultural area of 1.669 million hectares is estimated. For 2006 (this figure) an estimate of 1.635 million hectares is made.

18 Product Board MVO, http://www.mvo.nl/duurzame-productie/download/071108%20MVO-FactsheetPalm%20NL.pdf.

Agricultural crops

Land use agricultural crops (thousand hectares)



The use of land for sugar beet decreased by almost 40% between 1986 and 2006, partly because it was less attractive for the European farmers to produce (decreasing subsidies).

On the other hand the area for sugar cane has increased by 25% (gap caused by falling sugar beet production filled by increased demand for ethanol) and corn by almost 10% (partly because of the production of cattle feed and biofuels).

Land use for soy has increased by almost 80%, particularly because of the increasing demand for meat (in particular soy is by the the cattle feed industry). The area for rape seed has grown by 80% (mainly due to the use of Cole seed for biodiesel).

19 Source: http://faostat.fao.org/site/339/default.aspx, april 2008.

The area of wheat and barley was less in 2006 than in 1986, with dips of 5% and almost 30% respectively.
One of the reasons for this dip is the European Community regulation created to restrict the over-production of grain: farmers receive compensation for leaving their land fallow.
Changing crops has also occurred as a result of the low grain prices.

4.6 Developments in yields per crop per hectare and per country

The tables on the following pages show how the yields per hectare (kg/ha) have developed in the last twenty years.

Growth and dips of the yields through the years

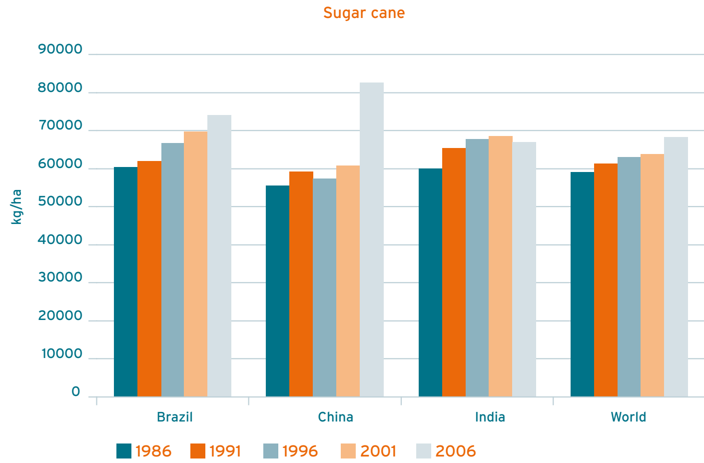
The average yield per hectare for all the crops in the world has increased during the last twenty years. This means that higher production can be achieved without extra land being needed. There are opportunities to increase production with better management and better technology especially in regions where the yield per hectare has been left behind.

Yield differences between the various biomass sources

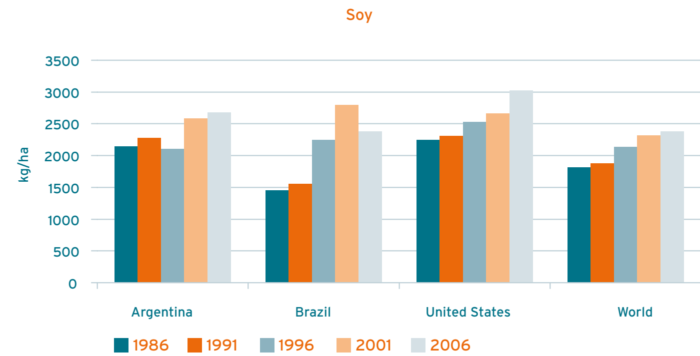
High yields per hectare can be found for sugar cane, corn and sugar beet; the lowest yields are for soy and rape seed. This has nothing to do with the efficiency of the use of the yield. Will this, for example, be divided into a part being used for food and another for energy and materials? Or will a part of the crop be seen as unusable waste? It also says nothing about the energy yield a crop ultimately supplies per hectare.
This last information can be found in paragraph 4.7.

Difference in yield between the production countries of the same biomass sources

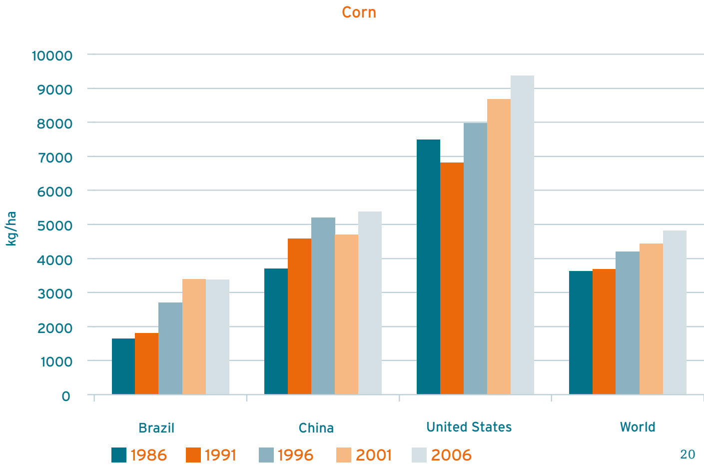
The yields can substantially differ between countries, but also in the countries. Soil condition, access to water, climate and management are aspects which influence the yield.



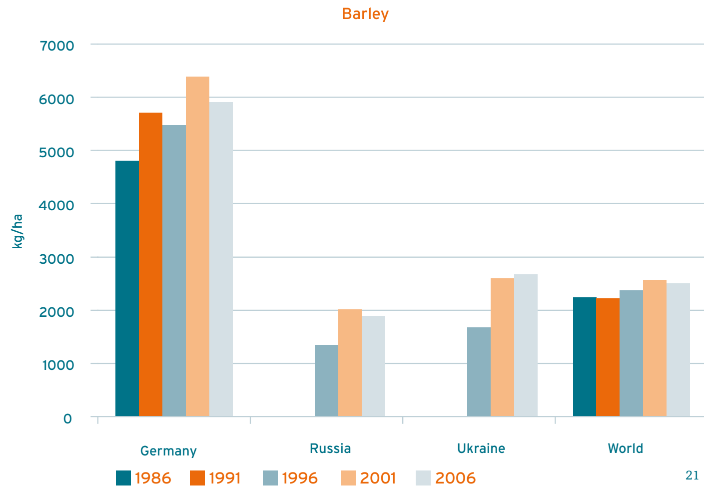
In the last twenty years the yield per hectare has increased by more than 10%. Brazil and (especially) China are efficient producers with high yields per hectare



