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Rain Forest for Biodiesel?

Ecological effects of using palm oil as a source of energy

A study by WWF Germany in cooperation with
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Cover photo: Palm oil seedlings in a plant nursery. Central Kalimantan, Indonesia.
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Summary

Palm oil is an extremely versatile commodity which traditionally has been used both as a foodstuff and as a raw material in non-food items such as cosmetics, soaps, shampoos and washing detergent. Only recently, with rising mineral oil prices and challenges from climate change, have there been calls for palm oil to be used as a renewable energy source.

In Europe, the production and use of vegetable oils as energy sources are influenced by prevailing political and legal conditions, such as tax exemption as provided under the Renewable Energy Act in Germany or the recent European Union directive on promoting use of biofuels in the transport sector as a way to cut greenhouse gas emissions.

Like other vegetable oils, palm oil can be used as a fuel in vehicles or for electricity or heat generation. But for it to be used as a biofuel, it either has to be processed to make it similar to mineral diesel fuel, or vehicles and machines have to be modified to accept pure vegetable oil. Furthermore, the palm oil biodiesel must comply with existing fuel quality standards of several countries. Poor fuel quality has often been the main cause of machine breakdowns. In Europe, palm oil currently does not fulfil the standards‘ specifications relating to melting points. There is though enormous potential for the use of palm oil as a biofuel if the standards soften this demand. More vegetable oils could then be used in their pure form or as part of a mix in power stations, depending on their size. Already, around 1.5 million tonnes of palm oil were used in this manner in power stations throughout Europe in 2005.

More than 80 per cent of the world‘s palm oil is produced in Indonesia and Malaysia. Significantly smaller amounts are grown in Nigeria, Thailand and Colombia. Palm oil outranks soybean, rapeseed and sunflower in terms of output per hectare. It is feared that if demand for palm oil increases further, valuable tropical forests in the producing countries will fall victim to the intensive cultivation of oil palms.

On the surface, the use of palm oil as an energy source appears environmentally-friendly as it replaces fossil fuels and is CO_2 neutral. But what if the entire production chain of turning palm oil into a biofuel is taken into account?

This study examines the issue more closely. It was undertaken by the Institute for Energy and Environmental Research and the Institute for Climate, Environment, Energy, both of Germany, and commissioned by WWF in Germany, Netherlands and Switzerland. The study investigated the environmental effects of oil palm cultivation, looking at various land-use changes and calculating the corresponding energy balances and greenhouse gas balances.

The life cycles of conventional diesel and biodiesel were compared when considering the energy balances. Differentiations were made between palm oil use for vehicles and in power stations. For both uses, it was observed that the production of palm oil biodiesel requires considerable amounts of fossil energy compared to that of conventional diesel. On the other hand, considerable energy credits result from the by-products of palm kernel oil, such as tenside and glycerine, that are greater than the entire energy expenditure for the production of palm oil biodiesel.

Alternative land-uses play a role in calculating the greenhouse gas balances. For this purpose, various scenarios were developed i.e. use of natural forest, fallow land and plantations of other crops, such as coconut or rubber, for planting oil palm. The natural forest and fallow land scenarios also considered the effects of the different depreciation periods. A further differentiation was made with the natural forest scenario between sustainable and typical management of palm oil plantations.

The study concluded that the use of tropical fallow land for planting oil palm is clearly more effective in terms of CO_2 savings. then clearing of natural forests. The results are not as unequivocal when converting other plantations into oil palm plantations as it depends on the preceding crop. When plantations of other crops are converted into palm oil plantations, it means the products traded on the world market, for eg. natural rubber, will no longer be available and have therefore to be substituted by alternatives such as synthetic rubber. All this needs to be considered.

There are hardly any differences in the energy balances and greenhouse-gas balances when comparing use

of palm oil fuel for vehicles and in power stations. Considerable energy and greenhouse gas savings can be made during the production if this is managed according to „best practice“. Best management practices include the capturing of biogas from oil mill effluents, the use of fibres and kernel shells, and sustainable and optimised production methods.

Compared to the production of other biofuels, the energy balance for cultivating oil palm turns out positive. However, it is only the cultivation of oil palm on tropical fallow land which can be considered positively in terms of greenhouse gas savings. If the oil palm to produce biofuel is grown on plantations of other crops, the balances worsen noticeably.

On the basis of this study, it is evident that palm oil will experience strong growth. The UN FAO has predicted that global demand will double between 2000 and 2030. Several considerations, however, have to be taken into account to ensure that the savings in fossil energy and emissions of greenhouse gases are not offset by negative environmental impacts such as loss of biodiversity, air and water pollution, and social problems such as poor working conditions and land rights conflicts.

Most important as well is the need to ensure that the use of palm oil as a biofuel does not affect its availability as a foodstuff. In most cases, there is a need to ensure that the poor in developing countries who depend on palm oil as a foodstuff do not bear the brunt.

But even if energy balances and climate-gas balances turn out to be positive, environmental aspects should be considered in an overall ecological assessment. This includes, above all, pressures on air and waters arising from palm oil production as well as the loss of biodiversity as a consequence of clearing tropical primary forests.

Considering the risk of palm oil production for nature and environment and a continuous demand for this energy source the actual benefit of palmoil utilisation as a contribution to the reduction of greenhouse gases have to be assessed. In particular the extension of cultivated area should accompany a stringent use of tropical fallows. The efficient application of this option and the assessment of the cost-effectiveness require urgent research.

In order to ensure the sustainable production and use of palm oil, the Roundtable on Sustainable Palm Oil (RSPO) developed guidelines that require minimum social and ecological standards to be met. However, these guidelines have their limits because they are voluntary in nature and they currently do not consider greenhouse gas emissions from the production of palm oil.

In the long run, WWF recommends an international multi-stakeholder process to develop globally applicable sustainability standards for the production of bioenergy.

1 Background and aims

Palm oil has increasingly been at the focus of public discussion recently against the background of various efforts to increase its use as a source of bioenergy. This is also being encouraged by fundamental government policies such as the exemption of biofuels from mineral oil tax, the Renewable Energy Act, the compulsory blending of biofuels with conventional fuels, and the EU's Directive on biofuels' share of total fuel consumption. One important element of this discussion alongside technical and economic issues is the enormous increase in the amount of palm oil that has been coming onto the world market over the last few years, leading in many cases to the clearing of natural tropical forests.

This raises questions as to what potential palm oil has as a source of energy and what effects its increased use as an energy source might have in the future – on the one hand on energy balances and greenhouse gas balances, and on the other on land-use in general and natural tropical forests in particular.

In order to find answers to these questions, the WWF commissioned the IFEU-Institut für Energie- und Umweltforschung Heidelberg GmbH (Institute for Energy and Environmental Research) to gather and evaluate current knowledge on the subject. The present study places the emphasis on the ecological effects, particularly with respect to palm oil's energy balances and greenhouse gas balances and the expected consumption of land. The corresponding technical, economic and political aspects are also examined. The Wuppertal Institut für Klima, Umwelt, Energie GmbH (Institute for Climate, Environment, Energy) also participated in the project, focusing on the political aspects.

The time horizon of this study covers developments expected as a result of the expanded use of first-generation biofuels, which, in addition to the biodiesel made from palm oil and rapeseed oil examined here, also include ethanol made from sugar cane for use as gasoline. According to current estimates, cheaper and more effective second-generation biofuels, such as synthetic BTL (biomass-to-liquid) biofuels made from wood, will reach market maturity around 2020 to 2030; other technically conceivable alternatives such as hydrogen drives or fuel cells are more likely to take until 2030.

2 Palm oil as a source of bioenergy

by Guido Reinhardt, Nils Rettenmaier and Sven Gärtner

Palm oil is an extremely versatile product which up to now has been used predominantly as a foodstuff and as a raw material for bioenergy or other technical purposes. Only relatively recently have efforts been made to use palm oil as a bioenergy source. The methods of growing the oil palms (from whose fruits the palm oil is extracted) and processing the palm oil are identical for all uses.

2.1 Palm oil: cultivation, processing and use

Oil palm cultivation

The oil palm (*Elaeis guineensis* Jacq.) originally comes from west Africa (Gulf of Guinea) and is one of the highest-yielding oil plants in the world producing 3.5-4.0 tonnes of oil per hectare. It grows best on deep and well-drained soils at a mean annual temperature of 24-28°C (with minimal annual and daily fluctuations), a mean annual rainfall of between 1500 and 3000 mm, and a mean relative humidity of 50-70%. It is therefore essentially restricted to the zone of evergreen tropical rainforest on either side of the equator (10°S – 10°N) and to altitudes of up to 500 m above sea level. The oil palm has spread all over the tropics since the mid-19th century and has been grown commercially in extensive plantations since the early 20th century (Rehm & Espig 1996 and Franke 1994).

Processing the oil fruit

The oil palm's main product is its oleaginous fruits, which can be harvested all year. The plum-sized fruit yields two different oils: palm oil (produced from the pulp) and palm kernel oil (from the seeds). After the palm kernel oil has been pressed out, a press cake remains which is rich in protein (15-16% crude protein) and is used as animal feed.

Uses of palm oil

The properties and uses of vegetable oils are determined by the length of the fatty acid chains, the amount of unsaturated fatty acids they contain, and the number and position of the double bonds. For practical purposes, seven main groups are distinguished.

Due to its high content of oleic acid (about 39%), palm oil – like olive oil – belongs to the oleic acid group; 80% of production is used in foodstuffs (salad/cooking oil, margarine). The remaining 20% is used in the non-food sector (see Table 6). Statistically, its use as an energy source has been minimal up to now.

Picture 1: Oil palm plantation in Malaysia. Photograph: IFEU

Picture 2: Cross-section of oil fruit. Photograph: IFEU

1 = Palm kernel: palm kernel oil
2 = Pulp: palm oil
3 = Fruit bunches

Palm kernel oil, by contrast (like coconut oil), belongs to the laurinic acid group (laurinic acid content approx. 43%); its content of unsaturated fatty acids is lower (about 17%). These properties, along with the high melting point, are why palm kernel oil is used in long-life bakery products. Because of the high content of short-chain fatty acids (10-14 C atoms), most of production is used by the chemical industry in the production of detergents (Rehm & Espig 1996).

Tab. 1: Uses of palm oil and palm kernel oil

	Foodstuffs	Non-food products
Palm oil	cooking oil, margarine, animal feed, coffee whitener, potato chips	candles, soaps, inks, polishes, tin plating of iron
Palm kernel oil	cooking oil, cooking/frying fat, margarine, confectionery	soaps, ointment base, detergents, cosmetics

Hallmann 2000

2.2 Palm oil – a product in world trade

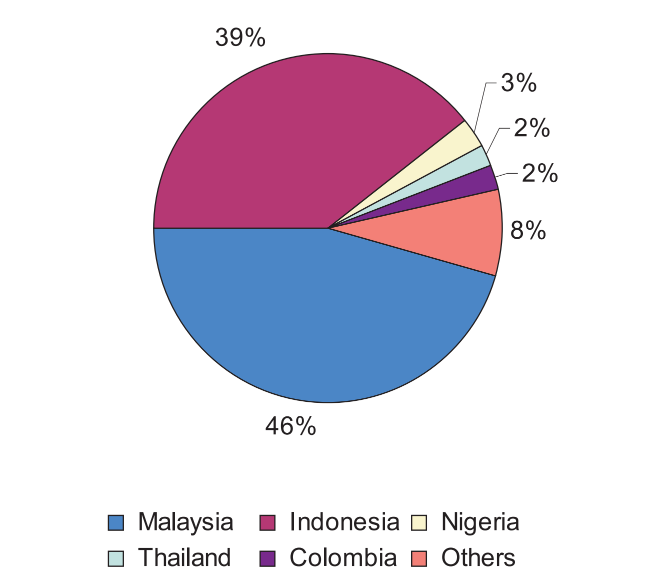
The main cultivation areas of the oil palm are in south-east Asia (Malaysia, Indonesia, Thailand, Papua New Guinea), west Africa (Nigeria, Ivory Coast) and increasingly south and central America (Colombia, Ecuador, Brazil), although it is much less widespread there (see Table 2). Fig. 1 shows that in 2004 about four fifths of the world's palm oil production came from two countries: Malaysia (46%) and Indonesia (39%). A long way behind in third place was Nigeria (3%), followed by Thailand and Colombia (2% each).

Tab. 2: Palm oil: worldwide areas under cultivation and production volumes

	Area [1,000 ha]	Oil production [1,000 t]
Malaysia	3,466	13,976
Indonesia	3,320	12,100
Nigeria	367	790
Thailand	270	668
Colombia	157	632
Others	1,012	2,485
Total	**8,592**	**30,651**

ISTA Mielke 2004

Fig. 1: World palm oil production 2004



ISTA Mielke 2004.

According to the FAO the oil palm is grown on approx. 12 million hectares worldwide (FAOSTAT 2006). However, about 3 million hectares in Nigeria (approx. 90 % of the area cultivated there) are not rated as productive by (ISTA Mielke 2004). Deducting this hectarage, the area cultivated worldwide is slightly less than 9 million ha. The amount of land given over to oil palms has multiplied since the mid-1970s, largely due to rapid expansion in Malaysia and Indonesia (see Fig. 2).

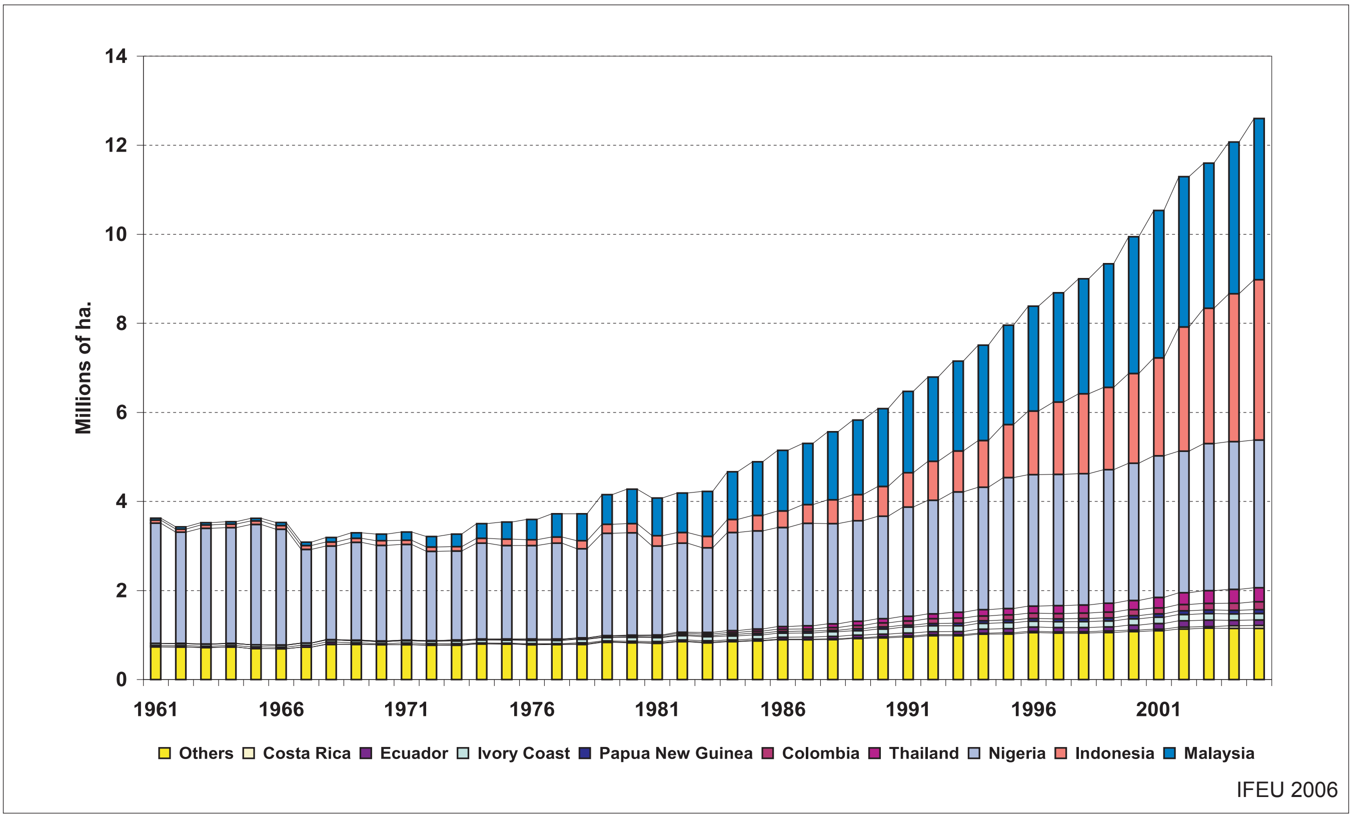
Of all oil crops worldwide, soybean occupies by far the most land (just under 90 million ha.), followed by rapeseed (25 million ha.) and sunflower (20 million ha.). Land devoted to growing oil palm is thus only the equivalent of about 10% of the soy hectarage; even so, it delivers a comparable global output. The reason for this is palm oil's almost ten times higher average yield of 3.57 tonnes per hectare compared to 0.38 tonnes for soybean oil (see Table 3).

Tab. 3: Global average fruit and oil yields of the most important oil crops 1999/2000 2003/2004

	Fruits t/(ha*a)	Oil t/(ha*a)
Cotton seed[1]	1.10	0.12
Peanut[1]	1.42	0.22
Oilseed rape[1]	1.54	0.58
Soybean[1]	2.28	0.38
Sunflower[1]	1.17	0.44
Oil palm[2]	17.84	3.57

[1]USDA 2006
[2]IFEU 2006 (based on ISTA Mielke 2004)

Fig. 2: Worldwide area planted with oil palms



FAOSTAT 2006

With a production of over 30 million tonnes a year, palm oil ranks among the four most important vegetable oils in the world which together make up approx. 80% of the world's output. In 2004/05, palm oil and soybean oil each accounted for about one third (31% and 30% respectively) of production. They were followed by rapeseed oil with 14% and sunflower oil with 8% of global production (see Fig. 3 and Table 4).

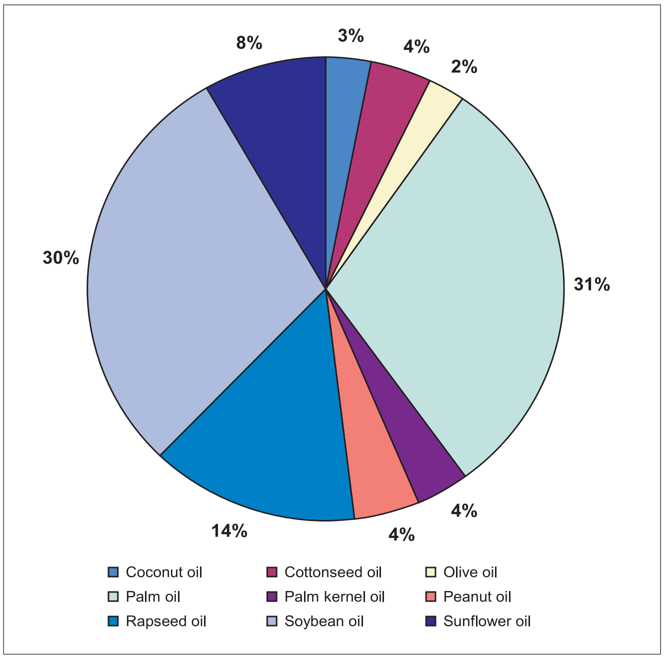
Tab. 4: Global production of the most important vegetable oils

	Global production 2004 [m t]
Palm oil	33.24
Soybean oil	32.43
Rapeseed oil	15.67
Sunflower oil	9.18
Peanut oil	4.91
Cotton seed oil	4.75
Palm kernel oil	4.01
Coconut oil	3.26
Olive oil	2.74
Total	**110.19**

USDA 2006

Production of vegetable oils has come to play an important role worldwide, growing by almost 50% over the past eight years to about 110 million tonnes in 2004/05. Palm oil (+96%) and soybean oil (+47%) have been largely responsible for this increase. Production in Malaysia has almost doubled over the last ten years; it even tripled in Indonesia between 1995 and 2004.

