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# An alternative to 5.75% biofuels in 2010

More sustainability at lower cost?

**Report**

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# Summary

As an alternative to petrol and diesel produced from mineral oil, biofuels are receiving widespread government support. The aim of this support is to lower the greenhouse gas emissions of the transport sector, reduce dependency on fossil fuel and support agriculture.

Increasingly, however, respected organizations (including FAO, OECD, JRC, MNP and the UK Gallagher Commission) are concluding that current, first-generation biofuels are not effective in achieving these goals. Biofuels are contributing to the rise in global food prices and may lead to deforestation, and for some biofuels there is even a risk of greenhouse gas (GHG) emissions being increased. Although sustainability criteria are being developed to address these problems, they are not yet in place. It has been concluded, furthermore, that most of today's biofuels are an expensive way of tackling global warming.

**Costs per avoided tonne of $CO_2$**
A common way of comparing environmental options is to assess the cost to society of preventing one tonne of $CO_2$ emissions using the options in question. As the following data show, biofuels are relatively expensive compared with other GHG mitigation options,

| **Option** | **Cost per tonne $CO_2$ saved (Euro)** |
|---|---|
| Biofuels | 400-4,000 (OECD, 2007 & 2008) |
| Concentrated solar power | 130-300 and falling |
| Energy from waste | 60-85 |
| Wind, offshore | 60 |
| Wind, onshore | 47 |
| Savings under the ETS system | 10 to 30 |

In the Netherlands oil companies are under an obligation to substantially increase the share of biofuels in pump sales, to 5.75% in 2010. Given the unintended negative side-effects of this move and current doubts about the accruing benefits, Stichting Natuur en Milieu (Netherlands Society for Nature and Environment) commissioned CE Delft to develop and examine an alternative to this 5.75% biofuels obligation. This alternative consists of 2.5% biofuels in 2010 and a package of alternative environmental policy measures to reduce GHG gas emissions and support development of sustainable energy systems. The alternative options can be financed via the lower costs of biofuels in the proposed alternative.

In the Netherlands the 5.75% biofuels target is expected to raise the price of diesel by about 3 Eurocents and the price of petrol by about 4 Eurocents. As a result the 5.75% goal is expected to cost Dutch motorists between 418 and 485 million Euro annually. Reducing the 5.75% biofuels target to an alternative target of 2.5% in 2010 thus saves Dutch motorists about € 260 million a year.
In this study it is proposed to use about 75% of these financial savings (i.e. € 200 million) to fund alternative GHG mitigation measures. These funds can be

collected by the government by introducing a voluntary buy-out system for Dutch oil companies for biofuel use over and above 2.5%. The official goal stays 5.75% but in practice 2.5% will be reached. Companies will use the buy-out system because with the proposed price it is approximately 25% cheaper than using biofuels. Such a system has already been proposed as an option by the Dutch government and is already up and running in the UK (with a higher buy-out tariff).

While the options in the alternative have been carefully selected, changes are possible. The main selection criteria were as follows:

- Measures additional to current environmental policies.
- Focus on renewable energy and options supporting the transition to sustainable energy systems.
- No relatively cheap options likely to be introduced under existing policy arrangements like the European emissions trading scheme.
- Support for innovation.

The following options were selected:

- More efficient car air-conditioning systems and tyres, electrically powered transport and use of lignocellulosic (i.e. woody) biomass in refineries serving the transport sector (70 million Euro per year).
- Woody biomass, offshore wind and Concentrated Solar Power (CSP) in the electricity sector (100 million Euro per year).
- Investments in research into blue energy (energy from mixing fresh and salt water) and biofuels from woody biomass (30 million Euro per year).

Table 1 GHG reductions and land use of the proposed Dutch alternative compared to the reference situation of a 5.75% biofuels target in 2010

| Mitigation scenario | GHG reduction (Mt) | Land use (ha) |
|---|---|---|
| **Reference**: 5.75% biofuels target | 1.5 or less | 440.000 |
| **Proposal**: 2.5% biofuels target + alternative GHG measures | 2.95 | 190.000 |

Compared with the target of 5.75% biofuels in 2010, the alternative (2.5% biofuels and a package of alternative GHG mitigation measures) has the following advantages:

- At least 1.4 Mtonne more GHG emissions savings per year.
- Use of 250,000 hectares less agricultural land (equivalent of 12.5% of Dutch farmland).
- Less risk of deforestation.
- Less competition with food.
- More innovation in renewable energy (investment in second-generation biofuels, CSP and blue energy).
- Slightly lower costs for motorists.