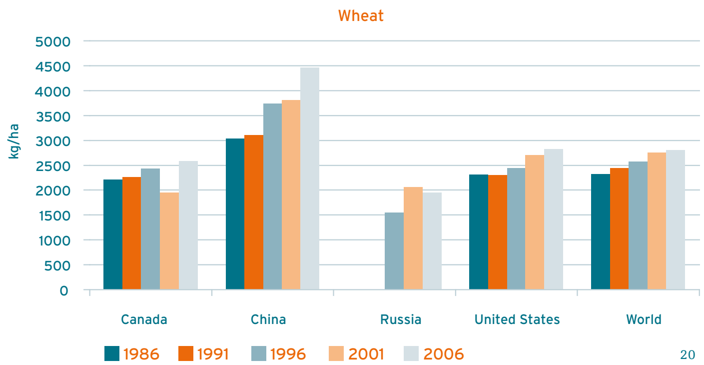
In the last twenty years the yield per hectare has increased by more than 25%. Argentina and the United States are performing better than average in 2006.



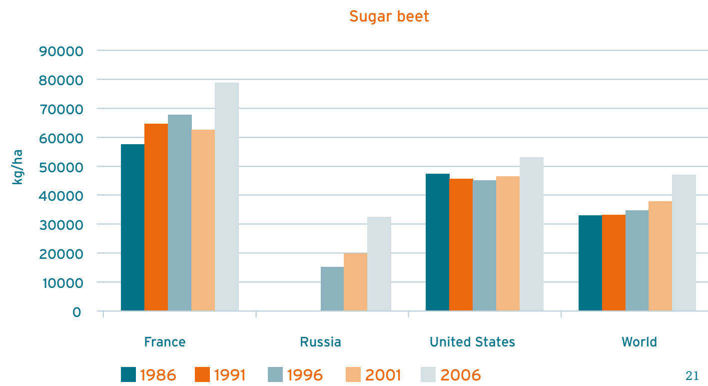
During the last twenty years the yield per hectare has increased by more than 30%. US and Brazil are the leaders. US produces twice as much per hectare compared to the global average, whereas Brazil stays behind.



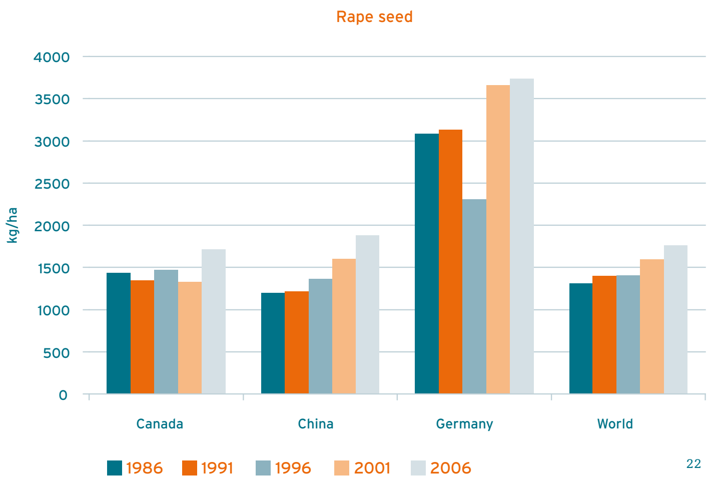
During the last twenty years the yield per hectare has increased by more than 10%. Germany produces far more than average.



During the last twenty years the yield per hectare has increased by more than 20%. China is the world's top producer when it comes to yield per hectare.



During the last twenty years the yield per hectare has increased by over 40%. France produces above average.



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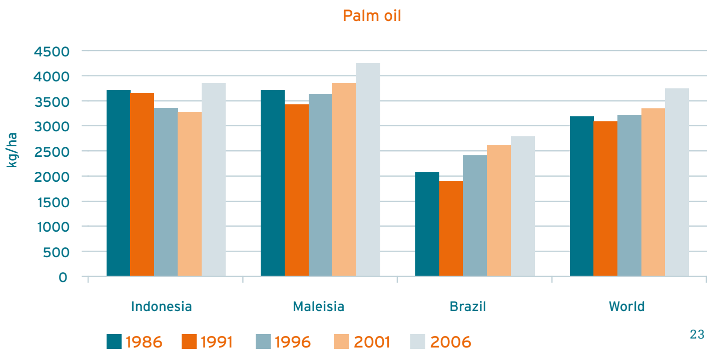
During the last twenty years the yield per hectare has increased by over 25%. It is possible to increase production even further. Germany for instance produces twice as efficient as the global average.



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During the last twenty years the yield per hectare has increased by more than 15%. Brazil stays behind compared to the global average. Maleisia is the most efficient producer.

4.7 Energy yield per hectare

The yield from a crop per hectare says nothing about the energy yield. Which crop provides the highest energy yield per hectare? The table below gives an indication of the energy yield per hectare per year for a number of crops in various circumstances. The current commercial conversion technology is assumed for starch and wheat crops (wheat, corn, sugar beet and sugar cane) and oil containing crops (soy, palm oil, jatropha). This means fermentation for converting starch and sugar into in ethanol; estrification for converting oil-containing seeds into biodiesel. Other conversion technology is needed for wood and grasses that have not yet been used commercially: second generation technology (see paragraph 4.13).

The range shows that the yield varies, depending on the environmental factors. The production of ethanol from sugar cane in Brazil provides more biomass per hectare than in India.

20 Source: http://faostat.fao.org/site/339/default.aspx, april 2008.
21 Source: http://faostat.fao.org/site/339/default.aspx, april 2008.
22 Source: http://faostat.fao.org/site/339/default.aspx, april 2008.
23 ISTA Mielke (Oil World Annuals 1999, 2004, 2007, Oil World 2020).