Fig. 3: World production of the most important vegetable oils in 2004



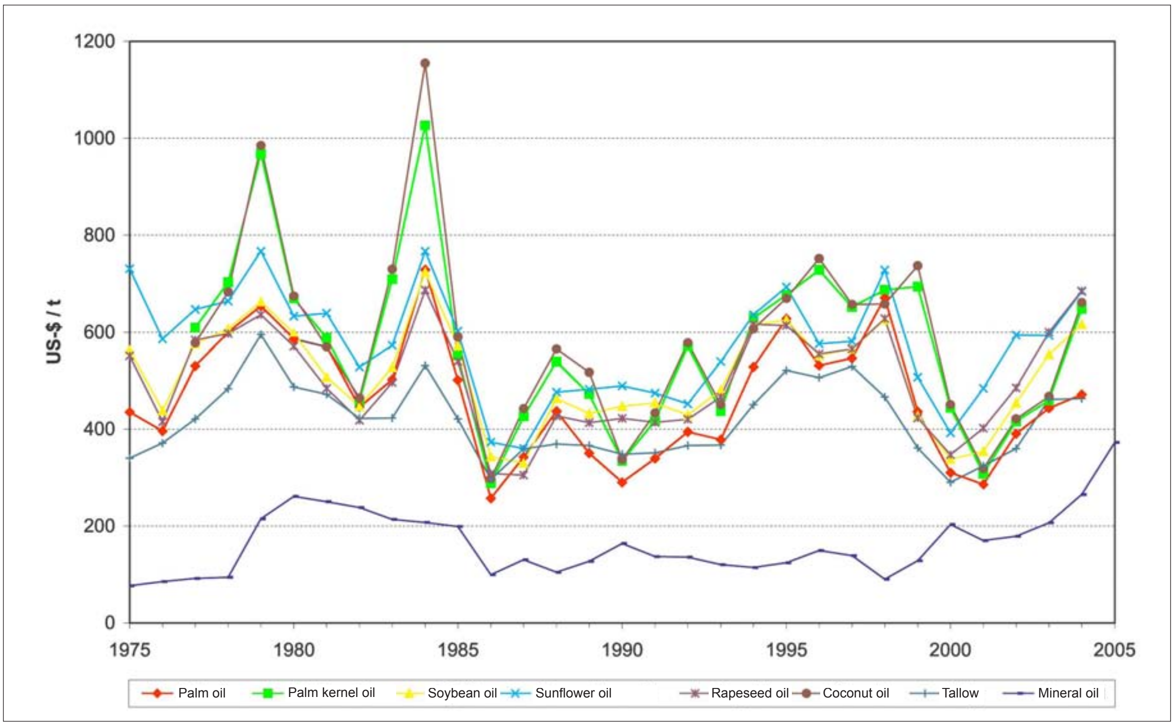
USDA 2006

The prices of the different vegetable oils and vegetable-oil raw materials have had a strong influence on production and world trade over the past decades. The relative stability of vegetable-oil prices in the 1950s and 1960s led to a continuous growth in production and world trade. Following a sharp rise in the 70s and the subsequent volatility of both world market prices and the relation between the different vegetable-oil prices, uncertainty about prices among oil-crop producers increased significantly in the 80s and 90s (Franke 1994).

Producers of coconut, palm and olive oil were particularly hard hit because there is little they can do to respond to short-term fluctuations (see Fig. 4). Particularly striking are the coconut-oil peaks in 1979 and 1984 (caused by El Niño events in 1977/78 and 1982/83) and the related drought-induced crop failures in south-east Asia (Philippines, Indonesia) (MPI 2006).

Fig. 4 shows the prices of different vegetable oils in the period from 1975 to 2005. In the first six months of 2006 (RBD), palm oil cost approx. $450 per tonne, soybean oil approx. $550 per tonne and rapeseed oil about $750 per tonne. No direct connection exists between the prices of vegetable oils and the price of mineral oil, which is also shown. However, there were signs of a link between ethanol made from sugar cane and the price of crude oil, which could also have effects on the price development and profit margins of other biofuels in the future (OECD 2006).

Fig. 4: Average annual prices of different vegetable oils on the north-west-European market.



ISTA Mielke 2004 and mineral oil MWV 2006

2.3 Palm oil as a source of bioenergy

Like other vegetable oils, palm oil can also be used as a fuel for internal combustion engines, both in vehicles and in stationary plants – i.e. power stations, district-heating stations and (block-type) cogeneration plants.

2.3.1 Use as a fuel (mobile)

Although pure vegetable oils are very similar to conventional mineral diesel fuel, several important parameters (e.g. viscosity) differ (see Table 5). As a result, in their pure form they are usually not suitable as fuels for conventional diesel engines. There are two possible ways of adapting them for use in diesel engines: either the diesel engines are modified for the use of pure vegetable oils, or the pure vegetable oils are chemically converted to make their properties very similar to those of mineral diesel fuel.

Two chemical processes can be used to do this:

Transesterification: a reaction product of the transesterification of vegetable oil with methanol is (vegetable-oil) fatty acid methyl esters (FAME), most properties of which are similar to diesel fuel; it is generally referred to as biodiesel. In this process, the vegetable oils are converted using methanol and caustic soda (catalyst), which is neutralized with phosphoric acid after conversion. Glycerine is also produced during transesterification.

Tab. 5: Properties of different vegetable oils and biofuels

	Density (15 °C) [kg/dm³]	Calorific value [MJ/kg]	Calorific value [MJ/l]	Viscosity (20 °C) [mm²/s]	Cetane number	Flash point [°C]	Fuel equivalence [L]
Diesel[1]	0.84	42.7	35.9	5.0	50	80	1.00
Rapeseed oil[1]	0.92	37.6	34.6	72.3	40	317	0.96
RME[1]	0.88	37.1	32.6	7.5	56	120	0.91
Palm oil[1]	0.92	37.0	34.0	29.4*	42	267	0.95
PME[2]	0.88	-	-	4.4**	58	182	-

* Viscosity at 50°C **Viscosity at 40°C [1] FNR 2005 [2] Cheng et al. 2005

Hydrogenation: in the VEBA process, vegetable oil (about 10%) is blended with crude oil before it is processed to diesel fuel. After the hydrogenation processes, the vegetable oil is almost identical to the diesel fuel. The newly developed NExBTL process (NESTE OIL 2006) is also based on the hydrogenation of pure vegetable oils or animal fat.

Vegetable-oil fuel

In order to be able to use pure vegetable oil as a fuel it is necessary to adapt the diesel engine‘s combustion technology to vegetable oil‘s typical properties (high viscosity, different ignition and combustion behavior). Engine systems specially developed for vegetable oil, such as the Elsbett engine, have been successfully tested over the last two decades in cars, trucks and tractors.

Apart from diesel engines that are specially designed for vegetable-oil fuel, it is also possible to adapt series diesel engines and their periphery to vegetable oil operation (e.g. by modifications to the combustion chamber, the injection nozzles and injection electronics). Such methods have recently been becoming more popular than special engines.

Poor fuel quality has often been the main cause of breakdowns. A legally binding standard (DIN V 51605) for the production and marketing of rapeseed oil as a fuel has been in force since the beginning of July 2006.

However, the use of pure palm oil as fuel in Europe involves complex processes due to its high melting point (36-40°C). For example, the fuel tank, lines and filters have to be constantly heated, and special pumps are needed. Companies specializing in converting engines, such as the rapidOil AG from Munich, are currently working on corresponding technical solutions and expect to reach market maturity in 3 to 6 months (Rapidoil AG 2006).

In warmer regions, palm oil can be used as pure fuel or blended with diesel fuel in certain ratios. In Malaysia and Thailand there are efforts to domestically market a blended fuel made up of 5% refined palm oil and 95% diesel fuel (see below).

Biodiesel (FAME)

„Biodiesel“ is the generic term for all types of fatty acid methyl esters (FAMEs) made from different raw materials and used as fuels. They are transesterified vegetable oils that have been adapted to the properties of mineral diesel fuel and can therefore be combusted in conventional diesel engines. In Germany, this term may only be used for fuels that correspond to the DIN EN 14214 standard, which was introduced in 2003.

This standard does not make a direct reference to the kind of raw materials the corresponding fatty acid methyl ester has to be made from. However, limits applying to certain parameters (e.g. oxidation stability, iodine number, content of polyunsaturated fatty acid, coconut residues) indirectly restrict the possible range of raw materials.

Because of its solvent-like properties (limited material compatibility), biodiesel (FAME) may only be used as a pure fuel in approved and/or retrofitted vehicle types. Some vehicle manufacturers, however (e.g. VW, Audi, Skoda, Seat and BMW), have only approved the use of rapeseed oil methyl ester (RME).

Apart from its use as pure fuel, biodiesel conforming to DIN EN 14214 may also be blended with mineral-oil diesel up to a volume of 5% (DIN EN 590) without being specially labeled. This does not require special approval from the vehicle manufacturers, and engines do not need to be refitted.

Biodiesel from palm oil (PME)

Rapeseed oil is the main raw-material basis for biodiesel in Germany. Rapeseed oil is particularly well-suited for the production of biodiesel, since even without additives it has a CFPP figure (Cold Filter Plug Point, filterability limit under laboratory conditions) of between -10 and -12° C and oxidation stability figures of 9 hours and more. It should also be noted that most additives have currently only been tested using RME.

By contrast, biodiesel made of raw materials with a high content of saturated fatty acids (e.g. from palm oil or animal fats) performs poorly in cold conditions. There have been repeated reports of filters being blocked by palm oil methyl ester blends, causing problems for users and gas stations. For chemical-physical reasons, it currently seems unlikely that additives will make it possible for enable methyl esters with very low CFPP figures (e.g. palm oil methyl ester (PME) or blends containing substantial proportions of PME) to be used in northern winters in a way that conforms with DIN EN 14214 (AGQM 2006).

Efforts are currently being made at the European level to change the DIN EN 590 diesel fuel standard so that the added biodiesel does not have to comply with the low-temperature properties (CFPP figure) required by the biodiesel standard DIN EN 14214. Such a blended fuel could then be made suitable for winter use with suitable additives (based on a maximum biodiesel share of 5%). This would open up the European biodiesel market for PME.

Because of a lack of statistics it is not known to what extent PME is already being used in the trucking business (high cost pressure). The Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e.V. (biodiesel quality management working group, AGQM) expressly points out, however, that any damage caused by poor fuel quality (e.g. failure of components in the fuel-supply or exhaust-treatment systems) will not be covered by manufacturer warranties.

Despite the remaining technical and legal uncertainties, the first major investments and planning projects are currently underway in Europe. In Zwijndrecht, the Netherlands, a joint venture involving Golden Hope Platations Bhd and Godiver Handelsgesellschaft mbH is planning a 30,000 tonne biodiesel plant, and in Northern England Biofuels Co. Plc will shortly be commissioning a 250,000 tonne plant to produce biodiesel from palm oil (among other things) (F.O. Licht 2006).

2.3.2 Use as a fuel (stationary)

In principle, fatty acid methyl esters (FAME) can be used as a fuel in the same burners as heating oil. However, pure vegetable oil is normally used for stationary applications in power stations, district-heating stations and (block-type) cogeneration plants. For example, vegetable oil can be used in modern plants instead of heating oil (extra light) if the oil is preheated, or else it can be blended (10-20%) with light heating oil in a „hot combustion chamber“ (particularly in small heating systems). By contrast, all heavy-oil burners with rotation/pressure atomizers and oil pre-heating systems (50-60°C) can be operated with pure vegetable oil without the addition of heating oil (especially large heating systems). Furthermore, it can be used without problems in burner types that are suitable for vegetable oils (Hartmann & Kaltschmitt 2002).

In thermal power stations, palm oil is combusted to produce steam. The latter‘s thermal energy is first converted into mechanical energy by a turbine, and this, in turn, drives a generator which converts it into electrical energy (electricity).

Pure palm oil is especially suitable for plants that otherwise burn heavy heating oil. Due to its high melting point (see above), the use of palm oil involves a certain amount of additional effort (heating), although enough process heat is usually available.

In Europe, approx. 1-1.5 million tonnes of palm oil was used in power stations in 2005, compared to total imports of palm oil amounting to 3.5 million tonnes. About a third of this was supplied by the Dutch company Biox B.V. (Kerkwijk 2006). Starting in 2007, Biox will be supplied by IOI Group Bhd and Golden Hope Plantations Bhd (both based in Malaysia) and intends to build another four palm oil-based power stations in the Netherlands. In 2005, an estimated 400,000 tonnes of palm oil was used for power generation in the Netherlands alone (F.O. Licht 2006).

3 Future demand for palm oil and politics

by Andreas Pastowski

Adding together the use of palm oil as an energy source and all other uses, the Food and Agriculture Organization expects palm oil production to double between 1999/2001 and 2030 (FAO 2006b).

For the future, the following are likely to be the most relevant factors determining global output and the uses to which palm oil is put:

- The development of the population, per-capita income, consumer habits that determine global demand as a whole, and the demand for individual products in the energy and non-energy fields.

- The price of crude oil, which is an important determinant of the use of vegetable oils as an energy source.

- The overall political conditions relating to the cultivation, export and use of oil plants and the products made from them, and especially relating to their use for energy purposes in the transport and energy sectors.

Potential global area of cultivation

Exact predictions on the further development of the energy-related palm oil market are impossible to quantify. This is due to marked price fluctuations, particularly in the agricultural sector, and uncertainty on the crude-oil markets. Furthermore, the palm oil market depends on subsidies and tax benefits in the main importing countries like the EU, as long as there is no consistent global allocation of carbon emissions to all energy sources. Thus, data are only available on the policies governing the promotion of renewable energies. Here too, however, none of the decisive parameters have been cast in stone – e.g. how should biofuel‘s share of total fuel consumption be divided among rapeseed-oil biodiesel, palm oil biodiesel and ethanol. Global or country-specific consumption estimates in the form of extrapolations based on demographic or economic developments represent another quantifiable – albeit not very reliable – parameter.

3.1 Prospects of the palm oil market

In the past, the global demand for vegetable oils has primarily depended on its use in the production of foodstuffs and cosmetics. In many of its applications, palm oil faces intense substitution competition from other vegetable oils whose respective output can be varied within much shorter periods; as a result, volume and price fluctuations are passed on to palm oil via substitution mechanisms. Such a market situation is marked by big fluctuations in the sales and yields of the agricultural production companies and the number of jobs they offer.

In the countries where the most oil plants are grown – unlike the EU – there are hardly any subsidies aimed at evening out fluctuations in the agricultural field. Against this background, any prospect of opening up additional markets offers considerable potential for steadying the supply and prices of oil plants, sales, export income and related employment figures. This applies all the more to the energy markets, because in the future these will be marked by major increases in demand and a growing structural lack of affordable fossil fuels.

The advantages of more diversified sales markets became particularly evident following the establishment of a market for bioenergy directly related to sugar-cane cultivation and the combined production of sugar and ethanol in Brazil. The growing use of rapeseed oil as an energy source in the European Union could be an explanation of why the fluctuation margin of the annual average prices of vegetable oils has been declining since the mid-eighties and the price corridor of the various vegetable oils has also been narrowing. The economic advantages of growing oil plants for the combined production of vegetable oils both for traditional uses and as an energy source therefore represent a strong economic incentive to expand the cultivation of oil plants, even at the expense of other crops that do not have this advantage.

Both the development of the crude-oil price and the demand for vegetable oils will be determined in the future by global population growth and the increasing per-capita income in many regions of the world. This will also affect today‘s main oil-palm-growing countries. Both factors suggest the likelihood of a marked increase in the demand for palm oil both for traditional and for energy-related uses. Especially in the main countries where the crop is currently grown, this could lead to more of their output being covered by domestic demand, which might limit future export potential.

In the case of ethanol, a link has been discovered with the price development of mineral crude oil. If there is a similar tendency in the case of palm oil, non-subsidized palm oil would hardly be marketable after a foreseeable period of time, since the higher profits would be eaten up by the even-faster-rising agricultural production costs based on the price of crude oil (OECD 2006). In the view of Malaysian analysts, the profit limit has already been reached, despite the currently high crude-oil price of over $60 a barrel: crude palm oil must not cost more than $430 a tonne if it is to remain profitable, as production costs calculated on the basis of the crude-oil price rise more quickly by comparison, and it already reached a price of $426 in July 2006 (Star Publications 2006).

It seems difficult to fix a scientifically justifiable lower profit limit for vegetable oil relative to fossil fuel, i.e. the crude-oil barrel price at which palm oil become profitable. When the crude-oil price rises, the cost of fertilizers also rises, among other things, so that the production cost of palm oil is also affected. On the other hand, more money can then be made with non-energy palm-kernel oil, because the fossil tenside that is substituted will also go up in price, i.e. there are opposite and feed-back effects.

What makes the calculation more difficult is the fact that rising crude-oil prices also make alternative fossil petrochemicals in the mobile sector more attractive, i.e. a switch to biodiesel is not inevitable. In the field of stationary fuels, finally, vegetable oils can also be substituted by coal or uranium (Reinhardt 2006).

Because of its high output per unit of area and the further diversification of the sales markets as a result of its use as an energy source, palm oil is an economically attractive agricultural product for the growing countries. For a number of reasons, today‘s production is largely concentrated on Indonesia and Malaysia, although this does not exclude the possible existence of even greater potential in other equatorial regions. Palm oil offers importing countries a chance to overcome the limits of their own production potential and in some cases to use cheaper palm oil produced with less subsidies to meet their targets for the use of biogenous fuels. Producer countries, by contrast, can substitute crude oil with their locally produced biodiesel and thus make balance-of-payments savings.

After all, in their present stage the markets for palm oil as an energy source in the importing countries are artificial markets; they import palm oil primarily because the biodiesel made from it is the subject of tax breaks aiming to protect the climate and encourage the use of renewable energy sources. However, the extent of tax benefits is the subject of discussion, along with other political ideas aimed at increasing the use of biogenous energy sources. In Germany, the system of compulsory blending (with gasoline and diesel) to be introduced on 1 January 2007 will increase demand for biofuels and thus for vegetable oils even more than tax breaks, since this has to be carried out independently of the costs, and higher costs can be passed on more easily via the large quantities of the fuel blends. Politics is thus currently the main determinant of the demand for palm oil for energy purposes.

In the long run, therefore, we can expect a considerable expansion in the use of palm oil as a source of energy: over the total prediction period up to 2050, the Food and Agriculture Organization FAO predicts an annual growth rate of 3.2% for the non-food sector, compared to only 1.5% for the food sector. Total palm oil consumption in 2030 is put at 54.2 million tonnes of oil content equivalent compared to 25.6 million tonnes in 2001 (FAO 2006b).

3.2 EU policy on biofuels and its implementation

The Green Book „Towards a European Strategy for the Security of Energy Supply“ (CEC 2000) emphasizes the importance of alternative fuels for the security of supply, their possible contribution toward reducing greenhouse-gas emissions and the potential offered by fallow biomass. The report accompanying the Green Book estimates that, if suitable basic conditions are created, alternative fuels as a substitute for gasoline and diesel fuels can reach a 20% share by 2020 (CEC 2002).

Two proposals were made on directives in the wake of the Green Book in June 2001: on the one hand, the member states would be committed to certain quantity targets on sales of biofuels in the period from 2005 to 2010; on the other, they should be given an opportunity to broaden the hitherto narrow framework for granting tax benefits for biofuels (CEC 2001a, 2001b, 2001c). The „Directive of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport“ (CEC 2003a) aims at increasing „the use of biofuels or other renewable fuels to replace diesel or petrol for transport purposes in each Member State.“ The member states are to ensure that biofuels and other renewable fuels reach a specified minimum share of their markets and should lay down corresponding benchmarks. The suggested reference values for these benchmarks are a 2% share (measured by energy content) of all gasoline and diesel fuels for the transport sector put into circulation on their markets by 31 December 2005, and a 5.75% share by 2010. This EU Directive simultaneously lays the foundation for the national policies in the Netherlands and Germany examined below. EU policies also have a certain orienting influence on Switzerland.

In the White Paper „Energy for the Future: Renewable Sources of Energy“ (CEC 1997), reference was already made to the need to expand biofuels‘ share of the market and to the fact that prices were not competitive without supporting measures. The Commission‘s first proposals on the introduction of tax benefits in the EU member states date from this time. The „Directive of 27 October 2003 on restructuring the Community framework for the taxation of energy products and electricity“ (CEC 2003b) makes it possible for the member states to grant tax benefits on fuels produced from renewable raw materials and on biomass products – right up to full exemptions.

Three EU member countries (Austria, Slovenia, Czech Republic) set themselves more ambitious targets for the market share of biofuels for 2005; however, the targets of most member states are well under the 2 percent envisaged by the EU. This may be because the market shares of biofuels in 2003 were for the most part well below 2 percent and in some cases around 0 percent. The EU target of a 5.75 percent share for biofuels by 2010 is thus quite ambitious.

Although it should be taken into account that the target can be partially met by the production and blending of ethanol, and that not all countries have to make an equal contribution to reaching the target, the gap is nevertheless clearly recognizable. The question is how it is to be filled. This suggests that the EU target might be partly reached by importing vegetable oils. The low market shares up to now indicate that there has been little or no production capacity and infrastructure for the production of vegetable-oil-based biodiesel or ethanol in the corresponding member states. Since building up such production capacity takes time, there is a tendency to switch to imported biofuels. Biodiesel made from rapeseed oil currently has a market share of approximately 85-90% of EU biodiesel consumption; FEDIOL, the European oil-mill federation, expects exclusionary effects in favour of an approx. 20% market share for palm oil biodiesel. Another decisive factor apart from the lack of refinery capacity which has been pushing up the demand for imports is the rising price of rapeseed oil caused by keen competition from the use of rapeseed oil as a foodstuff (Krishna & Mudeva 2005).

Up to now, palm oil has not been relevant as an alternative energy source within the framework of the Clean Development Mechanism (CDM); the number of CDM projects involving palm oil production is still small, even though they can help improve the greenhouse gas balance. This is evidently a result of the general methodological difficulties of implementing CDM projects in the transport sector, which also affect alternative fuels. Furthermore, CDM projects with palm oil as an alternative source of energy can only be implemented in potential CDM host countries, which excludes the countries of the EU.

3.3 Policy on biofuels in the Netherlands

In March 2006, the Dutch government set programmatic targets according to which biogenous fuels should make up at least 2 percent of combined gasoline and diesel sales by 2007, and 5.75 percent by 2010 (VROM 2006). This corresponds exactly to the EU target with the exception of the later target year of 2007. Another aim is to ensure a minimum of sustainability in the production of biofuels by excluding fuels whose production involves extensive deforestation, for instance. To this purpose the government of the Netherlands intends to initiate a corresponding certification system at the EU level.

It was announced at the same time in the Netherlands that tax incentives worth two percent would be introduced in the course of 2006 in order to reach the share of biofuels envisaged for 2007. Furthermore, the Dutch government intends to provide €60 million between 2006 and 2010 to promote innovative projects in the field of alternative fuels, in order to exhaust market potential as far as possible and maximize CO_2 reduction. This almost exactly mirrors the EU targets; a simultaneous aim, however, is to ensure that imports of biogenous energy sources do not have negative environmental consequences and to establish an EU-wide framework for this. It will remain to be seen whether the introduction of an EU-wide certification system at the initiative of the Dutch government will succeed and an effective contribution can be made toward protecting the rain forests. Due to the Netherlands‘ geographical position, with its large sea ports and refineries, it can be expected to be the primary route for importing palm oil into the EU market because of the favourable logistics.

3.4 Policy on biofuels (bioenergy) in Germany

At the end of 2004, the Federal German Government adopted a new fuel strategy as part of its first progress report on the strategy of sustainability (Presse und Informationsamt der Bundesregierung 2004). Starting from an approx. 1.2 percent share for biofuels in 2003, the targets set by the EU are expressly confirmed as national objectives. The expectation is that biodiesel and bioethanol will play a major role in reaching the targets by 2020, particularly as admixtures blended with conventional fuels. However, restrictions are expected caused by a domestic lack of land and competition from other forms of use that make a greater contribution to climate protection. Therefore 5 per cent is assumed to be a plausible combined share of biogenous fuels with diesel and gasoline (Arnold et al. 2005).

The Federal Republic of Germany has made use of the „EU Directive restructuring the Community framework for the taxation of energy products and electricity" (CEC 2003b) for biofuels; the government received confirmation of this from the Commission on 18 February 2004. The original intention in Germany was to exempt biofuels from mineral oil tax by 2009. Tax exemption for biofuels has been abolished because of the budgetary situation, the growing demand for biofuels, the EU's ambitious targets, and the shortfalls in tax revenue that have already been experienced or are expected in the future.

The German Bundestag (lower house of parliament) passed several changes in July 2006. Pure biodiesel has been taxed at a rate of 9 euro cents per liter since August 2006. From 2008, the tax will rise by 6 cents a year to 45 cents per liter by 2012. Pure vegetable oil, however, will remain tax-free up to the end of 2007; starting in 2008 it will be taxed at 10 cents per liter. Tax rates for vegetable oil will also rise every year by up to 45 cents per liter from 2012 and thus approach the full tax rate of 2.04 cents per liter. By contrast, pure biofuels used in agriculture and cogeneration plants will remain tax-free. Because the tax does not distinguish between either the types of raw material used or their origins, it has the same effect on all vegetable oils. Since the costs of biodiesel vary considerably, depending on the vegetable oil used, and the tax eats up most of the price advantages compared to mineral-oil-based fuels, a growing trend towards cheaper imported vegetable oils for biodiesel production must be expected in the future.

As far as further developments are concerned, much will depend on the compulsory blending scheme announced by the federal government. The Ministry of Finance has proposed a biodiesel blending quota of 4.4 percent in energy terms or 5 percent in volume terms starting on 1 January 2007. This corresponds to approximately 1.5 million tonnes of biodiesel, or about half of German biodiesel manufacturers' output. The Biofuel Quota Act also empowers the government to enact an ordinance in 2007 setting ecological criteria for the exclusion of imported vegetable oils from blending. These include criteria relating to the principles of sustainable cultivation, demands for the protection of natural habitats as well as for CO_2 reduction.

Another potential subsidy method in Germany whose importance for palm oil is yet to be clarified is the idea of promoting electricity generated from biomass using cogeneration plants. With annexes/plants up to 50 kWel it is assumed rapeseed oil will also be in the future the most important source of energy (IE et al. 2005, S. 57). With plants in the capacity range above 500 kWel increasing their market shares, there is likely to be greater interest in the use of soybean oil and palm oil; in the future, market shares are expected to shift accordingly in favour of these vegetable oils. However, some grid operators are refusing to grant the „renewable resource bonus" (NawaRo-Bonus) of 4 to 6 cents per KWh for electricity generated in stationary cogeneration units using vegetable oils from abroad. The background is that the Renewable Energies Act (EEG) does not unequivocally classify vegetable oils as renewable resources. Up to final clarifying of this legal question and because of the importance of the NawaRo bonus for the operational efficiency of the unit, the use of the imported vegetable oils is currently afflicted with uncertainties in such plants (IE et al. 2005, S. 59).

With its North Sea and Baltic Sea ports, Germany is in a good logistical position to use imported vegetable oils. Current projects for expanding the capacity for the transesterification of vegetable oils are considering Emden or Rostock, among other locations, and a technical design that is flexible enough to use various different vegetable oils. The reduction of tax benefits will intensify the search for more economical vegetable oils for the production of biodiesel than the rapeseed oil that has predominantly been used up to now. Furthermore, compulsory blending will encourage the major mineral oil corporations and their central purchasing departments to get more involved, and this could well mean that cost advantages will be more systematically exploited in the future, leading to higher import shares.

3.5 Policy on biofuels in Switzerland

As a non-EU country, Switzerland does not have to take a position on the EU's targets. Up to now, Switzerland has only announced the qualitative objective of making greater use of alternative fuels in the future. There are also pilot projects testing the practicability of alternative fuels involving vehicle fleets. Switzerland is expected to clarify its objectives and strategy on the future use of alternative fuels in the course of an ongoing legislative procedure on tax exemptions for environment-friendly fuels. It is currently unclear how imported vegetable oils will be handled in this context (BUWAL 2006).

Switzerland currently plans to amend the law and introduce tax benefits for environment-friendly fuels. To this purpose, on 3 May 2006 the Federal Council passed a draft law amending the mineral oil tax law (EFD 2006). Assuming it is confirmed by the Federal Assembly in the autumn or winter of this year, the law will provide for tax incentives for environment-friendly fuels from mid-2007, with the aim of lowering CO_2 exhaust levels in road transport. The reduced tax incomes to be expected from this are to be completely offset by a correspondingly higher tax on conventional fuels. The bill provides for a tax exemption for „fuels from renewable raw materials," i.e. fuels manufactured from biomass or other renewable energy sources. The Federal Council will define fuels from renewable raw materials in terms of their contribution to environmental protection. This definition could include minimum requirements relating to the overall ecological balance (Entwurf Änderung Mineralölsteuergesetz (Draft Amendment to Oil Tax Law) 2006). Depending on how these are structured, they could become a criterion for the exclusion of certain vegetable oils.

Even though there is no official target figure for the use of biogenous fuels, Switzerland will take a top position in the promotion of biofuels if this amendment is passed by the Federal Assembly. The complete exemption of biofuels from mineral oil tax and the compensation of the shortfall in government revenue by an increase in the tax rates for mineral oil products could represent a very strong financial incentive to use biogenous energy sources in transport. This would primarily apply to the use of pure biodiesel and vegetable oils; as far as the blending of biodiesel is concerned, the tax effects would balance each other out because of the way the law is structured, which could lead to an indifferent attitude toward blending in the petroleum industry from the tax perspective.

In Switzerland, the economics of using imported vegetable oils (e.g. palm oil) to produce biodiesel is burdened by higher transport costs, since the country has no sea port (like the Netherlands or Germany) from which to supply the immediate hinterland. This makes longer overland and in some cases alpine transport journeys necessary. To this extent it is uncertain whether the higher transport costs can be offset by the lower product prices and whether imports of palm oil for energy purposes can really be expected to increase in Switzerland.

3.6 Policy on biofuels in the palm oil producer countries

Malaysia is forging ahead with the domestic introduction of a blended palm oil fuel made up of 5% refined palm oil and 95% diesel (MPIC 2006). Parallel to this, there are plans to start producing a total of 180,000 tonnes of PME (biodiesel) this year at three sites – exclusively for export to Europe and other regions (F.O. Licht 2006). Altogether there is a capacity of approx. 1 million tonnes of PME planned (F.O. Licht 2006)

Indonesia already hopes to earn $1.3 billion from exports of biofuels by 2010 and intends to build or expand 11 refineries for this purpose. Since May 2006, diesel within Indonesia can also contain up to 10% of biogenous fuel. Together with Malaysia, Indonesia has decided to reserve 40% of palm oil exports for biofuels. 3 million hectares of land are to be additionally prepared for palm oil production. In Malaysia the palm oil production is to be increased from 11.8 to 18.8 million tonnes by 2020, which would extend the managed surface from currently 3.5 million hectares to 5.1 million hectares. (Thukral 2006b and Star Publications 2006).

Apart from ecological problems, issues like weak governance and poor enforcement of regulations in Indonesia could make it difficult for the country to raise the US$ 22 billion needed from investors for the expansion of its oil palm refinery capacity (Kleine Brockhoff 2006).

Furthermore, in Indonesia, weak governance and unclear regulations also lead to unregulated or the transformation of natural forest, that is illegal or legal but not necessarily good for the environment. Due to the political reforms implemented since the fall of the

Suharto regime in 1998, decentralization has given more power to the provincial governments. They in turn are also susceptible to irregular and bad practices at the local level when granting licenses to use land classified as „degraded natural forest.“ (Kleine Brockhoff 2006).

3.7 The framework of international palm oil trade

At present, the amount of raw materials available in the EU member states alone will not be enough to enable the EU to meet its targets on the use of alternative fuels. It is also uncertain whether it will be possible to reach the targets solely on the basis of potential output in the member states in the future. 1.19 million tonnes of rapeseed was imported into Germany in 2002/2003, for example. 68% of this came from France and another 16% from the Czech Republic. In the same period 740,000 tonnes were exported to the Benelux countries (Belgium, Netherlands and Luxembourg) as well as to Great Britain and Mexico (Thraen et al. 2004, S. 83).

It is currently unclear to what extent the EU can achieve a high level of self-sufficiency in alternative fuels in the future by processing residual biomass and waste products as an energy source, since this method is only just getting started. The predominant use of oilseeds for the production of biodiesel in the EU has already pushed prices up, especially for rapeseed oil. Since in principle any vegetable oil can be used as the energy source (either direct or after processing into biodiesel), the increase in rapeseed oil prices provides an incentive to use other (perhaps imported) vegetable oils or biodiesel made from them. Thus, the use of biomass as an energy source can stimulate trade both in the corresponding raw materials and in the energy sources derived from them. This development has clearly already taken place in the case of ethanol; its raw products cannot be transported, but ethanol itself is internationally traded in considerable and increasing quantities in the meantime.

The trade in vegetable oils can be limited for technical reasons if the raw materials required to produce biogenic fuels are too bulky or perishable to be transported over large distances. In the use of palm oil as an energy source, both the unprocessed raw product (palm oil) and the biodiesel which is made out of it can be traded internationally, since the raw product also keeps well and there are only insignificant differences in the transport costs.

There are currently two parallel trends in vegetable oils which might affect the amounts of palm oil imported by EU member states.

Transesterification plants for processing vegetable oils are being planned in the exporting countries. They can extend the value chain in the producer countries, raising economic utility. It is then biodiesel that is exported, if it is not used domestically; income from exports will be correspondingly higher. Malaysia, however, has already announced a moratorium on licenses for palm oil transesterification plants until the government is convinced that the use of palm oil as an energy source will not lead to restrictions on its use as a foodstuff (Thukral 2006).

There are isolated plans to build transesterification plants to process imported vegetable oils into biodiesel near ports in certain EU member states. The plants are being designed in such a way that all kinds of vegetable oil can be used. Parallel to this, some long-term supply contracts are being concluded with the producers in the growing countries to ensure reliable supplies of the raw material at stable prices and quantities.

The EU is pursuing a two-pronged and in some ways rather contradictory strategy in this context. On the one hand, the EU wants to take the interests of its domestic producers and their trading partners into account in the further development of the trade in vegetable oils. On the other hand, there are plans to change the „biodiesel standard“ EN 14214 to make it possible to use a broader range of vegetable oils to produce biodiesel (CEC 2006a).

The international trade in palm oil for the production of biogenic fuels is subject to the general WTO regulations on trade in agricultural products. It would be difficult to monitor any special treatment of agricultural products that are used exclusively to produce energy sources, because the decision on use is not taken until the oil arrives in the importing country. The situation is different in the case of palm oil that has already been processed to biodiesel in the growing country, since use as an energy source is the only option in this case. However, it is not clear whether it is possible to trace back to the primary material after it has been converted to biodiesel or whether the real origins might be concealed.

The EU specifies uniform tariff rates via the TARIC (Integrated Tariff of the European Communities). Currently, no import duties are levied on crude palm oil for technical and industrial use (with the exception of the production of food for human consumption) that is imported from Malaysia and Indonesia, the main countries where oil palms are grown. Since biofuels are currently not monitored separately by the customs authorities, it is impossible to determine the respective shares of ethanol, oilseeds and vegetable oil imports used in the transport sector. The EU Commission intends to examine the advantages and disadvantages – as well as the legal consequences – of formulating its own commercial-law nomenclature code for biofuels (CEC 2006a).

3.8 Conclusions

The implementation of the EU‘s policy of promoting the use of biofuels involves major challenges for the member states. In view of limited production capacity and the lower cost of imported vegetable oils as a raw material for producing biodiesel or for stationary use as a fuel, there is a growing tendency to switch to imported vegetable oils. The EU supports this by waiving import duties on palm oil imported for technical and industrial non-food use from the main producing countries Malaysia and Indonesia.

With many member states still busy creating a national framework for implementing the EU targets on the use of biofuels, few of them have confronted the issue of imported vegetable oils and the related potential risk of ecological side-effects. In Switzerland, the situation is on the one hand less favourable, because there has evidently been little in the way of profound discussion on biofuels up to now, and a strategy on the issue is yet to be formulated. On the other hand, there is an intense discussion on palm oil as a raw material for the foodstuff and cosmetics industry which has advanced to the stage that the Migros group has set standards for palm oil suppliers. The government of the Netherlands is examining various tax benefit options and at the same time putting forward the most far-reaching proposal on EU-wide standards on the ecological effects of imported vegetable oils. The German government is striving to meet the EU targets. Policy is currently moving away from tax benefits for biofuels to compulsory blending with mineral fuels. The government is to enact an ordinance in 2007 excluding types of biomass whose production violates the principles of sustainable cultivation or the protection of natural habitats.

This situation in the European importing countries contrasts with the ambitious economic-development objectives of the countries where oil palms are grown – and with the WTO‘s efforts to liberalize the trade in agricultural goods; here, the emphasis is on economic-efficiency gains, and ecological demands relating to the production of agricultural goods are generally perceived as a novel form of non-tariff trade barrier.

4 Environmental effects of palm oil production

by Guido Reinhardt, Nils Rettenmaier and Sven Gärtner

The production and use of palm oil as an energy source can have a wide range of effects on the environment. These are described in this section taking the following aspects under consideration:

- Consequences of deforestation, in particular the loss of biodiversity and ecosystem services in the natural forests cleared for oil palm plantations; possible alternatives to the clearing of natural forests.

- Comparison between the entire chains of production and use of palm oil biodiesel on the one hand and conventional diesel fuel on the other; comparison between the corresponding life cycles from pure palm oil to electricity and(or heat generation on the one hand and conventional power generation using fossil energy sources on the other. Energy balances and greenhouse-gas balances are examined as examples on the basis of such „life-cycle comparisons“.

- Other environmental effects directly related to the production and processing of palm oil.

- Optimization potential: overview of the main areas where ecological improvements could be achieved.

- Future hectarage requirements for palm oil grown for energy or non-energy purposes in the main producer countries of Southeast Asia.

4.1 Oil palm plantations and natural tropical forests

As already mentioned in section 2.1, the oil palm only flourishes in the inner tropics, which, for the most part, would be wooded if nature were allowed to take over. These natural tropical forests are characterized by enormous biodiversity and contribute to human welfare by providing ecosystem services.

4.1.1 Biodiversity and ecosystem services

Biodiversity

Biodiversity means variability among living organisms of any origin and covers variety between species (species diversity), variety within species (genetic diversity) and variety of habitat (ecosystem diversity) (UNCED 1992). Species diversity is thus only one aspect of biodiversity, although, for reasons of simplicity, it is generally used as a synonym for all biological variety.

To date, about 1.5 million animal and plant species have been registered and described worldwide, although conservative estimates put the real number of species at between three and ten million. Other calculations estimate the total number of all species as high as 30 to 50 million. The tropical wet forests are the ecosystems with the richest variety of species on the planet. It is thought that 50-75% of all existing species are indigenous to the tropical damp forests; other estimates put the figure as high as 90% (Radday 2006). It is a known fact that species diversity is declining day by day, largely as a result of human activity: the number of species in tropical forests is falling at a rate that is unique in the history of humankind. In the meantime, the speed of extermination is estimated at between 25-150 species a day (Wilson 1995 and Deutscher Bundestag 1990). This is all the more significant because every loss of species diversity is irreversible – unlike other forms of environmental damage, which can at least be partially reversed in some cases.

Species diversity is in turn regarded as one of the fundamental prerequisites of ecosystem stability, since habitats that are richer in species are usually more stable and resilient to outside influences (disturbances) due to their many interrelations and diverse feedback systems. The higher the number of species and reciprocal effects between them, the more effectively can fluctuations be offset.

A high level of genetic diversity is no less important, however, being a crucial factor in enabling species to adapt to changing environmental conditions and therefore for further evolution. In terms of usefulness for humans, the diversity of species in the tropical forests is of inestimable value for breeding working animals and useful plants, as well as for the development of medicines. According to (Myers 1996) the selling value of pharmaceutical products made from tropical forest plants was $43 billion in the industrialized countries in 1985. Up to now, fewer than 1 % of tropical rain-forest plants have been examined to determine their pharmaceutical properties. It is thought that over 1400 species have cancer-inhibiting qualities (Collins 1990). Here, too, there is a danger that this potential will be irretrievably lost as more and more of the tropical forest is cleared; after all, extinct species cannot be „brought back“ again.