Energy yield per hectare

Crop	Biomass yield (odt/ha*yr)	Energy yield in fuel (GJ/ha*yr)
Wheat	4 - 5	~ 50
Corn	5 - 6	~ 60
Sugar Beet	9 - 10	~ 110
Soy Bean	1 - 2	~ 20
Sugar Cane	10 - 25	~ 200
Palm Oil	10 - 15	~ 160
Jatropha	5 - 6	~ 60
SRC temperate climate**	10 - 15	100 - 180
SRC tropical climate**	15 - 30	170 - 350
Energy grasses good conditions	10 - 20	170 - 230
Perennials marginal/degraded lands	3 - 10	30 - 120

* Odt = oven dry ton, or dry material yield
** SRC= short rotation coppice, or short circulation wood production with harvesting every 3-7 years

24

Conclusions from table

Wood and grasses in the majority of cases are expected to have a higher net energy yield per hectare than the arable crops which are now being used (perhaps up to three times as much). This does not include sugar cane: this crop scores highly in regard to energy yield per hectare.

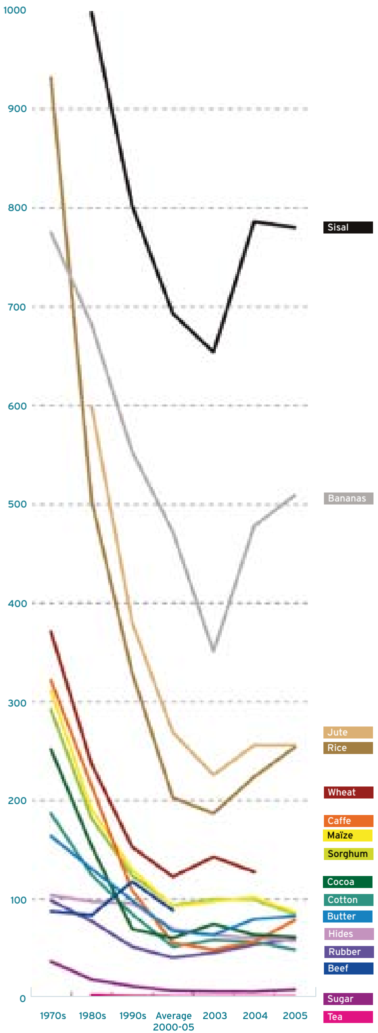
24 International Energy Agency (2006), Energy statistics International Energy Agency and United Nations Development Programme et al. (2004).

Furthermore marginal (poor in nutrients) soil can only be usefully planted with perennial wood and plant types. Decent energy yields can be gained here.

4.8 Price development of agricultural crops

The price increases of agricultural products in the last period are not a continuation of the earlier price increases. In reality the actual prices of agricultural products have fallen sharply in the last decades. Actual prices are how the price develops in relation to the general price level. Even if the price paid for the product increases (nominal price), that does not mean that the actual price also increases.

Trends in real commodity prices



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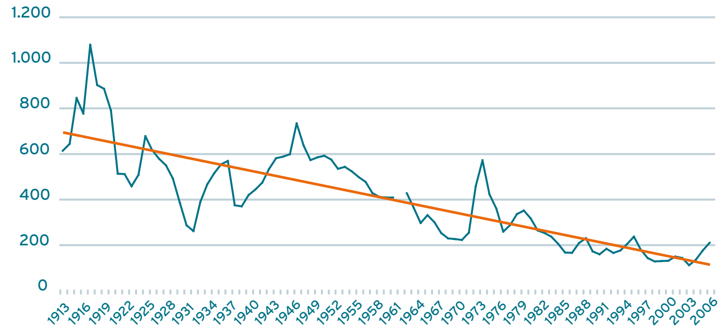
Base year is 2000
Basis for prices for individual commodities:
banana Ecuador (US$/tonne),
beef Argentina (US cents/lb),
butter New Zealand (US cents/lb),
cocoa ICCO indicator price (US cents/lb),
coffee ICO indicator price (US cents/lb),
cotton and hides (US (US cents/lb),
jute Bangladesh (US$/tonne),
maize (US US$/tonne),
rice Thailand (US US$/tonne),
rubber Malaysia (US cents/lb),
sisal East Africa (US US$/tonne),
sorghum US (US US$/tonne),
sugar ISA indicator price (US cents/lb),
tea FAO indicator price (US$/kg),
wheat Argentina (US US$/tonne).

Price development of wheat HRW 2 Kansas City in real terms, 1913-2006, $/t.

Source: Association Générale de Producteurs de Blé et autres céréales (AGPB)



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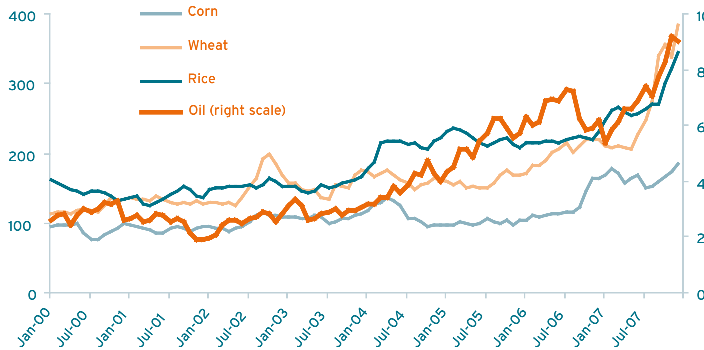
Surge in cereal and oil prices (US$/ton)



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Oil prices effect prices for agricultural products, even if they are not used for bio-energy (e.g. rice)

25 Trends in real commodity prices, http://maps.grida.no/go/graphic/trends-in-real-commodity-prices.

25a Vanhemelrijck, Johan (EuropaBio), 2008.