The diversity of the ecosystems also contributes directly to human welfare, since they provide services (generally regarded as cost-free), without which human life would be inconceivable and which would have to be provided in some other way if the ecosystems were lost.

Welfare services
Ecosystem functions – i.e. the functions that an ecosystem fulfils for itself and its environment by means of its complex structure – are therefore also referred to as ecological services. This suggests that these functions are regarded as valuable for human beings and for an intact environment. These services are highly diverse: ecosystems regulate the Earth‘s gas balance, control the climate, produce biomass, regulate the water balance and the water supply, form soils, control erosion and maintain nutrient cycles. By making comparisons with the cost of replacing these services thorough human technology, (Costanza et al. 1997) assessed the monetary value of worldwide ecosystem services (which are generally taken to be free) at $26.6 trillion, i.e. almost twice the global economic product and thus far beyond all value created by human beings. Tropical forests provide a huge number of ecosystem services on a global level (e.g. the Earth‘s gas balance), a regional level (e.g. climate control) and the local level (e.g. erosion control); their loss would have drastic consequences. Here, too, we can assume that, once destroyed, ecosystems and their functions cannot be restored.

4.1.2 Deforestation

A third of the Earth‘s land surface, about 3.9 billion ha., is covered by forest. Tropical forests make up approx. 6% of the world‘s land surface. Only half of the original forest surface that existed about 10,000 years ago is still there today. At least 14 to 16 million ha. of forests disappears on average every year. That‘s an area about half the size of Germany. 60% of the world‘s woodland is to be found in the following seven countries: Brazil, Canada, China, Indonesia, Russia, USA and the Democratic Republic of Congo (WWF 2005a). The largest still intact tropical forests are in the Amazon Basin (Brazil), the Congo Basin (Democratic Republic of Congo) and in the Indo-Malayan region (Indonesia, Malaysia, Papua New Guinea).

More forest has been cleared since 1850 than in the entire history of humankind. Human population, however, has also more than quadrupled from 1.3 billion to 6 billion during this period. With a rising population and consumption of timber products on the increase, the pressure on the forest is growing and the amount of woodland per capita is falling. In 1960 this figure was 1.2 ha.; by 1995 it had been cut by half; the prediction for 2025 is 0.4 ha. of forest per capita (Gardner-Outlaw & Engelman 1999).

The causes of the continuing destruction of the tropical forests are many and complex. Like other natural resources, the tropical forests are caught between general structural problems in the countries of the south. These include population growth, poverty, lack of land, global economic conditions and institutional deficits.

In most countries, especially in many developing countries, long-term forest management cannot compete with other forms of land-use. This paradox situation is caused by several distortions in overall conditions, as well as deficits in the timber industry itself. The expected future value of the forest (e.g. as a genetic resource for products) and the current welfare services it provides are not included when the forest‘s value is calculated (Radday 2006).

The value is measured in terms of the value of timber stocks, the basis of the future value-added in the form of wages and incomes. In this standardized procedure, forest clearing has an exclusively positive influence on the result and is equated with economic development. This effect is intensified by so-called „perverse incentives“ – distortions in the form of tax advantages or subsidies for types of land-use that impair the sustainable protection and development of the forest. In the Brazilian Amazon region, such misguided incentives were granted for years to encourage cattle rearing. The biggest destruction of forests there was caused by these incentives.

Similar relationships can be deduced from the history of the plantation and timber industry in Malaysia and Indonesia, palm oil‘s main production region. In Indonesia in particular, there is a clear link between land-use zoning for large-scale agricultural or forestry projects and the extensive transformation of tropical forest. This development continues unabated to this day, due to the combined failure of governments and the planning and monitoring authorities. The latest example is the so-called „Mega Oil Palm Project,“ a forest-conversion project covering 1.8 million ha. that was planned on the border between Kalimantan (Borneo) and the neighboring Malaysian states of Sarawak and Sabah. The planning for this project has been redimensioned in the meantime, following protests from environmental organizations (Radday 2006). Estimates by the World Bank predicting the end of the lowland rain forests in

Sumatra by 2005 at the latest, have already been largely confirmed in the meantime (Holmes 2002). Similar estimates by the WWF predict that the lowland rain forests of Kalimantan (Borneo) will disappear by 2012 if deforestation continues at the present rate (WWF 2005c).

The situation described above shows that overall economic and political conditions in the tropical countries producing bioenergetic raw materials could initiate a development that could substantially increase the pressure on the natural forests and practically cancel out any intention of maintaining the forest. The consequence could be a process in which the forest is sacrificed to large-scale agro-industrial projects. This will be explained in greater detail in the following with reference to a major palm oil producing country, Indonesia:

The term forest conversion relates not only to actual clearing, but also to the continuous process of declining forest functions with the intermediate phases of forest degradation and the forest fragmentation, which precede actual deforestation (Kessler et al. 2001).

Provincial governments in Indonesia generally use their five-year plans on land-use to administer the rededication of forest land. The ministry grants these applications on proof of the degradation of the forests. After decades of felling and forest fires on a massive scale, there is a plentiful supply of degraded forests in Indonesia. Government representatives themselves confirm that timber companies leave over 60% of the forest in a run-down condition – and there is a method behind this. As a consequence of the lack of forest declared available for conversion, many companies are stepping up the pressure on the national and also provincial governments to release permanent forest land for conversion into plantation zones, because:

- there is no longer enough forest available for conversion in the better developed western islands, which are closer to the markets; furthermore,
- the conversion of natural forest enables the companies to harvest large quantities of timber either for lumber production or for delivery to the cellulose industry – thus generating fresh capital for follow-up investment.

This pressure has often proved to be effective. 750,000 ha. of woodland that had previously not been classified as forest for conversion was converted into oil palm plantations in the whole of Indonesia up to 1999. 75% of this land lies in Sumatra and 20% in Kalimantan (WWF 2002).

Furthermore, the Indonesian palm oil industry is dominated by groups of companies that also operate in the felling and cellulose/paper-manufacturing industry. It is therefore likely that, after one of the felling companies has used felling rights, a plantation company from the same group will apply for permission to transform the degraded, managed forest – instead of waiting for the forest to regenerate. A new oil palm plantation can start making a profit as early as six to eight years after transformation. By contrast, it would take five to six decades before the felling company could start using the regenerated forest again (WWF 1998).

Fires

An indirect effect of forest clearing is forest fires, which can ultimately destroy a much bigger area of forest than legal and illegal clearing. Slashing and burning is cheaper and quicker for plantation companies than any other method of clearing. Until recently, therefore, „controlled burning“ was a widespread method commonly used by Indonesian plantation companies to clear forests. This involves the removal of wind breaks, the systematic clearing of vegetation and the burn-off of dry plant parts. In windy weather and when the vegetation is dry, however, such „controlled“ fires can quick get out of control. They can spread especially quickly in the managed forests that have been thinned out by felling, because exposure to the sun has dried out the ground vegetation particularly thoroughly here. When wildfires suddenly break out, they also threaten existing plantations and the workers‘ houses.

In general, however, it is very much in the plantation companies‘ interests if forests burn down „by chance“. Even when the fires got completely out of control at the end of 1997, and various bans on the use of fire were imposed by the Indonesian authorities, fire hot-spots were still observed by satellites in areas designated as future palm oil plantations. It is estimated that about 5.2 million ha. of land were damaged by fires in the Indonesian province of East Kalimantan, Borneo, alone during the 1997/98 El Niño season (Siegert 2004).

4.1.3 Social environmental effects

According to PROFOREST, the growing plantation business in tropical regions is not only causing direct environmental damage, it is also destroying the existential economic, social and cultural basis of indigenous subpopulations in particular. The traditionally diverse use of the forest is made impossible and substituted by palm oil monocultures; the people are driven from their traditional settlement areas and/or pushed to the fringes of society. The indigenous peoples‘ cultural and spiritual lives are also seriously affected, something that cannot be redressed by compensation payments alone.

Conflicts often arise relating to traditional and/or state-attested land rights, which put local communities at a disadvantage because their claims are often not formalized. These groups have frequently already been marginalized in the past and tend to lose out when additional employment opportunities are offered; this is because immigrant workers often have more experience in palm oil cultivation and are therefore given preference over local people.

Palm oil smallholders who supply the plantation companies on their own account or on a contract basis apparently benefit from being tied to bigger plantations, because it gives them a reliable market; other farmers, however, become completely dependent on the large plantation companies, who then dictate the prices.

According to information provided by NGOs, conventions of the International Labor Organization (ILO) have been violated after attempts were made on large plantations to enforce internationally valid rights (such as the formation of trade unions or compliance with industrial safety standards); however, this is denied by the plantation operators (PROFOREST 2003).

4.1.4 Alternatives to deforestation

There are however other ways of preparing areas for oil palm plantations other than the destructive clearing of natural tropical forests discussed above. For one thing, fallow or wasteland areas where natural tropical forests used to stand are very common in the Tropics these days; they could be used for creating new oil palm plantations. For another, existing plantations can be rededicated, as has happened, for example, in the last few years in Malaysia in particular. Many rubber, cocoa and coconut plantations have already been converted into oil palm plantations there.

Planting of tropical fallow land

After repeated fires (or the clearing of natural tropical forests) followed, perhaps, by a brief period of agriculture use, many areas develop into a kind of fallow or waste land, which, in many cases, is overgrown with alang-alang grass (*Imperata cylindrica* (L.) Beauv.). This grass prevents the land from developing naturally into secondary forest and is therefore considered to be particularly problematic.

According to a study by (Otsamo 2001), there is between 8.6 and 64.5 million ha. of alang-alang grassland in Indonesia alone, although this upper limit seems exaggerated. The same study quotes another source that puts the amount of tropical fallow land at 20 million ha. (Holmes 2002) also estimates the figure at several million hectares, (Dros 2003) at approx. 10 million ha.

This degraded land represents an enormous potential and could considerably reduce the pressure on natural forests. These sources provide no information on whether all this land – or part of it – is suitable for oil palm cultivation.

Conversion of other plantations

In Malaysia, where in the meantime oil palm plantations make up 11% of the country‘s surface area, the amount of land devoted to oil palm cultivation has doubled over the past 15 years. Against this trend (1990-2000: +1.4 million ha.) the total area covered by plantations only increased by about 0.5 million ha. in the same period (Yusof & Chan 2004). Two thirds of the increase thus came from the conversion of other plantations (rubber, cocoa and coconut) (see Table 9).

Tab. 6: Change in the total amount of plantation land in Malaysia 1990-2000 [in thousands ha.]

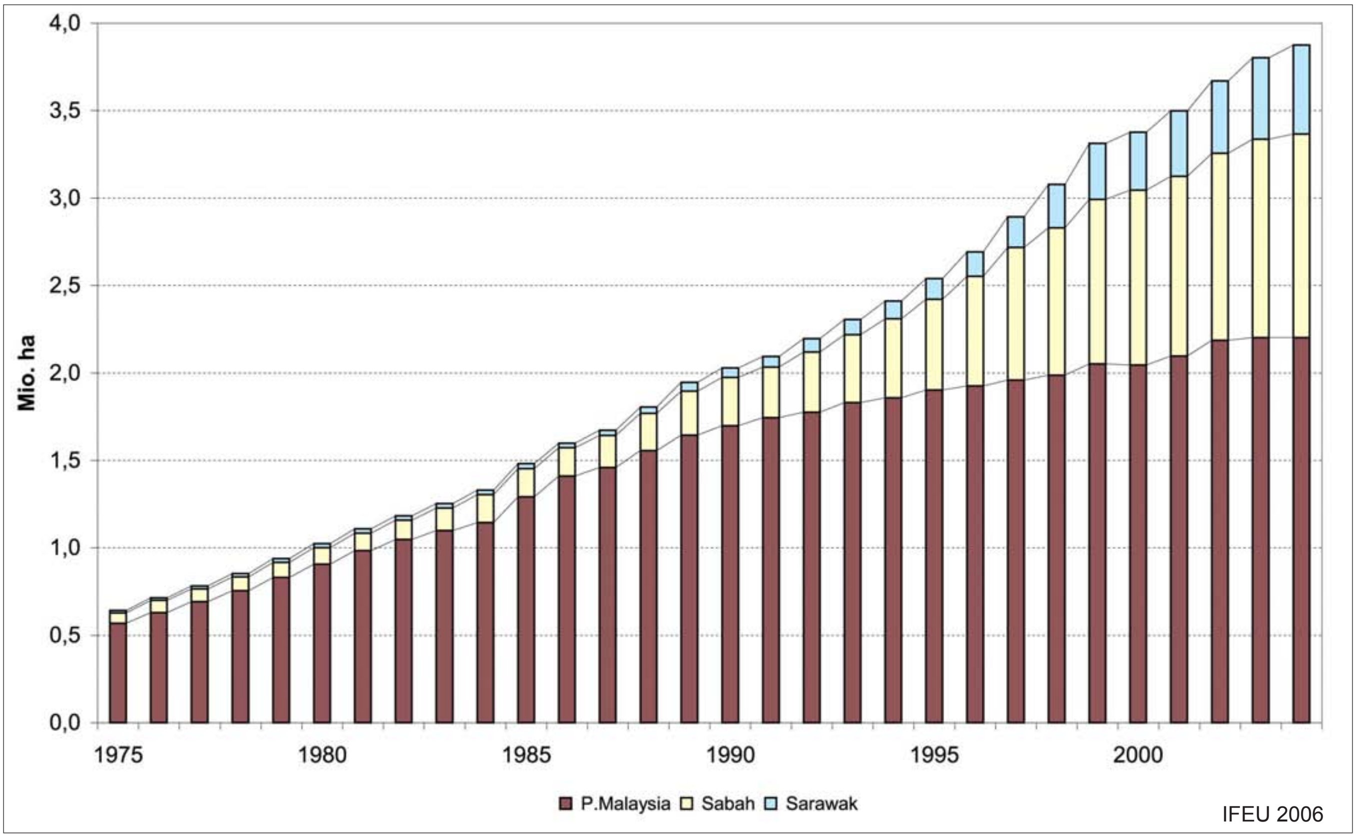
Year	Oil palm	Rubber	Cocoa	Coconut	Total
1990	1,984	1,823	0,416	0,315	4,538
2000	3,377	1,430	0,078	0,108	4,993

Yusof & Chan 2004

Expansion at the expense of the natural forest in Malaysia was carried out in particular in Sabah and Sarawak (see Fig. 5). In Sabah the rate of conversion as oil palm plantations was more than 54,000 ha. per year between 1985 and 2003 (Department of Statistics Malaysia). Assuming – as proposed by various authors – that at least 60 % of this area used to be other 40% consisted of scrubland, rubber, cocoa or coconut plantations, which had to yield in favour of the more profitable palm oil production. No corresponding data is available for Sarawak.

The above observations show that there are alternatives to clearing natural forests when establishing new oil palm plantations. The possible ecological effects of any change in use must, however, be examined before existing plantations are converted. Further research on is concerned (see section 4.2.6). ecological and economic sustainability is required as regards the option of using fallow land

Fig. 5: Increase in the amount of land devoted to oil palm cultivation in Malaysia, 1975-2004



MPOB 2006b

4.2 Palm oil as bioenergy: energy balances and greenhouse gas balances

The use of palm oil as a source of energy is generally regarded as environment-friendly, because at first sight it is CO_2-neutral and saves fossil raw materials, since it substitutes fossil energy sources. This may indeed be the case in some areas, e.g. when palm oil is combusted directly, and exactly the same amount of CO_2 is released as was withdrawn from the atmosphere when the oil palm was grown.

However, if we examine the entire life cycle of palm oil as an energy source – from the production of the biomass to processing and its use to generate energy – we see that the above-mentioned advantages are not necessarily inherent in the system. For example, considerable amounts of fossil energy are often used in the production of fertilizers and pesticides, as well as in plantation management. Furthermore, the use of fossil energy sources involves climate-relevant emissions, so that, if the entire life cycle is included, the CO_2 balance is not automatically neutral from the outset either. Another factor is that CO_2 is only one climate gas among many; we must therefore ask whether even a positive CO_2 balance is perhaps weakened or reversed by other climate-relevant substances. This might be the case, for example, if emissions from the effluent generated in palm oil processing were to release a lot of methane into the atmosphere, or if the clearing of tropical forests to prepare land for oil palm plantations were to release an excessive amount of carbon into the atmosphere in the form of CO_2.

In short, the ecological advantages and disadvantages of palm oil as an energy source cannot be listed and assessed easily; it must be determined very carefully, taking the entire system into account. This can be properly carried out with the help of life-cycle assessments.

4.2.1. Procedure and comparisons examined

Comparisons examined

As already described in section 2.3, palm oil can be used as an energy source in different ways, i.e. in both mobile and stationary applications. The following main uses are dominant in Europe:

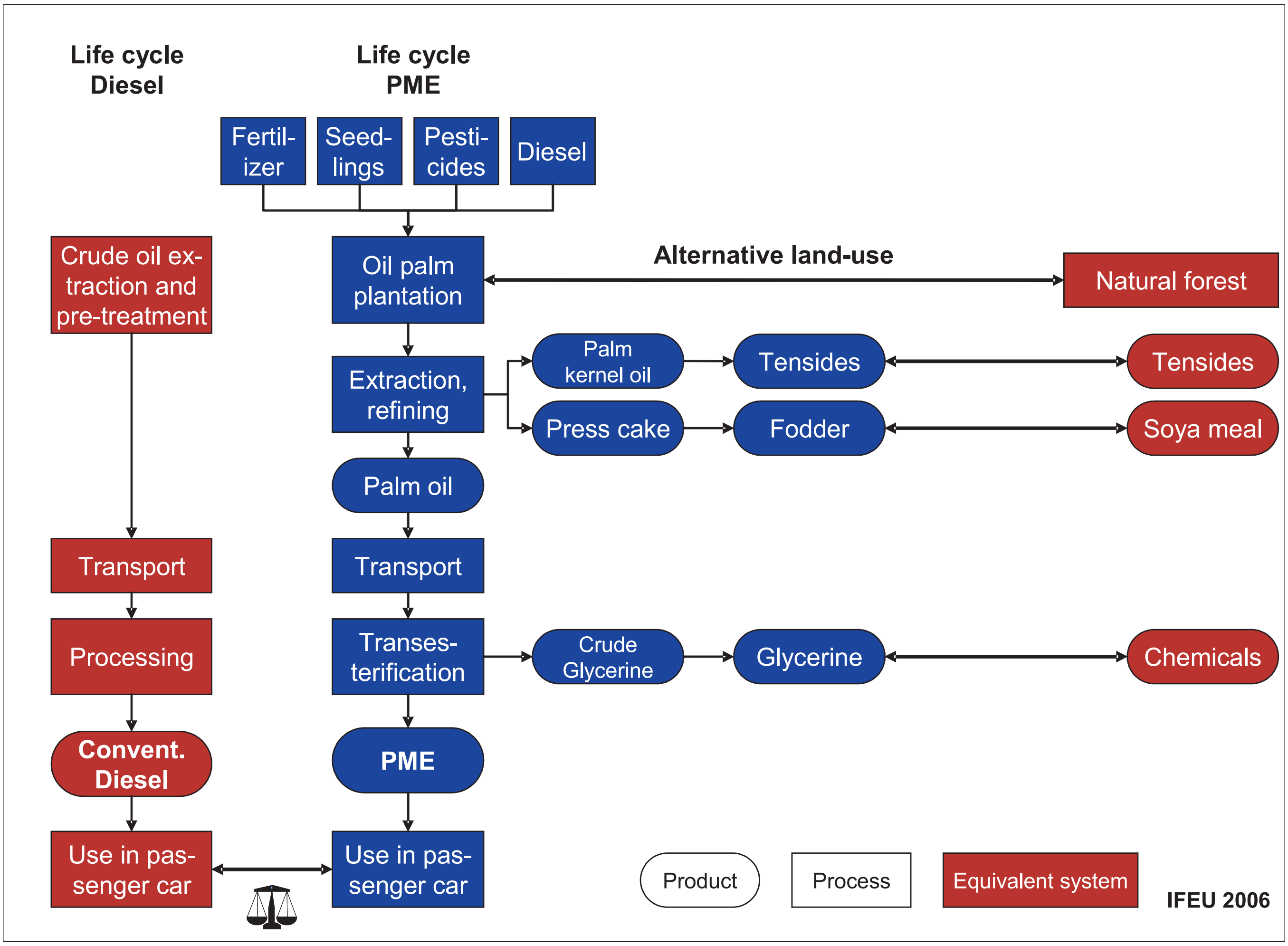
- Palm oil biodiesel, i.e. transesterified palm oil, used as a biofuel in vehicles that run on diesel. Conventional diesel fuel is substituted in this case.
- Pure palm oil in stationary plants for generating electricity, heat or both (cogeneration). Here, different energy sources (natural gas, light fuel oil, etc.) are substituted respectively, depending on which energy sources are used for conventional power or heat generation.