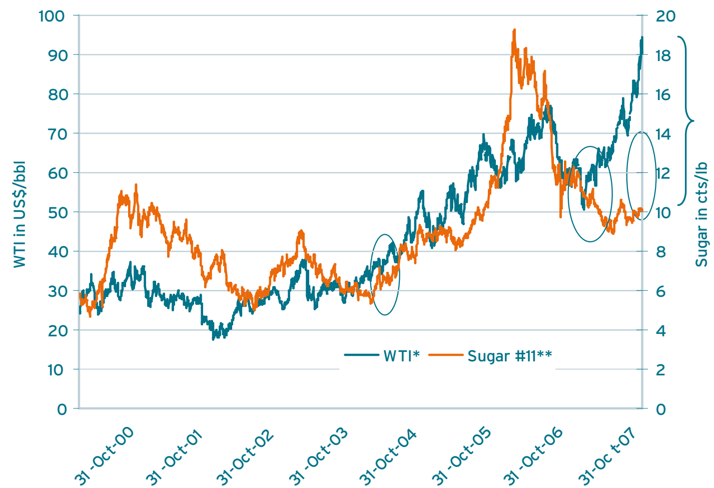
26 Presentation International Food Policy Research Institute (IFPRI), Joachim von Braun, februari 2008 (data van FAO 2007 en IMF 2007), http://www.ifad.org/events/lectures/ifpri/presentation.ppt#4.

Linking the sugar price and oil price

The market for petroleum and sugar is integrated more than for other crops. This is to do with the fact that Brazil has produced large quantities of ethanol from sugar cane since the seventies. Ethanol and oil operate in the same market; the result being correlation between the prices. The high oil price has pushed up the price of ethanol in the last years. The sugar price follows the petroleum price – Brazilian farmers can choose the end product during the production process: refined sugar or ethanol. If the sugar price does not increase, the farmers will choose ethanol (which consequently ensures scarcity on the sugar market and increasing prices).

The correlation has been out of step in the past year. The sugar supply has risen sharply mainly through the liberalisation of policy in certain countries. The market has become saturated. The continuously rising oil prices and the political decisions already taken in the field of biofuels will increase the demand for ethanol. The prices of sugar and petroleum are also expected to become closer again in the near future[28].

Oil and sugar



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* WTI = West Texas Intermediate, a type of natural oil used as benchmark for oil prices

** Rawsugar contract nr. 11, NYBOT, refers to world trade in raw sugar by the New York Board of Trade

Data: NYBOT and EIA, J. Schmidhuber (2007)

27 Based on a presentation by Schmidhuber, J., senior economist at the Food and Agriculture Organization of the United Nations (FAO) during the 16th International Sugar Organization seminar in London, november 2007. Title of the sheet: Oil and sugar - have they lost the track for good? Data from NYBOT and Energy Information Administration (United States) and J. Schmidhuber (2007).

28 Based on a presentation by Schmidhuber, J, senior economist at the Food and Agriculture Organization of the United Nations (FAO) during the 16th International Sugar Organization seminar in London, november 2007.

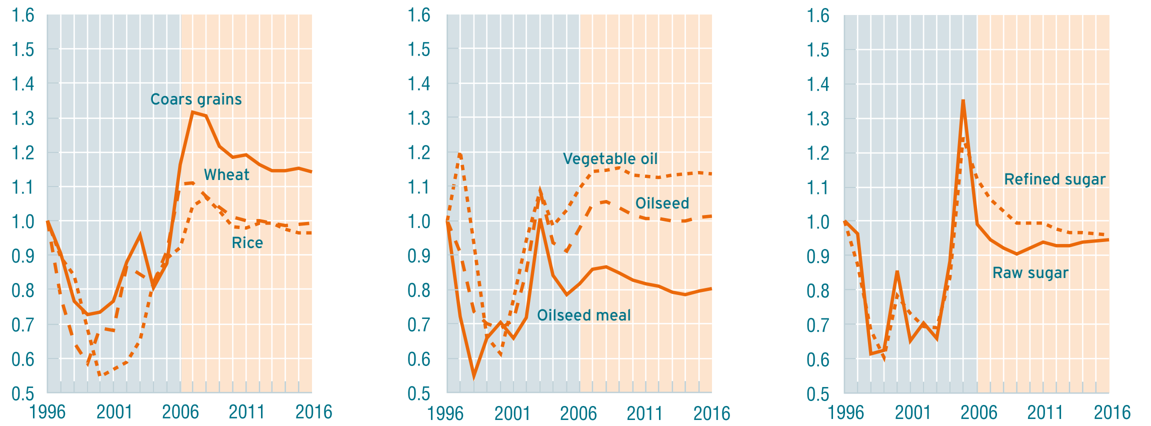
A glimpse into the future

An estimate of the price course of a number of products up to 2016 is given in the Agricultural Outlook 2007-2016 (OECD/FAO). Diagrams of grain, oil-containing crops and sugar can be found below.

The price of grain, oil-containing seeds and sugar has risen considerably in the last period. The demand from the bio-energy corner comes to a market which has been distinguished in the last year by breakdowns in the balance between supply and demand (through crop failure in an environment of increasing demand resulting in the pressure on the diminishing world supplies becoming even greater, for example). How will this develop further?

The price increases are expected to level out (partly through increasing the supply), but the prices will remain higher than before due to the increased demand. Population growth, changing eating patterns and bio-energy contribute to this (to what degree each factor contributes is unclear). The future demand for bio-energy is also uncertain. New policy and the development of the second generation can make the demand bigger or even smaller and also influence the price developments [29].

Index nominal prices, 1996 = 1



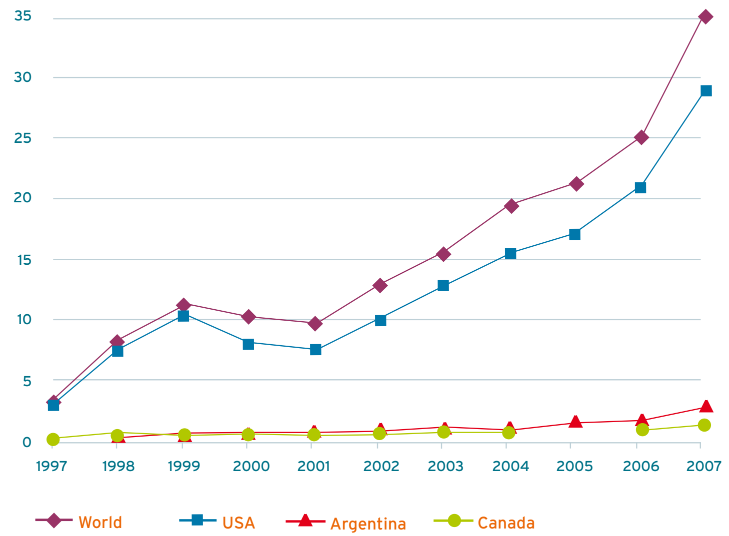
29 OECD/FAO Agricultural Outlook 2007-2016.

4.9 Use of genetically modified crops

Cotton, corn, rape seed and soy are the top four genetically modified crops in the world. If we compare the land used for these crops with the surface area needed for cultivating genetically modified crops, we can make a careful estimate that the proportion of genetically modified crops amounts to approx. 1/4 for corn, 1/5 for rape seed and 3/5 for soy.

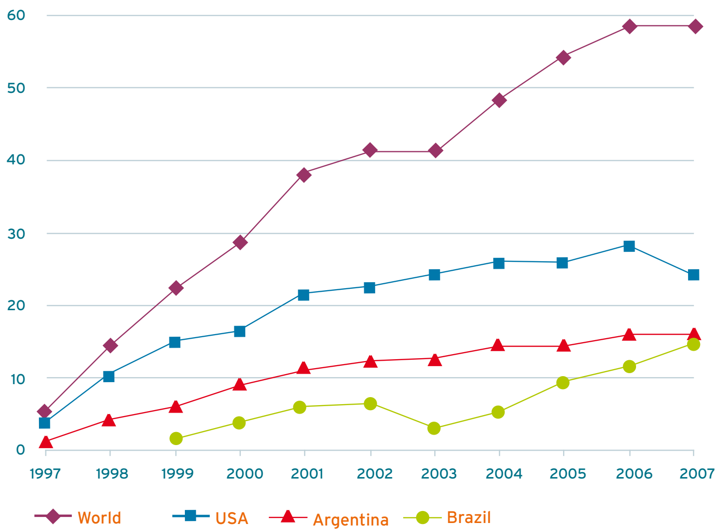
An overview of the surface area of corn, Cole seed and soya – which are all used for the production of bio-energy – can be found here and on the following page. The use of genetically modified crops has increased greatly in the last ten years, as can be seen from the diagrams. The complete production of these products often takes place in only a couple of countries.

Land use for genetically modified corn (million hectares)



The proportion of genetically modified corn in the total corn production in the United States in 2007 is 77% (1997: 9,5%)[30]

Land use of gentetically modified soy (million hectares)



The proportion of genetically modified soy in the total soy production in 2007 in the United States is 94% (1997: 4%).

The proportion of genetically modified soy in the total soy production in Brazil is 64% (1997: 10%). Between 1999 and 2002 genetically modified soy was grown illegally, figures are an estimate.

The proportion of genetically modified soy in the total soy production in Argentina in 2007 is 99% (1997: 22,6%).[31]

Land use of genetically modified rape seed (million hectares)

The proportion of genetically modified rape seed in the total rape seed production in Canada in 2007 is 87% (1997: 44,4%)

The proportion of genetically modified rape seed in the total rape seed production in the US in 2007 is 82% (1997: 10,6%)[32]

30 Data from http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/341.genetically_modified_maize_global_area_under_cultivation.html. De Figures are based on international agricultural statistics; partly on estimates and non-verifiable publications in media.
31 Data from http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/342.genetically_modified_soybean_global_area_under_cultivation.html. Figures are based on international agricultural statistics; partly on estimates and non-verifiable publications in media.
32 Data from http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/344.genetically_modified_rapeseed_global_area_under_ciltivation.html. Figures are based on international agricultural statistics; partly on estimates and non-verifiable publications in media.

4.10 Water requirement of agricultural crops

Agriculture is the largest consumer of fresh water in the world (about 70%). The map below shows an overview of water extraction for agriculture (irrigation) in 2001. The areas with far-reaching water extraction lie Africa and Asia in particular.

The opportunities for expanding or intensifying agriculture often go hand in hand with access to water (rain or irrigation) for many crops. In large parts of the world there is already talk of water shortage, when water is in greater demand because of the growing population, expansion of agriculture and further industrialisation.

Proportion of water withdrawal for agriculture, 2001

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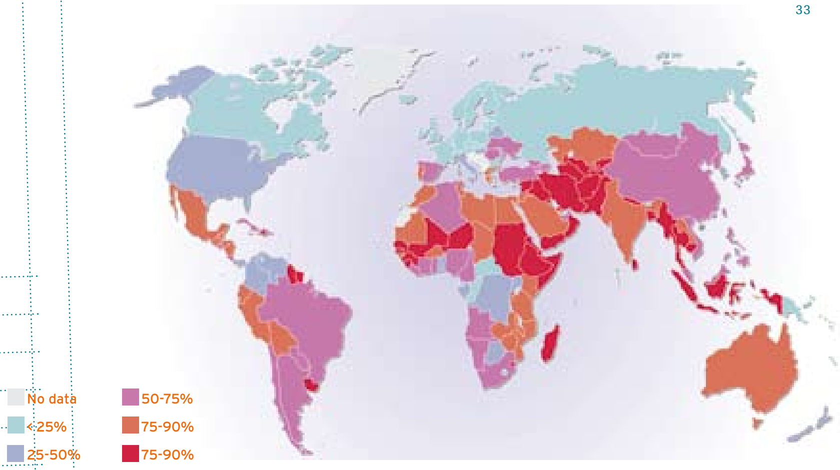