As briefly mentioned above, balances are drawn up over the entire life cycles of both palm oil and the respective conventional energy sources that are substituted by palm oil.

Mobile use

As an example of this, Fig. 6 shows the life-cycle comparison between conventional diesel fuel and palm oil biodiesel (PME). All operating media and by-products are included in the analysis. The latter are credited to palm oil in the balance. In the case of palm oil biodiesel, this involves three by-products. Palm-kernel oil, which is extracted from the seeds of the oil palm, is processed to tensides, substituting mineral-oil-based tensides. The palm kernel cake – the residue left after the seeds are pressed – is used as animal fodder and substitutes for conventional feeds such as soya meal. Furthermore, the transesterification of palm oil to PME produces large quantities of glycerine, which (after processing) can replace chemicals with equivalent uses e.g. in the pharmaceutical and cosmetics industry.

Fig. 6: Life-cycle comparison between conventional diesel and palm oil biodiesel (PME), both used in a diesel vehicle.

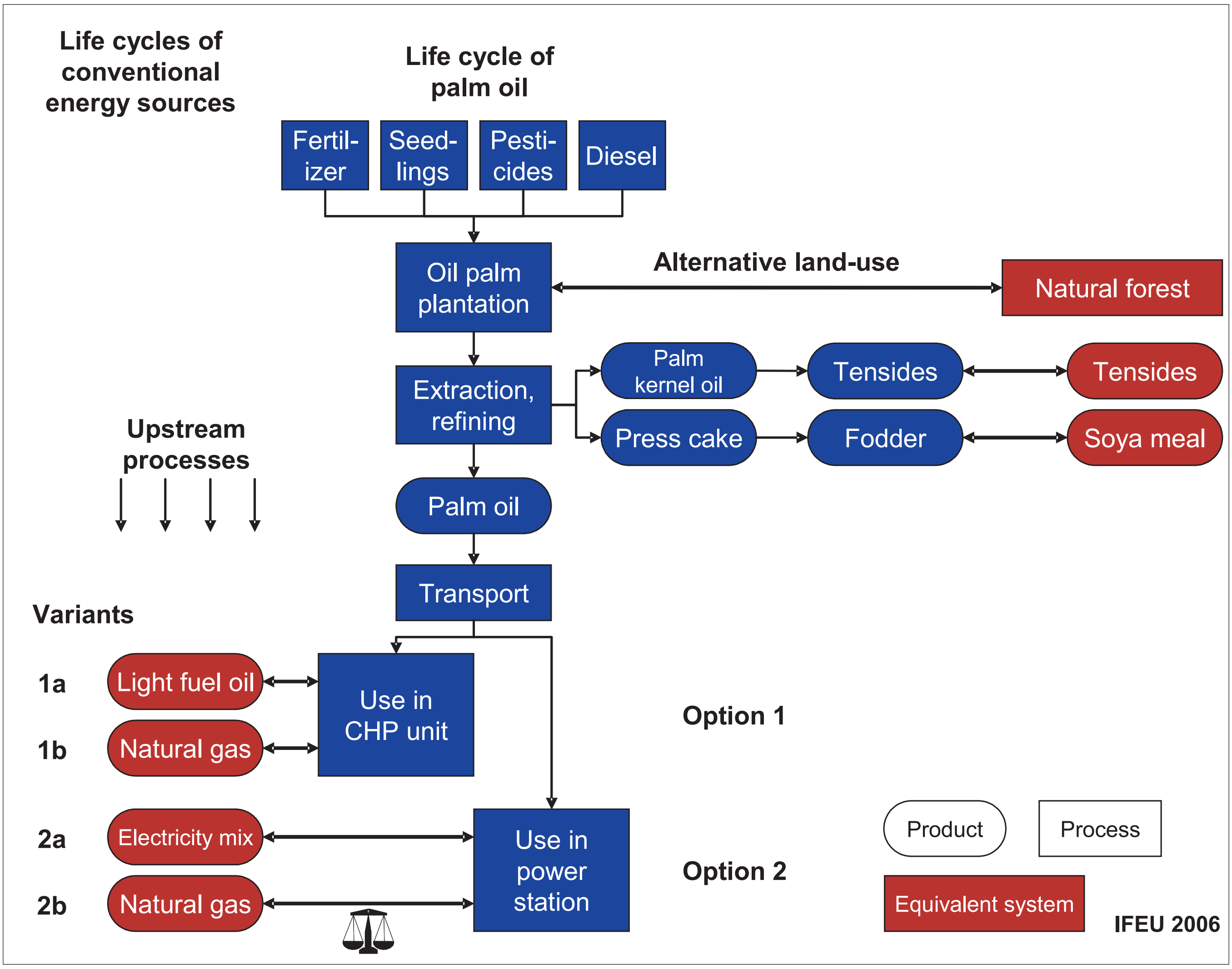


Stationary use

Results vary when palm oil is used as fuel in stationary plants; they depend firstly on whether both power and heat are generated or only power or heat, and secondly on which fossil energy sources are substituted respectively. After all, conventional electricity and heat can be generated in different ways. The following possibilities are considered here (see Fig. 7):

1: Combined heat and power unit (CHP unit): palm oil is used in a CHP unit for the cogeneration of heat and power.
1a: light fuel oil is substituted (LFO-CHP unit).
1b: natural gas is substituted (NG-CHP unit).
2: Power station: palm oil is used in a power station solely to generate electricity.
2a: Electricity from the public grid is substituted (electricity mix).
2b: Natural gas is substituted (NG power station).

Fig. 7: Schematic life-cycle comparisons between conventional energy sources and palm oil used as fuels in a combined heat and power unit (CHP unit) or a power station.

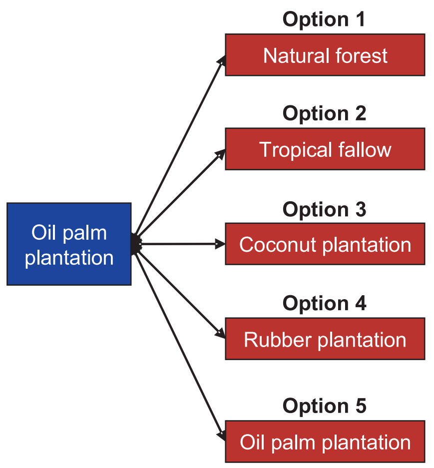


Alternative land-uses

In addition to the alternative land-uses (natural forest) shown in Fig. 6 and 7, there are a number of other options (see Fig. 8). As already mentioned in section 4.1.3, oil palm plantations can also be established on tropical fallow land (option 2) or instead of other plantations. Three options were selected to represent the latter: coconut, rubber and oil palm plantations (options 3-5). In option 5 the use of the palm oil changes from a foodstuff to an energy source (mobile and stationary use).

The options are presented in sequence. Details (in particular on the conversion of other plantation types) can be found in the respective chapters.

Fig. 8: Alternative land-uses



Analyzed environmental effects

Environmental effects (energy savings and greenhouse effect, see Table 7) were analyzed to determine the ecological advantages and disadvantages of using palm oil as an energy source (fuel).

The results shown here come from IFEU's internal database (IFEU 2006). As described, balances are drawn up covering their entire life cycles according to the life-cycle assessment standard (DIN 14040-43). Further details on system cut-off points, boundary conditions and procedures are documented in (Barks et al. 1999 and Reinhardt et al. 1999).

Tab. 7: Analyzed environmental effects

Environmental effect	Description
Energy saving	This test balances what is known as the conservation of resources for the non-renewable energy sources, i.e. fossil fuels such as oil, natural gas, coal and uranium ore. The simpler term „energy saving" is used for the results in the following.
Greenhouse effect	Heating up of the atmosphere as a consequence of human beings releasing climate-affecting gases. The most important greenhouse gas is carbon dioxide (CO_2), which is produced by the combustion of fossil energy sources. Emissions of methane (CH_4) and laughing gas (N_2O) are also measured and converted in weighted form into carbon-dioxide equivalents (CO_2 equivalents) (factor 23 for CH_4, factor 296 for N_2O).

IFEU 2006

4.2.2 Oil palms instead of natural tropical forest

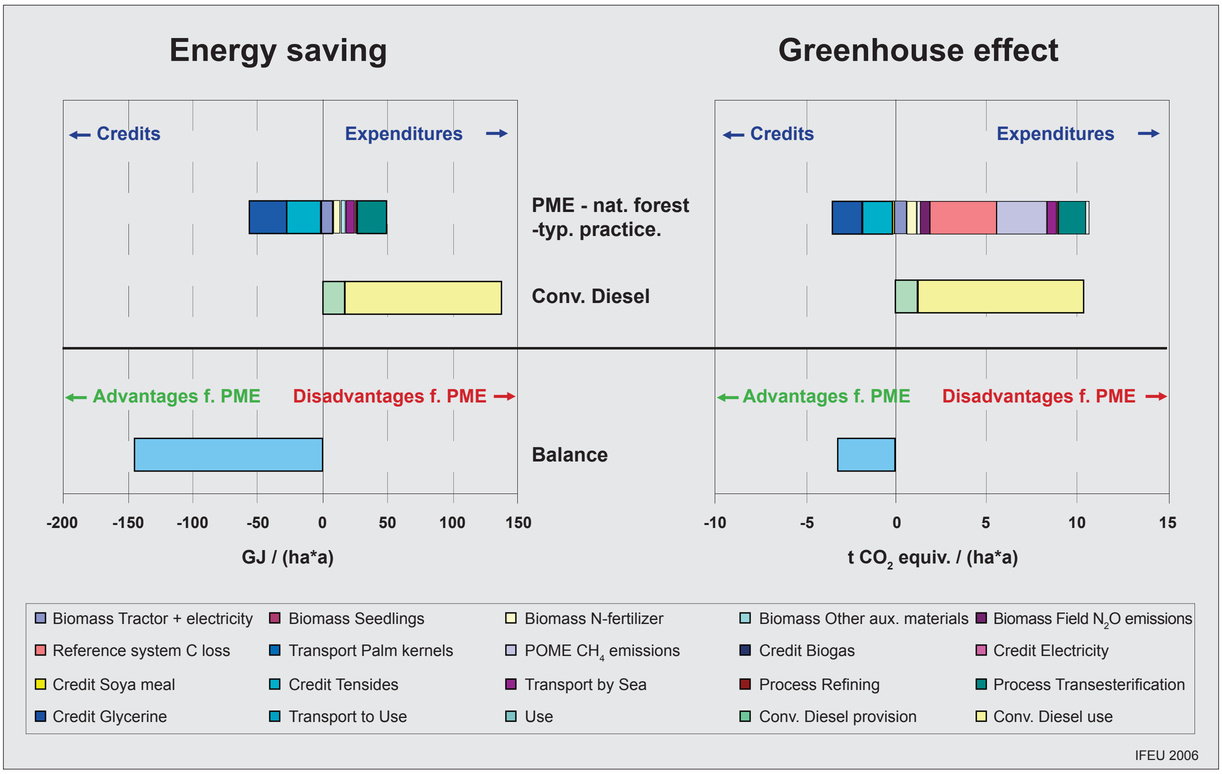
In the following section, the energy balances and greenhouse-gas balances of palm oil biodiesel (mobile use, see Fig. 6) and pure palm oil (stationary use, see Fig. 7) are calculated in the case that oil palms are cultivated instead of tropical natural forests. Since the carbon storage capacity of natural forest is higher than that of an oil palm plantation, the carbon loss has to be taken into account in the calculations as an environmental burden. According to (IPCC 1996), the natural tropical forest in Asia stores approx. 138 tonnes of carbon (C) per hectare, compared to only 30-50 tonnes C per hectare in a fully established oil palm plantation (IFEU 2006). On the basis of these figures we expect a C loss of 100 tonnes per hectare (this corresponds to a CO_2 loss of 365 tonnes per hectare) when a primary forest is converted into an oil palm plantation. In a life-cycle assessment, these 365 tonnes of CO_2 are debited to the oil palm plantation and, if appropriate, also to any subsequent use.

Mobile use

Fig. 9 shows the results of the energy balances and climate-gas balances of the life-cycle comparison between palm oil biodiesel and conventional diesel fuel shown in Fig. 6. It becomes clear that in some cases considerable amounts of fossil energy sources are used along the life cycle of PME from the production of the biomass via conversion up to its use as an energy source. On the other hand, considerable credits accrue particularly for palm-kernel oil (used as a tenside) and the resulting glycerine. The credits in the energy balance are actually bigger than the entire energy expenditure on the production of palm oil biodiesel. This is not the case with the climate-gas balances, since here a considerable amount of climate-affecting methane is given off during the storage of palm oil-mill effluent (POME); besides, significant quantities of carbon in the form of CO_2 are emitted into the atmosphere when natural forest is converted to plantations.

This last point represents the biggest uncertainty in the balances, whereas the other figures can be regarded as quite stable. For this reason, this point is discussed separately in section 4.2.5.

Fig. 9: Energy saving and greenhouse effect in the life-cycle comparison between palm oil biodiesel and conventional diesel.



Examples: energy expenditure on the production of palm oil biodiesel (PME) amounts to approx. 50 GJ; credits total approx. 60 GJ; annual overall saving of energy per hectare is approx. 150 GJ if palm oil biodiesel is used compared to conventional diesel.

When natural tropical forest is cleared for an oil palm plantation, there are unequivocal advantages for palm oil biodiesel in terms of fossil energy savings in the „overall balance of palm oil biodiesel versus conventional diesel fuel“. The same also applies in principle to greenhouse gases. However, it should be pointed out here that, in the results described here, the loss of carbon sustained in the conversion of primary forest into an oil palm plantation was written off over a period of 100 years. When shorter depreciation periods are used, the results can even dip into negative territory (see discussion in section 4.2.5).

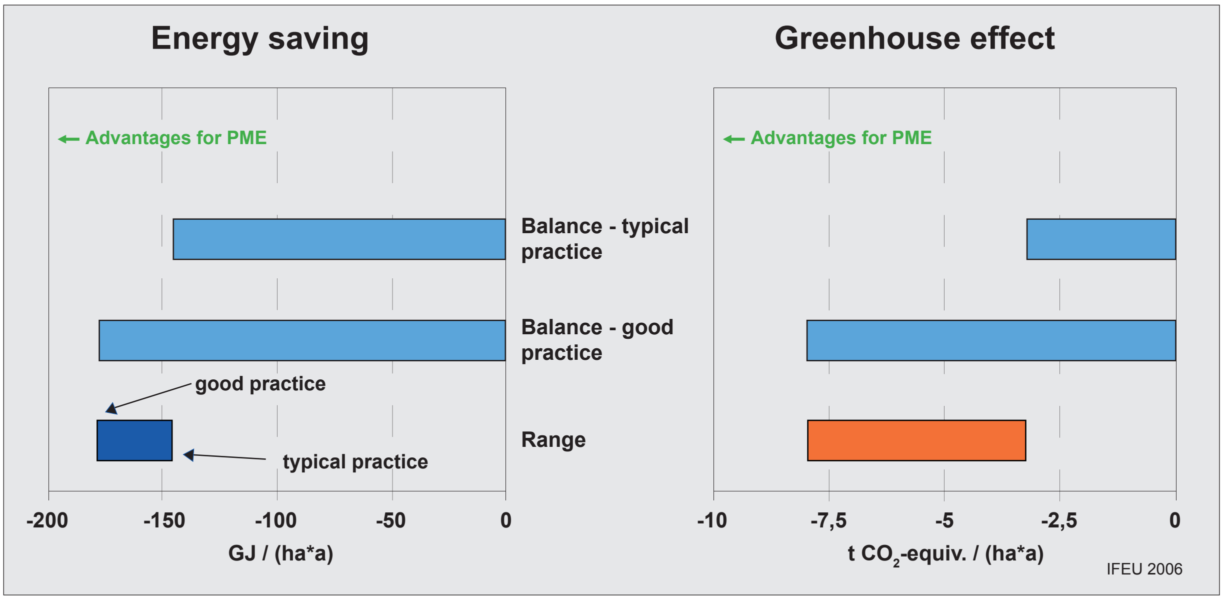
Scenarios

The results shown in Fig. 9 apply to average, globally typical methods of producing palm oil. By contrast there is optimization potential in some areas/are potential areas of improvement, e.g. better plantation management, better exploitation of by-products, exploitation of biogas in POME storage. In order to show the effects of different management methods on the results, a distinction is made between two management scenarios: „typical management“ and „good management“:

- „Typical management“: palm oil yield 3.5 tonnes per hectare per year. Only enough palm oil-mill residues (fibers and kernel shells) are combusted in the mill‘s own cogeneration unit to generate the power and steam needed to cover total process energy needs. The remainder is not used, it is returned to the plantations. The biogas emitted during effluent treatment (65% methane) escapes unused into the atmosphere.
- In the „good management“ scenario, surplus residues are used either directly on the spot or in a central biomass power station to generate electricity, earning electricity credits. Furthermore, the biogas from anaerobic POME treatment is collected and used for power generation. This energy is credited in the form of natural gas. Improved management increases the palm oil yield to 4.0 tonnes per hectare per year.

Natural-forest use leads to a climate-gas saving of 3 to 8 tonnes of CO_2 equivalents per hectare and an energy saving of approximately 150 GJ per hectare per year (see Fig. 10). It also becomes clear that „good management“ can achieve significant improvements: 2.5 times more greenhouse gases can be saved compared to customary palm oil production. Fossil energy savings can be increased by about 20%.

Fig. 10: Comparison of typical and good management. The lowest bar shows the margin of fluctuation of the results.



Stationary use

Fig. 11 shows the results for the four stationary uses of palm oil, each compared to conventional fuels. It becomes clear that the results of the energy balances and greenhouse-gas balances are analogous to those relating to the use of palm oil as palm oil biodiesel: Fossil energy sources and climate gases are definitely saved over the entire life-cycle comparisons.

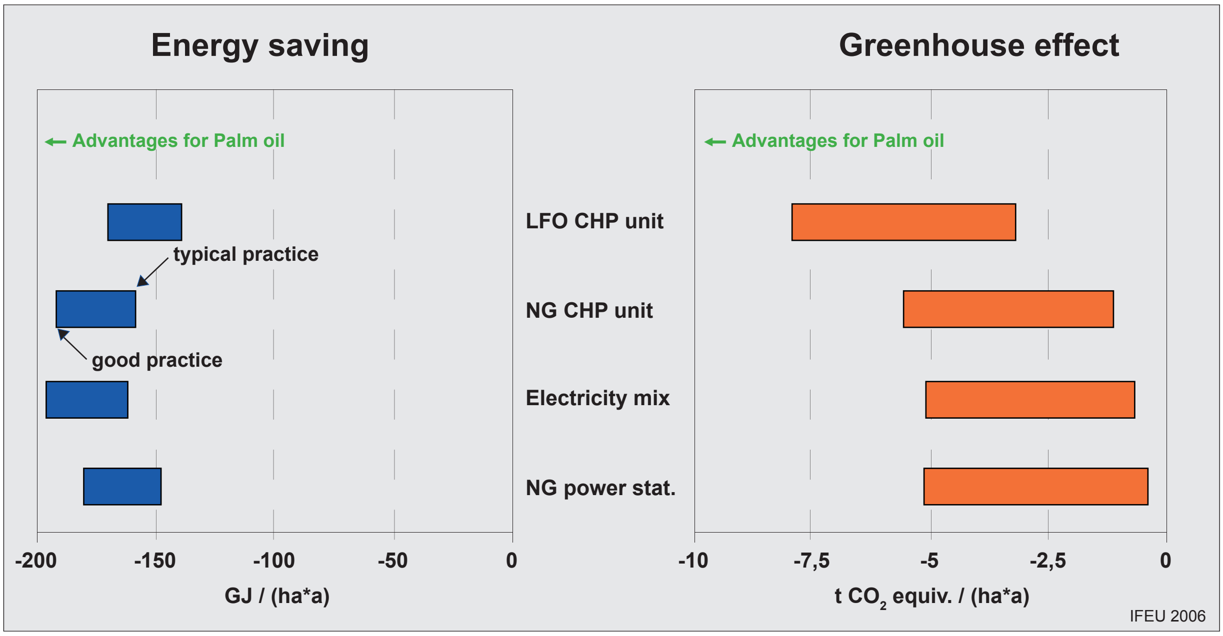
Stationary use is in the same category as mobile use with an energy saving of 140-195 GJ per hectare per year (total range/bandwidth?). This also applies to the results on greenhouse gases. The largest savings of climate gases are made with variant 1a (where palm oil replaces light fuel oil in a CHP UNIT). The main reason for this is that each source of conventional energy requires a different amount of energy to provide it, and emits a different amount of CO_2 per unit of energy content.