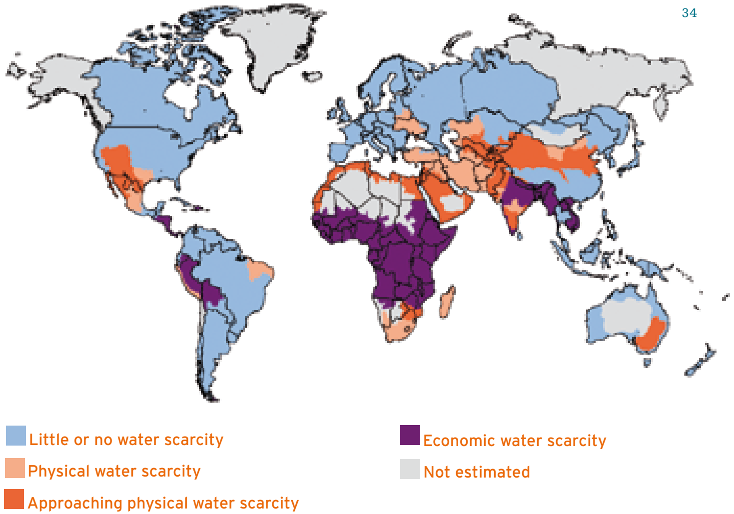
In some areas the availability of water provides opportunities for cultivating biomass, while water shortage is a serious impediment in other areas.
The large regional variations in climate and hydrology demand a detailed and local analysis of the possibilities per crop: which crops thrives under local conditions? (Dornburg et al.,2008) Can the water requirements be satisfied? Which crops help retain water in the soil or lessen evaporation? What opportunities are there for improvement in areas where water is critical?

The largest area where water is potentially available lies in Africa but access is limited for other reasons. For example through lack of capital or institutional agencies that organise access (economic water shortage). Partly for those reasons Africa is viewed as a continent where arable productivity could be greatly increased.

Good water management offers many opportunities. As shown by the International Water Management Institute:

"75% of the additional food we need over the next decades could be met by bringing the production levels of the world's low-yield farmers up to 80% of what high-yield farmers get from comparable land. Better water management plays a key role in bridging that gap."[35]

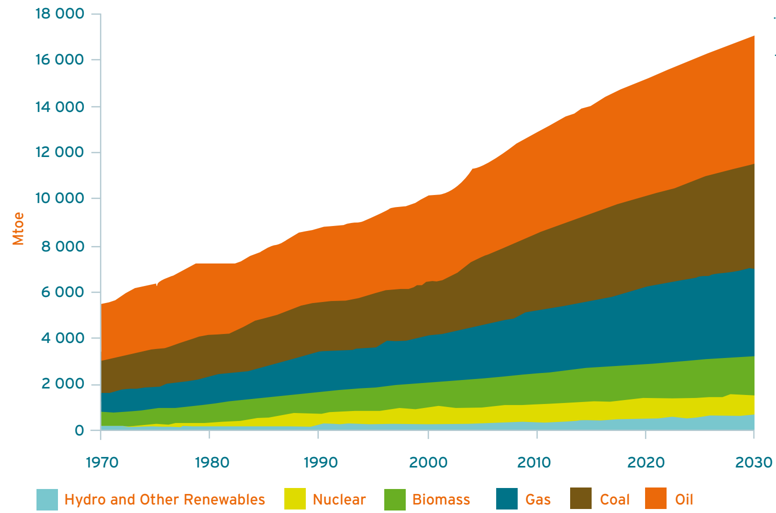
Areas of physical and economic water scarcity



[34]

4.11 Estimates of the proportion of bio-energy in world energy in 2030

The World Energy Outlook estimates the primary energy demand in the world every year[36]. In 2006 it was estimated that 14 million hectares of land was used for the production of biofuels and by-products (almost 1% of the available arable land worldwide). According to the World Energy Outlook 2006, if policy does not change, an estimated 35 million hectares will be needed in 2030 to satisfy the growing demand for biofuels (2.5% of the available arable land in the world). 3.8% (53 million hectare) could be needed if more objectives in the field of bio-energy are included in the policy.



33 Agricultural water withdrawals as proportion of total water withdrawals, http://maps.grida.no/go/graphic/agricultural-water-withdrawals-as-proportion-of-total-water-withdrawals.
34 Areas of physical and economic water scarcity, http://maps.grida.no/go/graphic/areas-of-physical-and-economic-water-scarcity
35 International Water Management Institute, 2007.
36 International Energy Agency, 2006, http://www.iea.org/textbase/country/graphs/weo_2006/gr1.jpg.

4.12 Production potential of bio-energy

The demand for land, water and biomass will increase in the coming decade due to population growth, changing eating patterns and growing welfare. Now a new demand for bio-energy has been created. Is there the potential to satisfy this demand?

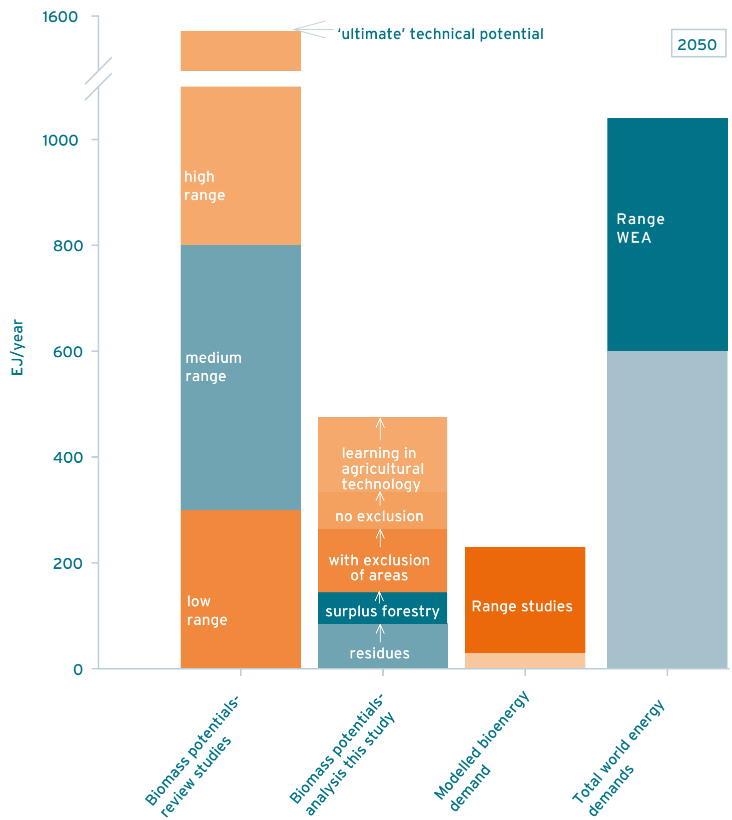
The potential of crop production for bio-energy is the subject of many studies. The WAB assessment (2008) compared these studies and calculated the potential, taking into account:

- availability and demand for water
- production and demand for food
- the energy demand
- the impact on biodiversity and agricultural-economic parameters

Information about figure

Assessed studies
Various studies recording the biomass supply potential have been compared. The quantity of biomass sources considered varies somewhat, just as the assumptions regarding scenarios and methods. The result is: great differences in respect to estimates of the biomass potential in 2050: between 0 and 1500 EJ per year.

The figure below shows the result of the WAB assessment.[37]



37 Dornburg et al., 2008.

Analysis of WAB assessment
The potential supply of biomass – taking into account the various uncertainties that were researched in this study – comprises three main categories:

1. Waste products from forestry and agriculture and organic waste residues:
   these include a supply of 40-70 EJ/year, with an average of about 100 EJ/year. This portion of the potential biomass is almost certain, although competitive uses for biomass could push the net availability to the lower limit of the range. This last mechanism must still be researched better, using improved models, for example, which include the economic aspects of these uses.

2. Surplus forestry: along with the waste products from forestry, an extra quantity of about 60-100 EJ/year can be obtained from additional forest growth.

3. Biomass produced via energy crops:
   a. An estimate of the contribution made by energy crops *to the possible available surplus of arable and pasture ground* results in 120 EJ/year, taking into account corrections for water shortage, degradation of soil and new claims on land for nature reserves ('with exclusion of areas' in the figure).
   b. The potential additional contribution of *areas with water shortage, marginal and degraded soils* to the production of energy crops is 70 EJ/year. This includes a large area where water shortage causes restrictions and where degradation of the soil is serious; protected areas are excluded from biomass production ('no exclusion' in the figure).
   c. *Learning effects in agricultural technology* can add about 140 EJ/year to the abovementioned potential of energy crops.

The three categories together lead to a biomass supply potential of about 500 EJ.

Demand for biomass
Energy demand models, that calculate the biomass use on the grounds of the cost of competitive energy options at various quantities of CO_2 load, calculate a demand of 50 to 250 EJ/year of biomass for the year 2050. This demand for biomass for energy production is less than the estimated available supply.

World energy demands
The total world demand for primary energy in 2050 is estimated at between 600 and 1040 EJ/year.

4.13 Second generation bio-energy

Second generation bio-energy is looked forward to. Optimists estimate that this can be used between 2010 and 2015. Expected advantages are[38]:

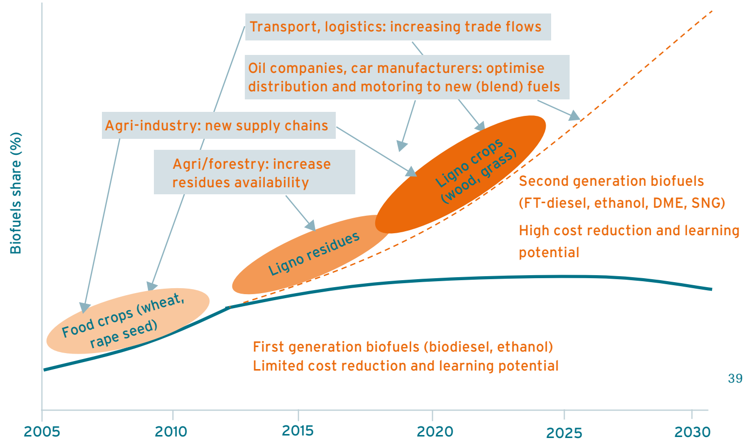
- Further reduction of CO_2 emissions (better greenhouse gas balance).
- Utilization of waste products from wood and agricultural products.
- Utilization of crops (energy farming) which do not directly compete with food and cattle feed (wood-like and grass crops, the so-called lignocellulose containing crops).
- Less pesticides/artificial fertilizers are needed (therefore less damage to the environment).
- No impact (back and forth) on food prices.
- Higher output: less land needed for the same energy yield.
- More types of land can be utilized, marginal soil as well. Products from first generation (oil, starch and sugar crops) often require qualitative good soil for adequate production.
- Cheaper to produce per unit of energy.

Possible disadvantages:

- Introduction barrier caused by large demand for first generation biomass sources.
- High investment costs for processing and production: sensitive to price of bio-energy.
- More limited sales opportunities: food market drops away.
- Competition for land and water remains.

38 Refuel, 2008.
39 Refuel, 2008.

A number of the expected advantages of second generation bio-energy are shown in the diagram below.
The following generation of bio-fuels offering opportunities to various sectors is assumed.



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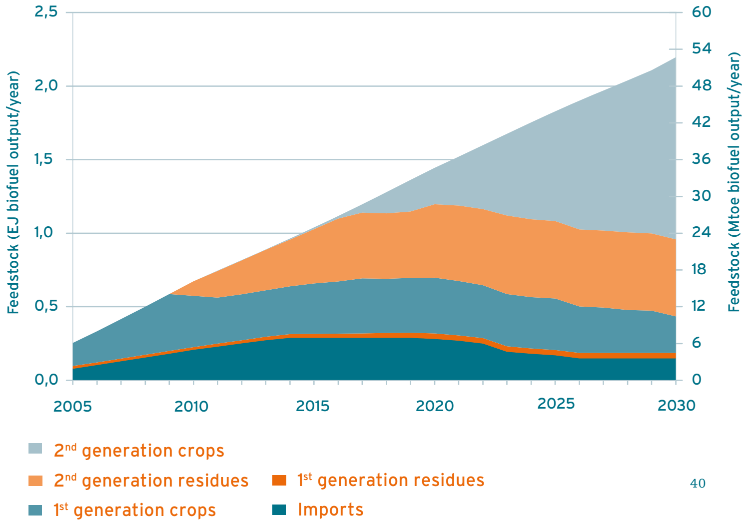
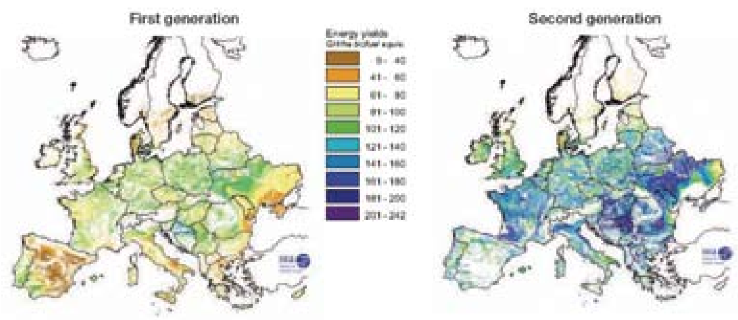
The utilization of the second generation depends on technology persevering in producing bio-energy from new crops and with new techniques. The quicker this happens, the quicker second generation bio-fuels can compete with the first generation.