Here, too, it should be pointed out that in the results described here the carbon loss in the conversion of primary forest into an oil palm plantation affects the balance over a period of 100 years. If shorter depreciation periods were used, the results would be negative (see section 4.2.5).

Oil palm plantations

Note: The results shown in the graph and discussed here apply to the life-cycle comparison shown in Fig. 7, i.e. for the comparison between palm oil production and natural forest.

Fig. 11: Results for the complete life-cycle comparisons between pure palm oil used in stationary plants on the one hand and conventional power generation on the other for the four uses examined in the scenario „palm oil instead of natural forest“

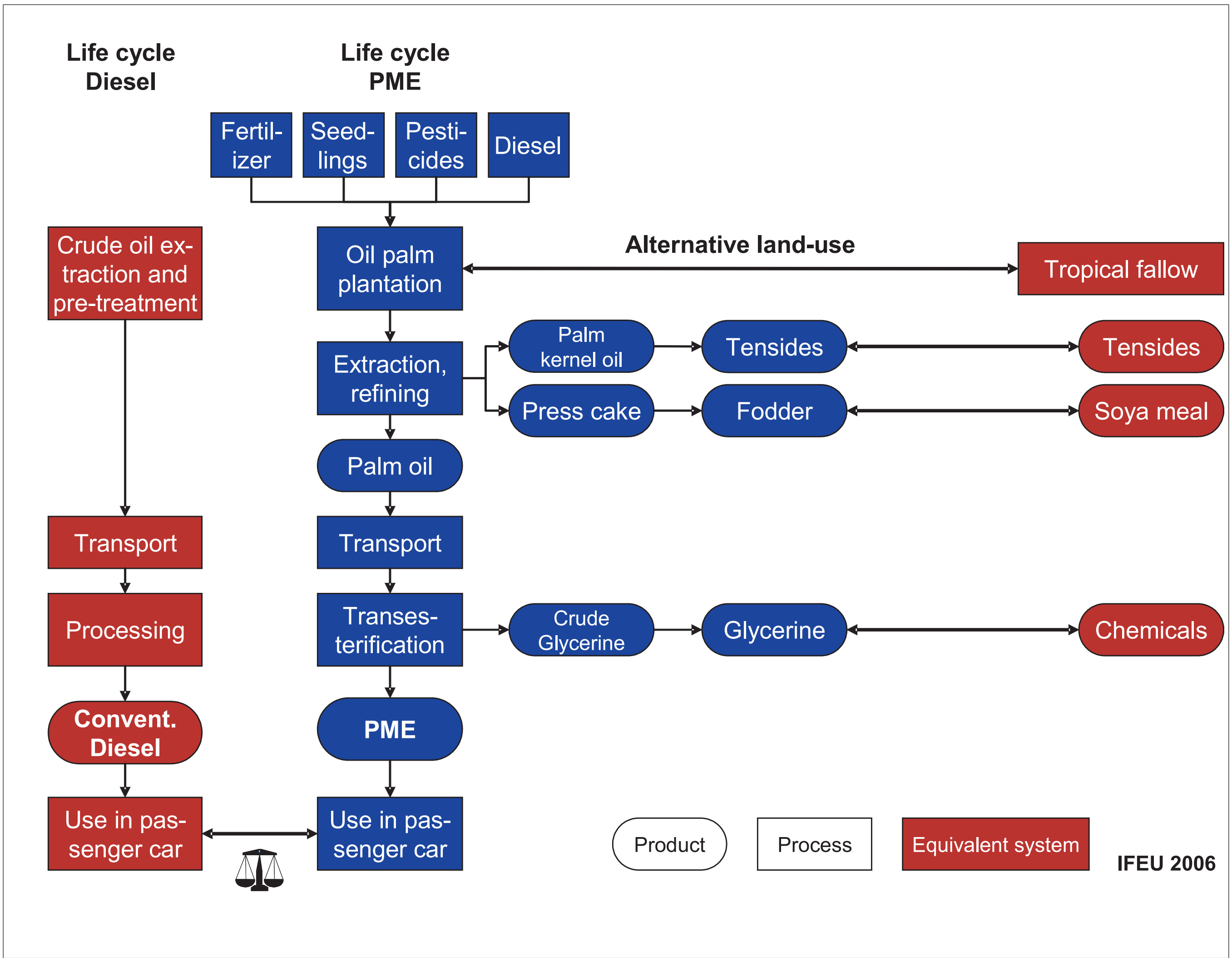


4.2.3. Oil palms on tropical fallow land

As already mentioned in section 4.1.3, fallow land in the tropics where natural tropical forests used to stand represents an enormous potential cultivation area for oil palms. 30-50 tonnes of carbon (C) per hectare are sequestrated by planting oil palms, and this is shown as credit on the balances (IFEU 2006). It is assumed here that a devastated area with negligible carbon content is planted with oil palms (otherwise it would presumably be used for agriculture).

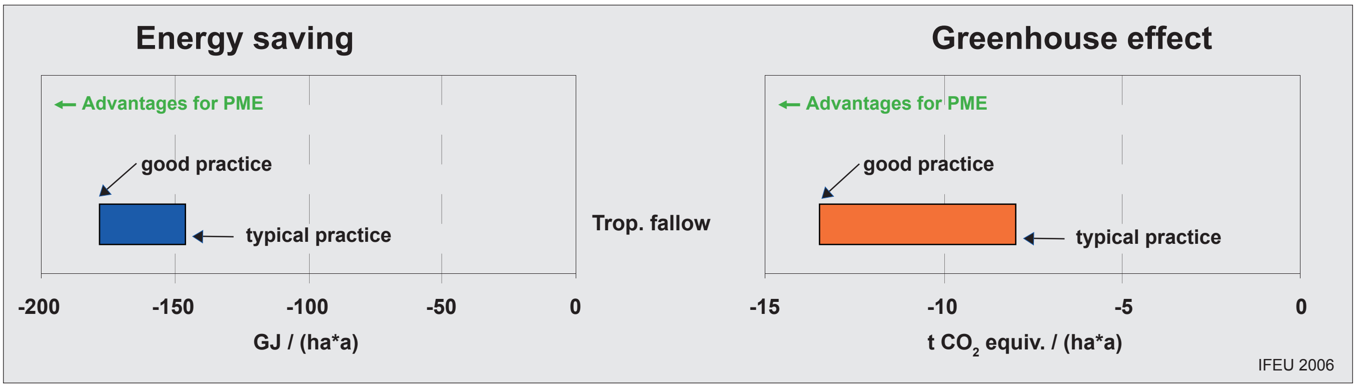
Fig. 12: Life-cycle comparison between conventional diesel and palm oil biodiesel (PME), both used in a diesel vehicle. Fig. 15/16 shows an example of a life-cycle comparison between conventional diesel and palm oil biodiesel (PME) with tropical fallow land as the alternative land-use.

Fig. 12: Life-cycle comparison between conventional diesel and palm oil biodiesel (PME), both used in a diesel vehicle.



When tropical fallow land is planted with oil palms, the energy-balance result is identical to the one with the natural forest option (see Fig. 10 and Fig. 11). In terms of greenhouse gases, by contrast, the result in the case of the fallow option (8–13.5 tonnes of CO_2 equivalents per hectare per annum) is much better, since additional carbon is sequestrated by the planting of the fallow land, and this is shown as credit on the balance. Despite the simplified assumptions on the carbon content of fallow land, the result can be regarded as qualitatively stable. However, the financial expense of establishing the plantation on such fallow land is several times higher than in the case of former natural forest land. Without corresponding incentives, therefore, it can be assumed that natural forest will continue to be cleared if rising demand leads to higher palm oil production in the future.

Fig. 13: Result of the life-cycle comparison between palm oil biodiesel (PME) and diesel fuel when tropical fallow land is planted.



4.2.4 Oil palms instead of other plantations

In addition to clearing natural forest and planting tropical fallow land, sometimes plantations of other crops (rubber, coconut, etc.) are converted into oil palm plantations. However, this means that products traded on the world market such as natural rubber or coconut oil will no longer be produced on this land and therefore have to be substituted by alternative products such as synthetic rubber. According to the basic rules of life-cycle assessments, this is taken into account by taking the equivalent benefit of the corresponding conventional products into consideration in the balance. In this case, therefore, the lost benefit is set off against/debited to the palm oil. Fig. 14 lists the options examined here and the corresponding credits. In addition to natural forest and fallow land (see above), the following three alternative types of land-use are examined as alternatives to oil palm plantations:

- Coconut: a coconut plantation is a possible alternative to an oil palm plantation. The coconut oil, which is used to produce tenside, is replaced by a synthetic tenside based on mineral oil. Coconut press cake, which is generally used as animal fodder, is substituted by soya meal.
- Rubber: a rubber plantation is a possible alternative to an oil palm plantation. Natural rubber is substituted by synthetic rubber (SBR) based on mineral oil.
- Cooking oil: palm oil from an existing oil palm plantation can be used as a bioenergy source instead of as a foodstuff. In this case the shortfall of cooking oil has to be substituted by a different cooking oil such as oilseed rape or sunflower oil. This requires additional land.

Fig. 14: Life-cycle comparison between conventional diesel and palm oil biodiesel (PME), both used in a diesel vehicle.

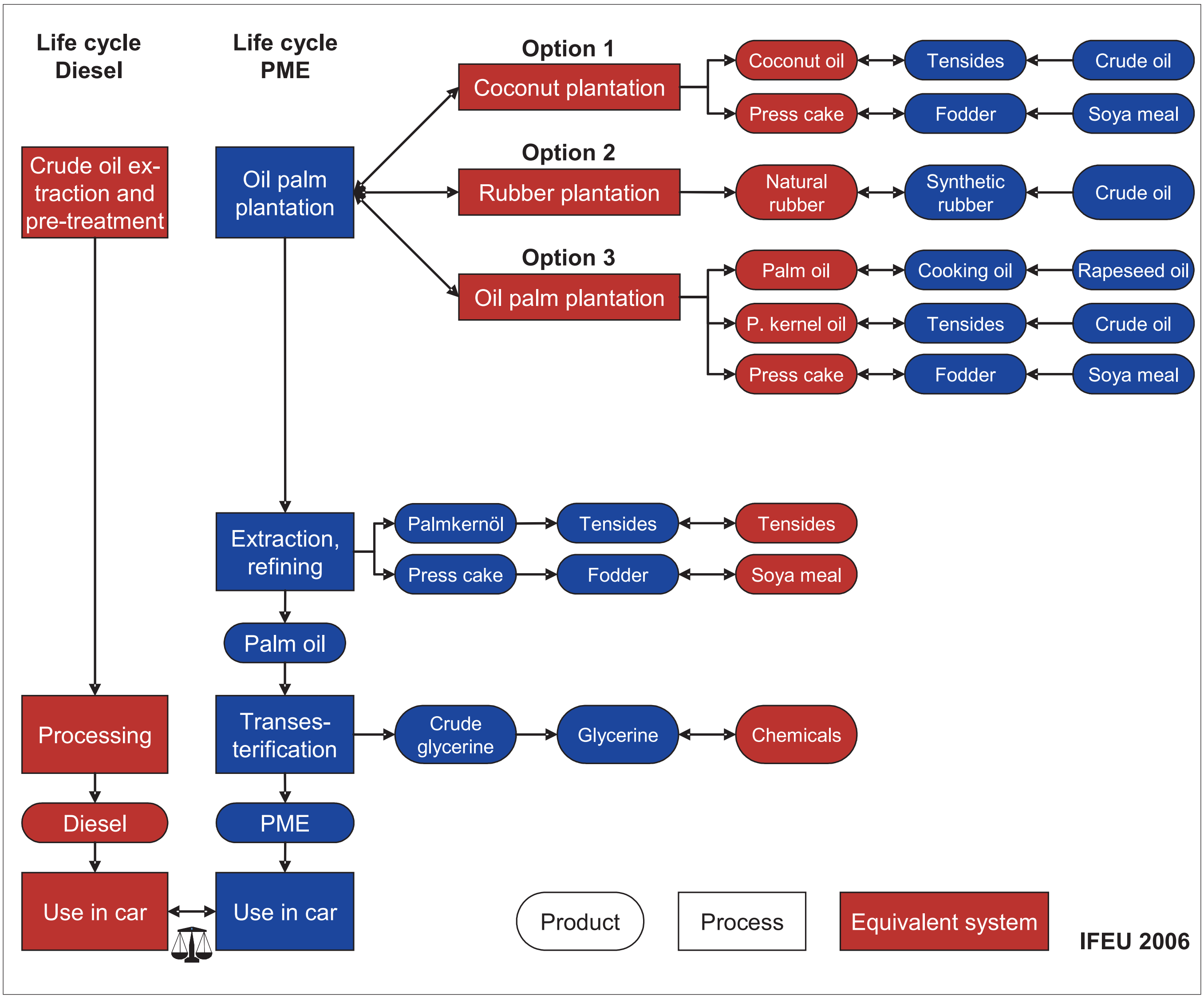
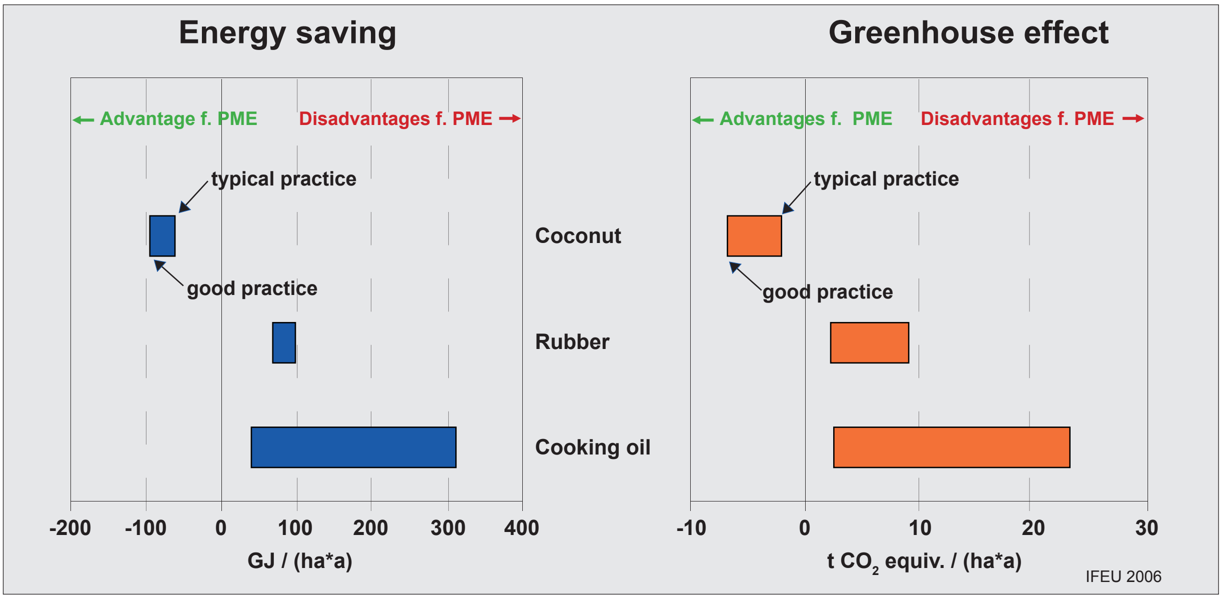


Fig. 15 shows the results for these scenarios: if oil palms are grown instead of other plantation crops, the results are much worse than in the conversion of natural forest; in the case of rubber and cooking oil, the positive result for palm oil actually becomes negative. This means that palm oil used to generate energy, when produced instead of rubber, leads to a higher net consumption of fossil energy and higher emissions of climate gases – despite the substitution of diesel fuel by palm oil biodiesel. Among other things, this is because the production of synthetic rubber requires a lot more energy than the production of diesel fuel.

The results on the stationary use of palm oil compared to the other possible land-uses, as discussed in Fig. 10, are analogous to the palm oil biodiesel results (see Fig. 11), which is why they are not discussed in detail here.

Fig. 15: Results of the life-cycle comparison between palm oil biodiesel (PME) and diesel fuel for the three examined alternative land-uses



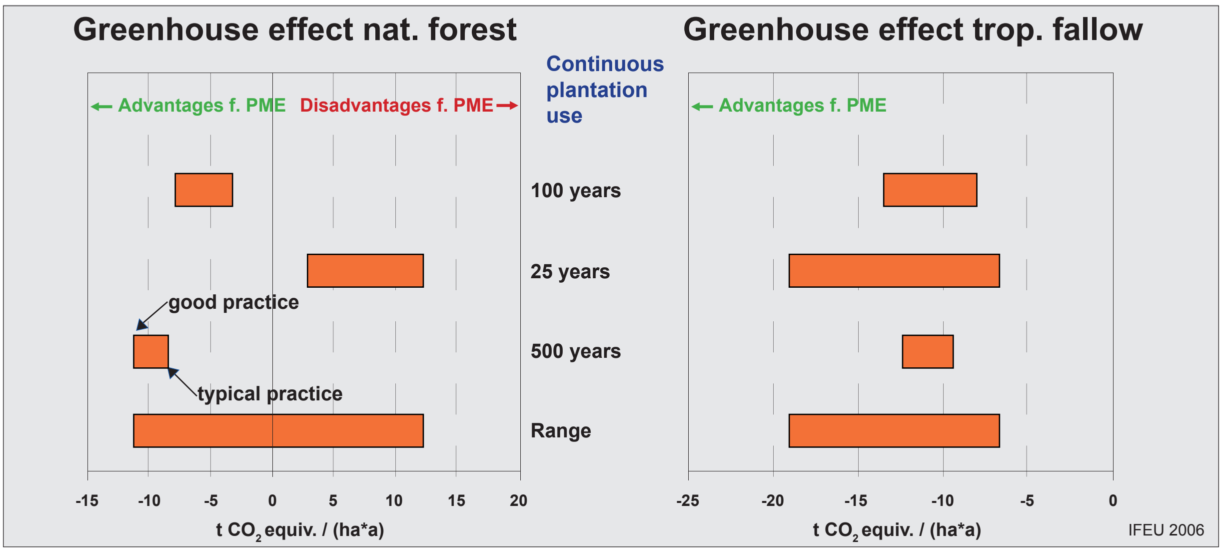
4.2.5 Land-use aspects

Charge/credit period

In the results presented up to now, the depreciation proposed by the IPCC is fixed at 100 years and continuous subsequent plantation use is assumed for the period thereafter. For natural forest the result of this approach is a climate-gas saving (see Fig. 10) of about 3-8 tonnes of CO_2 equivalents per hectare per year for the range "typical and good management". For fallow land it is between 8 and 13.5 tonnes of CO_2 equivalents per hectare per year (see Fig. 13).

If a period of only 25 years is fixed (approximately corresponding to one production cycle of an oil palm plantation), the overall balance for natural forest reverses its sign, i.e. over the entire plantation period of 25 years there would be an additional net climate-gas burden of about 12 tonnes of CO_2 equivalents year after year in the case of typical management, when palm oil biodiesel is produced on a plantation replacing natural forest. If fallow land is planted, a shorter set-off? period leads to an improvement in the balance: 7-19 tonnes of CO_2 equivalents per hectare per year could be saved (see Fig. 16).

Fig. 16: Effects of different depreciation periods of (100, 25 or 500 years) on greenhouse-gas savings for the natural-forest/fallow options assuming continuous use.



If the depreciation period is extended to 500 years (20 plantation periods), the annual greenhouse-gas savings for natural forest rise to approx. 8–11 tonnes of CO_2 equivalents per hectare; for fallow land, by contrast, the value is reduced to approximately 9-12 tonnes of CO_2 equivalents per hectare per year (see Fig. 16).

Subsequent use

Apart from the length of the set-off? period, the type of subsequent use also plays a decisive role. The following three scenarios are conceivable:

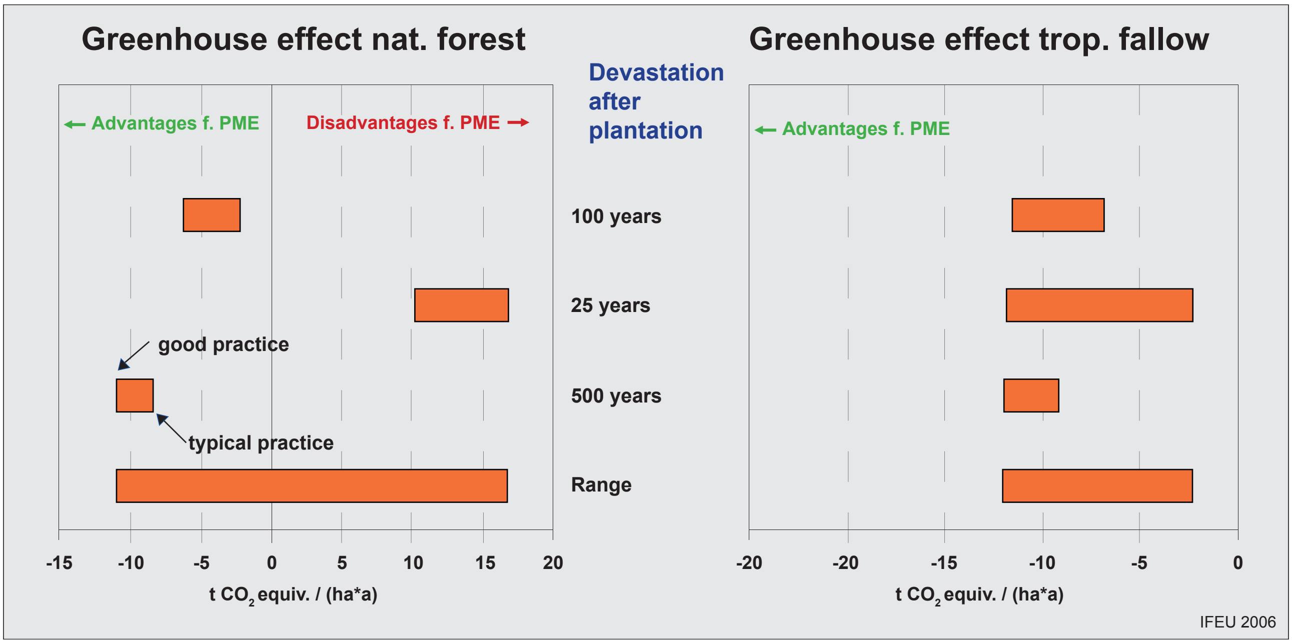
- Continuous plantation use (see above). The plantation is managed permanently and sustainably.
- One-off or repeated plantation use followed by the devastation of the land, since the plantation was not sustainably managed.
- One-off or repeated plantation use followed by development into secondary forest.

A sustainable, long-term management of oil palm plantations is doubtless possible. In the countries of south-east Asia in particular, we are assuming that, once land has been cleared, it will be used for a long time, due to pressure from the high population density. For this reason, we have based our fundamental scenarios on a set-off? period of 100 years, but also considered periods of 25 and 500 years. However, the sad experience of other tropical countries shows that devastation of the plantation land following a short- to medium-term exploitation phase is a quite realistic scenario. Fig. 17 shows that the results then worsen markedly compared to continuous, long-term use (see Fig. 16).

We regard development into a secondary forest after one-off use as improbable as an average option, which is why we have not given any results for it.

To sum up, it should be emphasized how sensitively the overall results depend on these two effects: i.e. on the actual size of the CO_2 loss or CO_2 sink, and on how to take this figure into account in the balance. This depends on how each plot of land will be used in the future, which no-one can predict in many cases.

Fig. 17: Effects of different depreciation periods (100, 25 and 500 years) on greenhouse-gas savings for the natural-forest and fallow options assuming that the land is degraded after 100, 25 or 500 years



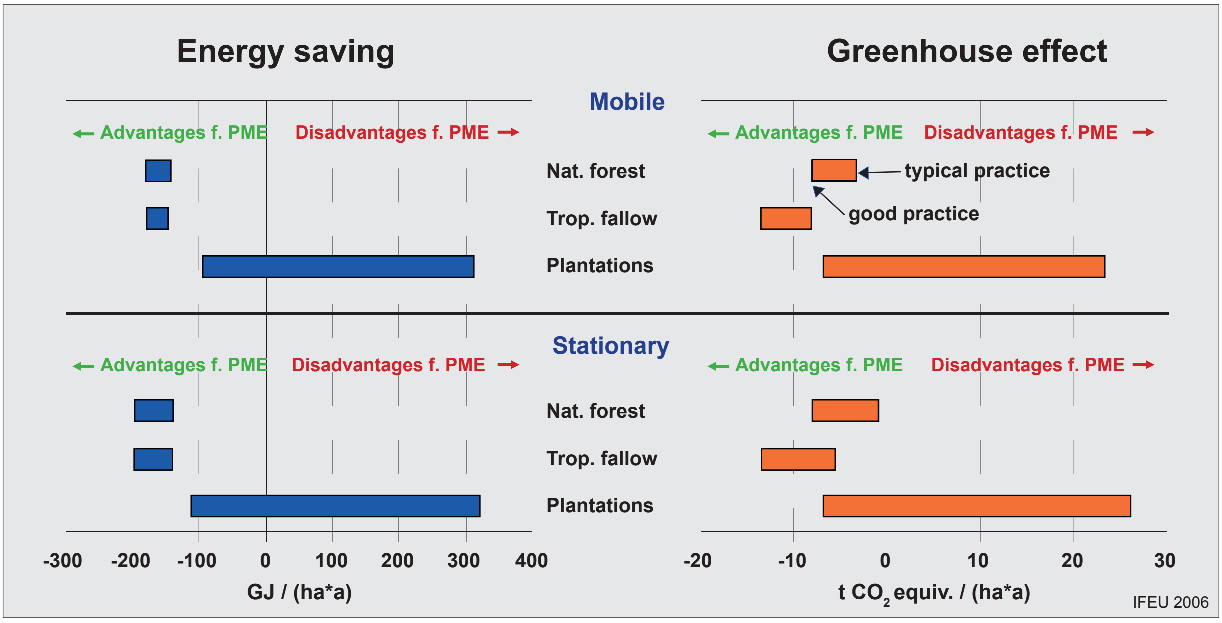
4.2.6 Overview of results for all alternative land-uses

Fig. 18 shows the results initially for both the mobile and stationary use of palm oil: over the entire life-cycle comparison in each case, i.e. compared to the respective conventional energy source and distinguishing between whether the palm oil plantations are cultivated instead of the natural forest, tropical fallow land or other crop plantations (cf. corresponding scenarios in sections 4.2.2. to 4.2.4.)

The main results are as follows:

- If oil palms are grown on tropical fallow ground or instead of natural tropical forest, then 150 GJ of fossil energy per hectare per year are unequivocally saved – comparing the complete life-cycles entitled „use of palm oil as a source of energy compared to conventional power generation".
- The results on greenhouse gases for the two specified options „natural forest" and „tropical fallow land" are analogous – i.e. advantages for the use of palm oil as an energy source – albeit with two differences compared to the energy balances:
  First: the results are more favourable when oil palm plantations are established on tropical fallow land than on former natural forest land, since carbon is sequestrated instead of being released.
  Second: The results shown in Fig. 18 were based on a depreciation period of the sequestrated or released carbon of 100 years. This depreciation period has only a slight influence in the „tropical fallow land" scenario compared to the „natural forest" option. While CO_2 savings are made under all the depreciation possibilities in the „tropical fallow" option, this is not the case with the natural forest: here, the shorter the depreciation period, the worse the result: in the case of set-off? periods of up to 25 years, i.e. only one plantation period, emissions actually increase (see section 4.2.5).
- It can therefore be concluded that planting oil palms on tropical fallow land is clearly more effective than clearing natural forest in terms of CO_2 savings.
- If, by contrast, oil palm plantations replace other plantations (rubber, coconut or cooking oil) then the results (here, too, over the entire life-cycle comparisons) are not uniform: advantages or disadvantages can result. Even when palm oil, a renewable energy source, replaces fossil energy sources, there can be a net increase in fossil-energy consumption and climate-gas emissions. This has to do with the fact that the energy balance and climate-gas balance of natural rubber, for example, are better that when oil palm is grown on the same land, even if the palm oil is used as an energy source.
- The result of the comparison between the stationary and mobile use of palm oil is that there are hardly any significant differences in the energy balances and greenhouse-gas balances.
- There is considerable optimization potential in the field of palm oil production and processing. Significant energy savings and even greater climate-gas savings compared to current, „typical" global palm oil production methods can be achieved if „good practices" are used in production in the future. The greatest potential for savings can be achieved by collecting the biogas from the effluent of the palm oil mills produced during anaerobic fermentation and using it as an energy source, by using all the fibers and kernel shells and by optimizing plantation management (also leading to higher yields). These opportunities for optimization are independent of whether the palm oil is used as an energy source or in the foodstuff industry. The balances described for the use of palm oil as a source of energy show the considerable potential for savings over the complete life cycles: over 15% energy saving and over 60% climate-gas saving.

Fig. 18: Results of the complete life-cycle comparisons between palm oil used as an energy source and conventional energy provision for mobile (palm oil biodiesel, PME) and stationary use (pure palm oil) differentiated according to the alternative land-use to the oil palm plantation



The range of the natural forest scenario differentiates between globally typical management and good management practices of palm oil production and processing

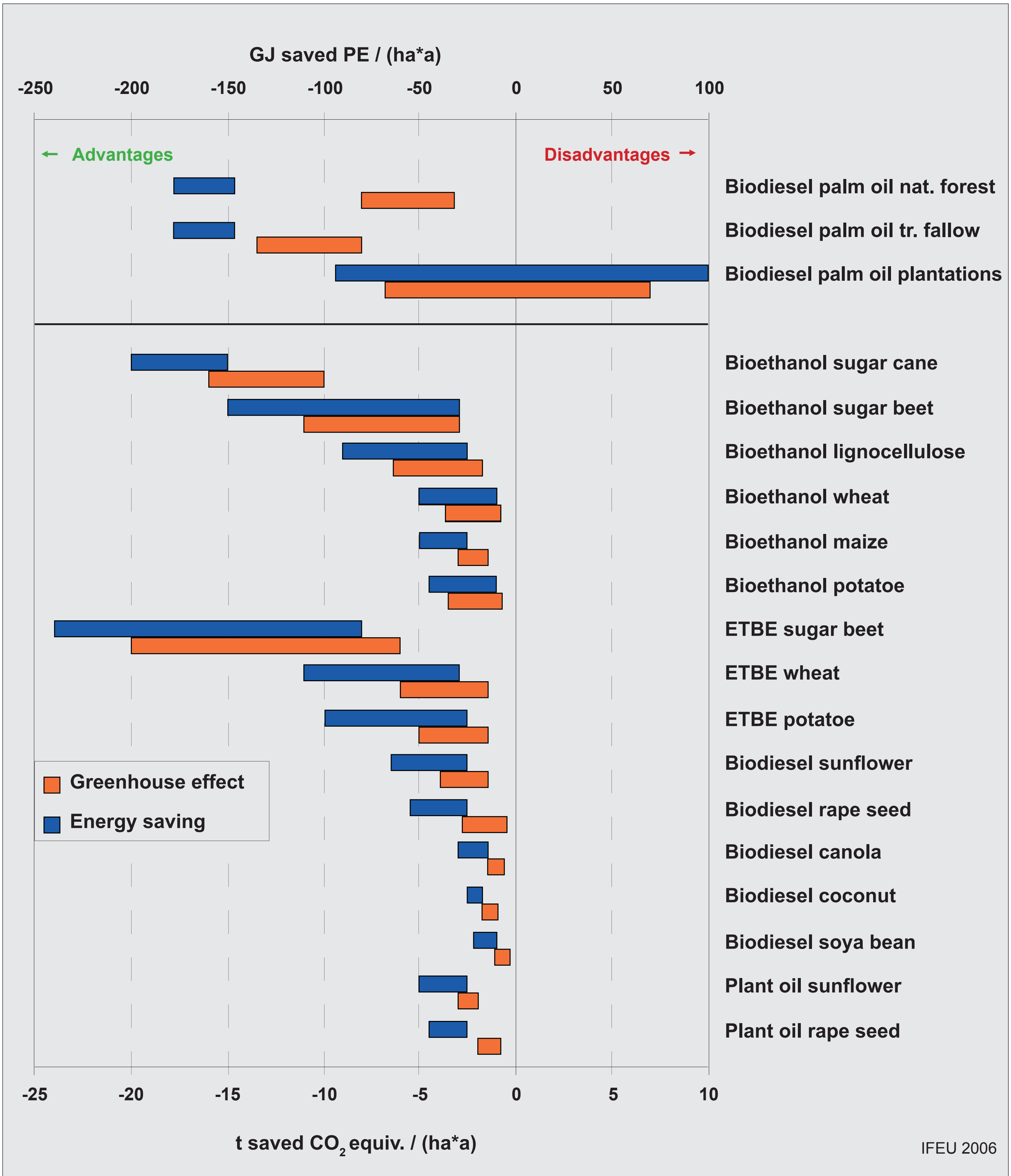
4.2.7 Comparison of palm oil biodiesel with other biofuels

Here are the results (see Fig. 19) of the life-cycle comparison between palm oil biodiesel and other biofuels made from grown biomass – in particular bioethanol (EtOH) as a petrol replacement, ETBE (ethyl tertiary butyl ether) as an antiknock agent, various biodiesels and pure rapeseed oil:

- When the oil palm is grown instead of natural forest or tropical fallow land, palm oil biodiesel, ethanol made from sugar cane, and ETBE from sugar beet have by far the best energy balances, i.e. the biggest fossil energy savings can be made per hectare with these biofuels.
- The results for palm oil biodiesel are not so unequivocal when it comes to saving climate gases: only oil palms grown on tropical fallow ground shows results that are about as high as with ethanol from sugar cane or ETBE from sugar beet and therefore more favourable than most of the biofuels mentioned.

  As regards the typical present-day way of producing palm oil instead of natural tropical forest, the climate-gas saving is no higher than with fuels made from sugar beet grown in temperate regions and less favourable than sugar cane grown in subtropical regions. And this is only the case if palm oil is grown instead of natural forest and the carbon loss when primary forest is transformed is written off over 100 years (see detailed discussion in section 4.2.5).
- There are already a number of alternatives to palm oil, at least when it comes to saving climate gases, which achieve the same benefits, but do not necessarily require natural tropical forest land.
- The results worsen markedly when palm oil is grown instead of other plantations: Here, the result shown in Fig. 18 initially remains valid: i.e. that palm oil biodiesel can even exhibit negative balances over the entire life-cycle comparisons, i.e. cause increased energy consumption and additional climate-gas emissions. Compared to the other biofuels, it also transpires that climate-gas savings under typical management regimes – even in the most favourable case for palm oil of planting coconuts as the alternative – are achieved or exceeded by many other biofuels.
- Here, too, we see very worthwhile optimization potential in the field of palm oil production and processing (see Fig. 10).

Fig. 19: Results of the energy balances and greenhouse-gas balances of different biofuels compared to their fossil-fuel counterparts in terms of annual savings of primary energy (measured in GJ) and climate gases (in tonnes of CO_2 equivalents) per hectare of grown biomass



4.3 Other environmental effects of palm oil production

Apart from the ecological spheres of influence already mentioned – energy consumption, greenhouse effect and land use – there are a number of other ecologically relevant areas that are linked to the production of palm oil. These are outlined briefly here without quoting individual figures, since there are not enough data for this.

Picture 3: Typical appearance of an oil mill for processing oil palm fruit. Photograph: IFEU

Emissions into the atmosphere

Some residues remain after the palm oil fruits have been processed to oil in the mill. These include empty fruit bunches (EFBs, approx. 22% of the weight), fibers (14%), kernel shells (7%) and effluent. Some of these residues, primarily fibers and kernel shells, are burned in the mill to generate energy. This leads to the emission of the pollutants typical of combustion – primarily nitric oxides, hydrocarbons and particles. Since no particularly sophisticated flue gas cleaning systems are installed as a rule, there are considerable pollutant emissions into the atmosphere which continue over the whole year as a result of daily operations.

Some oil mills also burn the empty fruit bunches in furnaces on the mill site and spread the ash as fertilizers on the surrounding plantations, since it is too cost-intensive and/or too much work to return them to then plantations and spread them. This burning is particularly harmful to the environment, because the fruit bunches are still relatively wet after the sterilization process, so that the combustion process can only be very incomplete – which is always the case when damp material is burned; this generates particularly high concentrations of pollutants. Here, too, no special flue-gas purification plants are installed. Although this method of „disposing“ of the fruit bunches is now banned in new factories in countries like Malaysia, it is still widespread worldwide. Even in Malaysia an estimated 10% of all plants are still affected.

Emissions into the hydrosphere

The effluent from the palm oil mills is subjected to anaerobic treatment on the mill site. In factories that try (at least to some extent) to achieve a sustainable system of palm oil production, this is predominantly done in open ponds; biogas – consisting predominantly of the climate-relevant gas methane – escapes into the atmosphere in this process (see section 4.2.2). Today, some of the anaerobically treated effluent is distributed in the surrounding plantations by ditch duct systems; often, however, it simply flows into a runoff ditch, since use on the land involves high costs. As a result, significant quantities of nutrients are still discharged into the rivers and pollute the ecosystems there, despite treatment. Only the mud which is occasionally drawn off from the ponds is used as a fertilizer on the plantations.

Furthermore, not all plants in the world have an appropriate concept for treating oil-mill effluent. In places where the effluent is untreated or insufficiently treated before it flows into the rivers, the risk to the aquatic ecological system is particularly high.

Picture 4: Effluent arising from the extraction of palm oil is temporarily stored in a cooling basin. Photograph: IFEU

Picture 5: Residue from palm oil extraction, partly used for power generation. Photograph: IFEU

Land use
During the refining of the raw palm oil and palm-kernel oil, approx. 9 kg of spent Fuller's earth accumulates per tonne of oil; at the moment this waste is dumped. Over 120,000 tonnes had to be disposed of in Malaysia alone in 2003. This required a corresponding amount of dumping ground, i.e. land otherwise available to nature.

4.4 Ecological optimization potential

As already mentioned in the previous sections, a number of residues are produced during palm oil extraction which, at present, are only insufficiently used or even have to be disposed of to the detriment of the environment. The main ones are the fibers, kernel shells and empty fruit bunches. There is significant potential for effective optimization here.

At present, about half of the fibers and kernel shells are burned inside the mill for power generation; as a result, the entire mill process can be operated with an autonomous power supply. The other half is normally used to stabilize the roads and tracks in the plantations – for lack of any other use, since returning the material as fertilizers is inefficient. Similarly, combustion for power generation is often not possible, since surplus electricity cannot be exported because most plantations are not connected to the electricity grid (Ma et al. 1994).