In the diagram below it is assumed that second generation can be relied upon from 2010 onwards. The use of first generation crops from Europe are expected to increase in the coming years as the import of electricity grows, and then to decrease in importance after 2020.



[40]

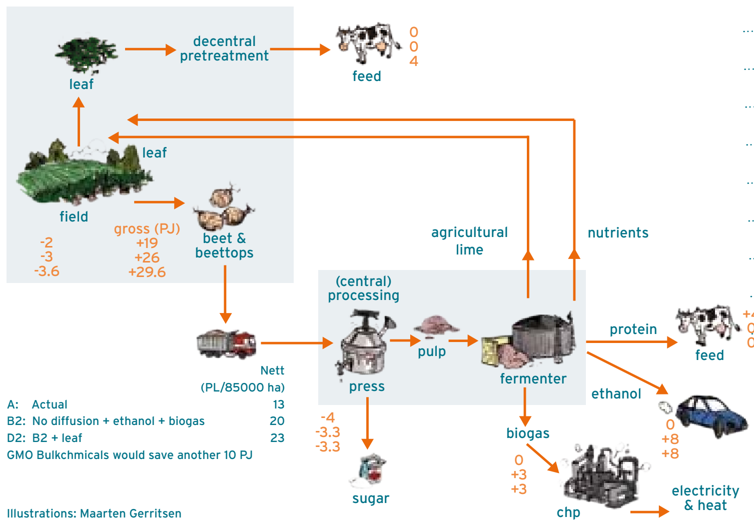
On balance second generation bio-energy is expected to bring in more per hectare. It is estimated that the highest energy yield per hectare will be obtained in East Europe.



[41]

4.14 Bio-refining: an example using sugar beet

In this diagram, originating from Prof. Johan Sanders (WUR) and produced by the Platform for Chain Efficiency, the possibilities of biorefining sugar beet are explained.



40 Refuel, 2008.
41 Refuel, 2008.

The current chains are illustrated through process A in this diagram (shown by the top number in each square on the figure). On the existing Dutch surface area of 75,000 hectares, 15 PJ, converted into energy, is harvested in the form of sugar. Pulp, after evaporation, is used for cattle feed (4 PJ). However an input of 2 PJ in the field and 4 PJ in the factory is necessary for the total yield of 19 PJ, so that the net harvest amounts to 13 PJ.

In chain B2 (the middle number in each square) the area is extended to 85,000 hectares. Not only is the beet harvested, but also the tops and tails. Diffusion does not take place (heating and expelling of the sugar with water), but the harvest is heated and pressed. Sugar ends up in so-called raw thin juice; the sugar yield is 10% less that by A, but due to the larger area, the crystal sugar yield is still almost as large. Pressed cake remains, consisting of left-over sugar and pulp. The sugar from the pressed cake is converted into ethanol (8 PJ), which is distilled and sold as bio-ethanol. The pulp is not dried but converted into biogas (3 PJ). The gross yield is 26 PJ, but in the process 3 PJ is needed on the field and 3.3 PJ in the factory (which can almost all be absorbed by biogas), so that a net yield of approx. 20 PJ remains. In chain B2 50% more is produced in energy terms all in all, while the sugar yield remains the same and the area is increased by approx. 13%. Watch out: these results were achieved with a first generation ethanol production method.

Chain D2 (the bottom number in each square) is similar to B2, but now the foliage of the beet is also used, mainly for cattle feed. The net yield of this chain is 23 PJ, an energy yield of 75%, while the sugar and cattle feed yield remains the same compared to process A.

Processing methods B2 and D2 for sugar beet as shown here are a simple example of biorefining:
the technology which separates the harvest into a number of components that are each processed and marketed. Biorefining is still being developed. One of the possibilities is the further division of the plant’s components so that proteins and other chemicals can be extracted, which further increases the value of the harvest and the (indirect) energy yield. A considerable energy yield can be booked by extracting chemicals from biobased raw materials: energy-intensive production of these materials from petroleum and natural gas is avoided.

If GM sugar beets are permitted, other varieties can be planted in which will raise the quality of the raw materials for bulk chemicals is improved. Another approx. 10 PJ fossil input can be avoided with this relatively small area.

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Energy Transition - Creative Energy

Trade and industry, government, knowledge institutes and civic organisations are working together to ensure that energy provisions in 2050 will be sustainable.
Energy will then be clean, affordable by everyone and supplied continuously. Energy Transition requires and provides Creative Energy.
Energy Transition aims at seven themes to realise the sustainable provision of energy. A platform has been established for each theme. The discussion about biomass affects several platforms.
This publication was initiated by the Biobased Raw Materials Platform and was realised with the cooperation of the Chain Efficiency Platform, the New Gas Platform, the Sustainable Mobility Platform and the Sustainable Electricity Supply Platform.

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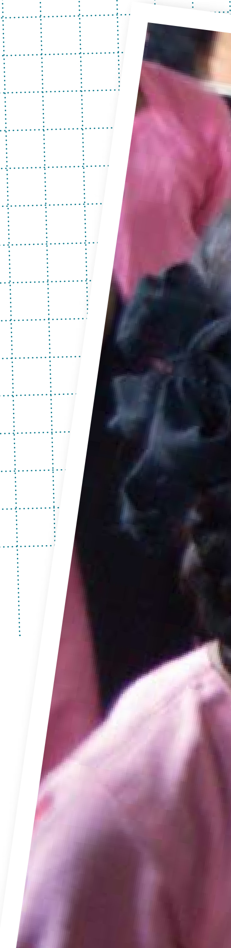

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