In the future, therefore, every effort should be made to use the remaining fibers and kernel shells everywhere and completely as an energy source, for example by connecting the palm oil mill to an electricity grid or by selling the raw material and using it as a source of energy elsewhere, as is already practised in isolated cases in Malaysia.

The large quantities of empty fruit bunches that accumulate cause the oil mills major logistical problems. Some of the oil mills take them back to the plantations in the empty trucks and – ideally – distribute them as mulch between the rows of palms. Since this work is extremely laborious and it is almost impossible to distribute the material evenly, in some cases it is simply dumped; at best it is spread around haphazardly, so that its soil-improving and fertilizing effect is not optimally exploited. Furthermore, in some cases the empty fruit bunches are still burned today in furnaces on the mill premises, and only the ashes are spread as fertilizer in the surrounding plantations.

There are several further possibilities for optimization. On the one hand, using suitable technologies the fruit bunches can be not only burned but also used to generate power. This also makes more economic sense than mulching (N et al. 2003). Since the oil mills are already power-autonomous by burning the shells and fibers, the oil mills would have to be connected to electricity mains for this purpose. Another alternative would be to use the fruit bunches internally for energy provison associated with selling all the fibers and kernel shells. Or else the fruit bunches could be burned together with the surplus of fibers and kernel shells in a central biomass power station (Ma et al. 1994). To achieve this, however, the bulky fruit bunches would have to be chopped up or pelleted and their high humidity content (65%) reduced.

There are also efforts to use the fruit bunches to make materials. Since they contain 30% cellulose they could replace approx. 30% of rubber-tree wood, a raw material (which is becoming increasingly scarce) used in the production of MDF (medium-density fiberboard) (Ridzuan et al. 2002 and Ropandi et al. 2005). Cellulose for paper manufacture or compost substrate (see below) can also be made from the empty fruit bunches.

In short, there are a number of options for using the fruit bunches efficiently. On the one hand this would avoid the environmental impacts otherwise caused; on the other there would actually be environmental advantages such as savings energy and climate gases, so that all efforts should be made to fully tap this potential in the future.

Sections 4.2.2 and 4.3 described the effects of the biogas missions from the palm oil mills' effluent on the energy balances and overall climate-gas emissions, as well as its other ecological effects.

The currently practised anaerobic treatment of the effluent is predominantly carried out in open ponds. About 60-70 m³ of biogas containing 65% climate-relevant methane escapes into the atmosphere for every tonne of palm oil produced during this process. Thus there is considerable improvement potential here: the methane contained in the biogas should be collected in closed biogas plants and used for power generation. On the one hand, this would prevent the escape of methane (a virulently climate-affecting gas, whose affect on the climate is about 23 times that of CO_2) and save additional fossil energy, thus preventing the release of fossil CO_2 when fossil energy sources are used. An additional side effect would be that this would somewhat reduce the amount of space required by palm oil mills, since the conventional pond systems would no longer be needed. Using established technologies, the substrate that remains after the biogas has been extracted can be spread over the surrounding plantations and have its fertilizing effect there.

In order to make optimum use of the nutrients in the oil mills' effluent, the German Federal Research Institute for Agriculture in Braunschweig has proposed a system for composting the anaerobically pre-treated effluent together with chopped up fruit bunches. This would bring all the nutrients together in a single product which could be used as an organic fertilizer in the plantations (Schuchardt et al. 2005).

Section 4.3 described in detail the (in some cases extremely serious) pollution of the atmosphere with nitric oxides, hydrocarbons and particles by the combustion of fibers, shells and fruit bunches.

The plants currently used for burning the fibers and shells or empty fruit bunches should be re-equipped with state-of-the-art pollutant-filtering systems (dust cyclone, flue-gas scrubbing, etc.), and else new installations should only be approved if they have this technology.

Another focus is the plantation industry itself, whose global practices not universally based on good technical management, a fact that is reflected by marked differences in yields per hectare (see section 2.2).

There are more areas in which the plantation industry could improve its level of efficiency, although this subject can only be touched on here for the sake of completeness. Certainly the most important priority here is the need for fertilizer to be spread in a needs-oriented manner using state-of-the-art techniques, possibly using the residues from the palm oil mills. As a rule this would reduce negative environmental impacts and raise yields at the same time. Furthermore, owls can be used to combat rodents, especially rats, instead of spreading rodenticides; this is already practised on some plantations. Another important issue is species diversity/biodiversity, which is reduced to a minimum on oil palm plantations that are run as monocultures. Here, too, there is a lot of potential for efficiency improvements.

Picture 6: Fruit bunches after removal of the individual fruits, partially used as mulch in the plantations. Photograph: IFEU

Picture 7: Fresh fruit bunches made up of large numbers of individual fruits. Photograph: IFEU

There are also further optimization opportunities, such as a process for recycling the Fuller's earth used in palm oil refining (see section 4.3). This consists of two steps: first the oil is extracted from the spent Fuller's earth by solvent extraction; then the Fuller's earth is processed by a thermal treatment (Cheah & Siew 2004). These optimization possibilities will not be examined in greater detail here, however.

4.5 Future land requirements for palm oil cultivation

The best way to gain an overview of the world market for biodiesel – and to calculate from this the amount of land that will be needed for palm oil cultivation until the second generation of biofuels can take over in around 2020 or 2030 – would be to predict the development of the crude-oil price and the biofuel policies of the EU and other major consumer countries. However, the EU has only fixed its objectives until 2010, and it is impossible to do much more than guess how the price of crude oil is likely to develop.

As far as the EU is concerned, the „Directive of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport“ (CEC 2003a) calls on the member states to ensure that biofuels reach a specific minimum share of their markets. The reference value is 5.75% for 2010 and relates to the total energy content of all fuels. This means that member states are free to choose the exact percentage of diesel and gasoline they want to substitute. They are also free to choose which biofuel(s) to use to reach this objective. For reasons of availability, however, the choice is largely limited to first-generation biofuels, i.e. biodiesel, bioethanol and bio-ETBE made from various raw materials, since only negligible quantities of second-generation biofuels will be available before 2010.

In principle, pure palm oil and palm oil biodiesel (PME) can also be used to reach these targets. As shown in chapter 2.3.1, palm oil biodiesel cannot meet the currently valid standards at present, either in its pure form or as a blended fuel. However, if the planned amendment of the DIN EN 590 diesel fuel standard were to be adopted, so that PME's low-temperature properties no longer stood in the way of the production of palm oil biodiesel, the result could be a huge potential market.

This raises the question of what effect the establishment of palm oil biodiesel in the European market would have. The analysis focuses here on whether there is enough palm oil available on the world market, whether production would have to be expanded in future – and if so, where.

The FAO expects production of palm oil to increase from 25.6 million tonnes of oil equivalent in 1999/2001 to 54.2 million tonnes in 2030. Because the demand for bioenergy is still growing, the FAO considers an annual increase in the technical-industrial field of 3.2% to be likely, compared to an annual growth of only 1.5% in the food sector. In view of this, the FAO, too, regards this as a potential threat to forests in the producer regions (FAO 2006b).

For the main producer countries in southeast Asia, extrapolations based on high annual growth rates of 5 to 12% – and assuming the continuation of present cultivation systems – expect the amount of land required in Malaysia to increase from 3.5 to 5.1 million hectares by 2020; in Indonesia the figure would jump from currently 5 to 16.5 million ha. If better management techniques are introduced (efficient land-use, ban on converting natural forest, better cultivation methods), the predictions are 4.3 million ha for Malaysia and 9.0 million ha for Indonesia. Hence, even if efficient management techniques are used, at least 3 or 4 million hectares of more land would be needed to grow oil palms in Indonesia.

Government agencies expect the need for additional land for palm oil cultivation to be as high as 30 million ha; provincial governments in Indonesia expect to issue licenses for 20-22 million ha in the wake of decentralization. However, rough estimates put the amount of available fallow land at no more than 10 million ha (Dros 2003). By as early as 2010, Indonesia intends to make 3 million ha of land available for palm oil production and to build 11 refineries (cf. chapter 3.6.). Since establishing new plantations in cleared natural forest areas is economically more profitable than converting fallow land, the interests of the timber and plantation industry come into play here. Because of the political realities in the main producer countries of Malaysia and above all Indonesia, it must be expected that, despite all commitments to international agreements such as the Convention on Biological Diversity (CBD), tropical rainforest will be cleared for oil palm cultivation unless effective regulatory mechanisms have a real impact.

Furthermore, of all the possible options (clearing the natural forest, use of fallow land, rededication of other plantations), the use of fallow land promises the biggest potential savings of fossil energy and greenhouse gases. Because of the uncertainties surrounding the longer-term prospects for subsidies and compulsory blending schemes in the EU after 2010, estimates for Europe can only be given up to 2010. According to the European Biodiesel Board, only 1.4% of total fuel consumption is covered by biofuels, despite a target market share of 2.0% that was already envisaged for 2005; biodiesel accounts for 80%, ethanol (gasoline substitute) for 20%. In turn, 90% of biodiesel is made from European rapeseed, with production of rapeseed biodiesel (RME) totaling 3 million tonnes in 2005. Biodiesel has a market share of 1.5% of total diesel consumption (EBB 2006a, EBB 2006b and UFOP 2006).

If Germany put the appropriate subsidies in place, it could meet the target of a 5.75% share of total fuel, since it has enough agricultural land available to produce the necessary biomass and rapeseed itself. By contrast, the EU as a whole lacks the raw materials in this field. This gap could be filled in the medium or long term with ethanol fuel produced in Europe; however, the technology is not in place (UFOP 2006).

According to the oil-plant growing and processing associations (UFOP and FEDIOL), imports of palm oil are a possible alternative with a potential biodiesel market share of up to 20% by 2010, compared to about 10% in 2005 (UFOP 2006, Krishna & Mudeva 2006). By 2010, assuming a 5.75% biofuel share by this time, (FEDIOL 2006) expects that EU-wide biodiesel consumption will average 12 million tonnes, and that this will be made up of at least 5.8 million tonnes of European rapeseed oil and up to 2.5 million tonnes of imported palm oil – i.e. 20% of biodiesel consumption. Soybean oil (approx. 2.4 million tonnes) and other vegetable and animal oils are further raw-material sources for biodiesel. Assuming an average yield of 3.25 tonnes per hectare per year for Indonesian palm oil (Dros 2003), this means a land requirement of approx. 770,000 ha for the European biodiesel market – in a producer country that is already particularly hard hit by natural-forest clearing. In addition to this, there is an unknown level of demand for stationary use.

The future level of consumption (or demand for imports) of palm oil forecasted by energy crops associations is shown above, and the amount of land required has been calculated on that basis. By contrast, the calculations of the IFEU Institute in Table 9 provide an overview of how much land would be required in order for palm oil biodiesel to substitute 1% of diesel fuel or 1% of total fuel respectively in the EU-25, Germany, Switzerland and the Netherlands on the basis of 2005 consumption levels. It transpires that the additional amount of land required is very significant – e.g. over 1 million ha to substitute 1% of the EU-25's fuel with palm oil biodiesel. Every percentage of substituted diesel fuel in Germany corresponds to 1% of the current worldwide production of palm oil on 8.6 million ha of land. Every substituted percentage of diesel fuel in the EU-25 corresponds to as much as 8%. The figures for every percentage of total fuel substituted are 2% and 12% respectively. Furthermore, countries like Malaysia and Thailand have also formulated political targets for using biofuel – in this case specifically palm oil (see chapter 3.6).

Tab. 8: Amount of land (in hectares) required to substitute 1% of the respective fuel consumption

	Hectarage required to substitute 1% of	
	diesel fuel	**total fuel consumption**
Germany[1]	102,000	189,000
Switzerland[2]	6,000	18,000
Netherlands[3]	19,000	34,000
EU-25	711,000	1,035,000

IFEU 2006 based on [1]MWV 2005;
[2]Erdöl-Vereinigung 2005;
[3]VNPI 2006

Compared to the substitution of fuel by palm oil, the results for substituting electricity are even more pronounced (see Table 12): the amount of oil palm plantation land needed to cover 1% of Europe's electricity needs is about twice the amount needed to substitute 1% of the fuel market, i.e. about 2 million ha.

Tab. 9: Amount of land (in hectares) required to substitute 1% of the respective electricity consumption

	Hectarage required to substitute 1% of electricity consumption
Germany	365,000
Switzerland	42,000
Netherlands	59,000
EU-25	1,927,000

IFEU 2006 based on European Commission 2003

5 Outlook

On the basis of the present study it is evident that the demand for and thereby the production of palm oil are experiencing strong growth. The FAO predicts that global demand will double between 2000 and 2030 (FAO 2006b). The use of palm oil as an energy source is leading to a significant increase in the demand for palm oil.

The results of the energy balances and greenhouse-gas balances on the stationary and mobile use of palm oil demonstrate that palm oil can save enormous quantities of fossil energy and greenhouse-gases in comparison to other vegetable oils, particularly when plantations are cultivated on deforested fallow land. The customary method of preparing additional areas for cultivation is not however to use fallow land, but particularly in Indonesia to lay out palm oil plantations on specially cleared natural forest areas. Increased pressure on the palm oil markets due to the rapid growth in demand for palm oil gives rise to speculation that further natural forest land is threatened with conversion into oil palm plantations, not only in Indonesia, but also in Sabah, Sarawak (Malaysia), in Papua New Guinea, in Colombia and Ecuador as well as in the longer term in Africa. The new establishment and operation of plantations is not only accompanied by a dramatic loss in the diversity of species, but in addition mostly also with major social problems, such as poor working conditions on the plantations and land rights conflicts with the resident population (Colchester et.al. 2006)

Environmental assessment and nature conservation

In addition to savings in fossil energy and emissions of climate gases, other effects on the environment and nature should also be taken into consideration in a comprehensive environmental assessment. These include the atmospheric and water pollution burdens connected with palm oil production as well as consequences for the diversity of species. Even where the energy balances and greenhouse-gas balances are positive, the protection of biodiversity as well as the unique natural habitats of plants and animals does not justify additional clear-cutting or use of tropical primary forests. This is because although there are a number of other options to save energy and protect the climate, a loss of species diversity caused by clear-cutting tropical forests is irreversible.

Energy balances and climate-gas balances can serve as a comparative basis for the suitability of different energy sources or also in order to identify exemption criteria for individual harmful or inefficient practices. And they can also serve more extensive environmental and nature conservation policy decisions, e.g. to call for optimization measures. However scientifically backed analyses are necessary for this. Not all aspects could be looked at in detail in this respect in the present study.

Thus for example, recently published studies showed that the (slash and burn) clearance of moor woodland released exorbitant amounts of CO_2 (Reijnders & Huijbregts 2006). As many of the tropical lowland forests which are suitable for the cultivation of oil palms are situated on swampy soils, the oil palm plantation's favourable greenhouse-gas balance is put into perspective and, if the emissions produced by the degradation of peat are taken into consideration, could even result in it being negative. The depreciation periods for the release of carbon dioxide also have a considerable role to play with regard to the results of the study: As far as this is concerned, the study was able to show that the greenhouse-gas balance throughout the 25-year economic exploitation phase of an oil palm plantation, with a proportionate crediting of the carbon difference, is clearly negative. Concerning the scenario of the conversion of natural forests, the balance only turns to good account after very long exploitation periods. In this context therefore a discussion of subsequent uses of the land used is called for.

Thus three plots arise from the present energy balances and climate-gas balances: A need for research to specify particular sections of the balances has been identified, including the carbon balances of the moor soils, the carbon reserves above and below ground and the previous and subsequent uses of palm oil plantation areas. Secondly, clear recommendations for the future optimisation of palm oil production to reduce the climate-relevant gases have been derived, which are to optimise palm oil production in the existing plantations and during processing. Thirdly the consequence that the climate-gas balances of palm oil on fallow land should turn out positively needs to be verified from the viewpoint of practical suitability.

Certification of palm oil: possibilities and limitations

The WWF, along with companies from the palm oil sector, food companies, banks as well as representatives of civil society, have created the Roundtable on Sustainable Palm Oil (RSPO), an organisation meanwhile comprising more than 160 full members. Through the members of RSPO about 40% of global palm oil production is covered, and in addition the most important buyers and processors of palm oil are represented in the RSPO. Even outside the palm oil sector the RSPO is regarded as the major global player concerning sustainable palm oil production.

The background to and goal of the RSPO is the sustainable production of palm oil as well as its promotion and use. In a first step, with the participation of all players, the principles and criteria of the RSPO were developed and passed in 2005. These guidelines stipulate that both ecological and social minimum conditions have to be fulfilled.

The new establishment of oil palm plantations requires among other things an environmental impact assessment (EIA) as well as a social impact assessment (SIA). Furthermore the clearance of natural forests with high ecological or cultural significance (high conservation value – HCV) is prohibited. The separating out of the HCV takes place within a participative land-use plan, which can be a part of the EIA. The RSPO guidelines are supported by a number of environmental and development organisations including the WWF, Oxfam and Sawit Watch. They are to represent a minimum requirement both for the conventional use of palm oil as well as its use as an energy source. Certainly the RSPO guidelines do not include any requirements with regard to greenhouse-gas balances; however the prevention of greenhouse-gas emissions, such as methane emissions in sewage ponds, is given as a general goal.

The present study makes it clear that an optimisation of palm oil production would have a considerable influence on the emission of greenhouse-gases and that big potential savings can be made. Several of these optimisations are partially covered by the RSPO guidelines, as has been mentioned already. Others require a weighing up between the greenhouse-gas emissions target and the advantages of prior practice, in order to ensure that no undesirable side effects (e.g. “leakage“) occur, e.g. when empty fruit bunches are no longer used as fertilizer in plantations, but rather primarily for power generation, the result could be a greater need for mineral fertilizers.

Effects of using palm oil as a source of energy on its use as a foodstuff

Neither the energy and greenhouse-gas balances, nor the RSPO guidelines, take a further potential side effect of the use of palm oil as an energy source, the financial burden on households in developing countries who depend upon palm oil as a foodstuff, into consideration. The apparent growing demand for palm oil has already led to an increase in world market prices. These price rises and also the foreseeable competition between conventional use and use as a source of energy are ultimately passed on to the end consumers. This primarily affects consumers from developing countries with low incomes, who moreover are often not able to fall back on other products.

Optimization potential: first and foremost the use of fallow land

There are in principle two options available to supply the growing global demand for palm oil for conventional use and as a source of energy. On the one hand the average productivity of oil palms can be increased. There is great potential particularly in Indonesia in this respect (Dros 2005). The second option consists of the expansion of the existing areas under cultivation. For this purpose the remaining tropical lowland forests should be comprehensively excluded where possible. Rather than this land, previously cleared, unused fallow land such as the so-called alang-alang areas should primarily be converted into in oil palm plantations. Initial estimates indicate that there is potentially enough fallow land available to supply the greater part of future palm oil requirements. An evaluation of the fallow land available with regard to its ecological and social importance as well as its potential to serve as a production area for palm oil plantations certainly represents one of the most important prerequisites for the future use of this land as a palm oil production area.

Gaps in knowledge and research needs

The forecasts of various institutions make it clear that palm oil will have an important role to play in future both in foodstuff production as well as for bioenergy. Chapters 2 and 4.5. The development of new areas for the cultivation of palm oil thus represents an important task from an environmental and nature conservation point of view. Exploring the availability of fallow land for palm oil production and ascertaining the feasibility and economic viability of this land option, provides a future research need.

The sustainable use of palm oil as an energy source involves pressing ahead with the development and establishment of internationally valid sustainability standards for bioenergy in which, in addition to the greenhouse-gas balances, land-use changes are also documented. A European as well as internationally recognized sustainability standard for bioenergy should include and use existing voluntary systems such as the RSPO. The RSPO certification system needs to be reviewed to see to what extent further criteria are necessary, in view of the increasing importance of energy source use such as e.g. the preparation of greenhouse-gas balances. An investigation is required as to how greenhouse-gas balances can be feasibly and cost-effectively introduced and prepared for the use of palm oil as an energy source.

The example of palm oil production and use clearly shows that a debate on the international establishment of standards for the production and use of biomass - irrespective of whether palm oil is used as an energy source or as a foodstuff – makes sense. The product flows cannot be accordingly separated from use, so that also with regard to other potential sources of energy which are likewise processed as foodstuffs, a comprehensive approach to the development of sustainability standards would appear helpful.

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