**Europe**

The approach proposed for the Netherlands (2.5% biofuels in 2010 rather than 5.75%, combined with other policies) might also be feasible for other European countries. For the EU-27 the budget for the alternative proposal would amount to about 6.2 billion Euro per year. By investing this EU-27 budget in electric transport systems, woody biomass for power plants, offshore wind power, energy from waste, CSP in North Africa and second-generation biofuels, at least 30 Mtonne more annual GHG emissions could be saved than under the current 5.75% biofuels programme.

**Sustainability criteria**

Also with the lower target of 2.5% biofuels it is crucial to introduce good sustainability criteria for biofuels. The possible speed of introduction of sustainability criteria is not investigated in this study. If introduction of these criteria is impossible before 2010, abolishment or a target below 2.5% may be considered for this year. This would increase the budget for alternative more cost-effective mitigation measures.

# Samenvatting

Biotransportbrandstoffen worden door de overheid ondersteund als een alternatief voor benzine en diesel geproduceerd uit aardolie. De bedoeling van deze ondersteuning is het verlagen van de emissie van broeikasgassen van de transportsector, de afhankelijkheid van fossiele brandstof en om de landbouw te ondersteunen.

Meer en meer gerespecteerde instituten (FAO, OECD, JRC, MNP en de Gallagher Commissie) concluderen dat eerste generatie biotransportbrandstoffen niet effectief zijn in het bereiken van deze doelstellingen. Biobrandstoffen dragen bij aan hogere voedselprijzen, geven risico op ontbossing en bij sommige biobrandstoffen is er zelfs risico dat ze zorgen voor extra broeikasgassen. Om deze problemen te voorkomen worden er duurzaamheidcriteria ontwikkeld maar deze zijn nog niet in werking. Ook wordt geconcludeerd dat biobrandstoffen een relatief dure optie zijn om broeikasgasemissies te bestrijden.

**Kosten per vermeden ton $CO_2$-emissie**

Een gebruikelijke manier om milieumaatregelen te vergelijken is te kijken naar de meerkosten voor de samenleving van het vermijden van 1 ton $CO_2$-emissie. Uit onderstaand lijstje blijkt dat biobrandstoffen relatief duur zijn:

| **Option** | **Cost per ton $CO_2$ saved (Euro)** |
|---|---|
| Biotransportbrandstoffen | 400-4.000 (OECD, 2007 and 2008) |
| Zonnespiegelcentrales | 130-300 en dalend |
| Energie uit afval | 60-85 |
| Windenergie op zee | 60 |
| Windenergie op land | 47 |
| Besparingen bij de industrie | 10 to 30 (in het ETS-systeem) |

De Nederlandse overheid verplicht oliemaatschappijen om het aandeel biobrandstoffen in de benzine en diesel verkocht aan de pomp te verhogen tot 5,75% in 2010. Gezien de onvoorziene negatieve effecten en de twijfels over de voordelen hiervan heeft Stichting Natuur en Milieu aan CE Delft gevraagd een alternatief hiervoor op te stellen en door te rekenen. Dit alternatief bestaat uit 2,5% biobrandstoffen plus een pakket van alternatieve klimaatmaatregelen om $CO_2$-emissies te verminderen en de overgang naar een duurzame energie-voorziening te stimuleren.

Een bijmengverplichting van 5,75% biotransportbrandstoffen maakt diesel ongeveer 3 Eurocent en benzine ongeveer 4 Eurocent duurder per liter in 2010. Dit betekent dat de Nederlandse automobilisten gezamenlijk jaarlijks tussen de 418 en 485 miljoen Euro extra brandstofkosten betalen als gevolg van de bijmengverplichting van 5,75% in 2010. Een verlaging van dit bijmengpercentage naar een alternatief niveau van 2,5% scheelt Nederlandse automobilisten jaarlijks 260 miljoen Euro.

Deze studie stelt voor om ongeveer 75% (d.w.z. € 200 miljoen) van dit bespaarde geld voor alternatieve $CO_2$-reductiemaatregelen en innovatie te gebruiken.

Bij een verlaging van het bijmengpercentage van 5,75% naar 2,5% worden oliemaatschappijen niet langer geconfronteerd met de daarmee gepaard gaande meerkosten. Deze kosten worden dan niet meer aan automobilisten doorgerekend in de brandstofprijzen. Om de alternatieve klimaatmaatregelen te kunnen financieren, dient de overheid wel eerst het 'benodigde' bedrag van € 200 miljoen te innen. Dit kan bijvoorbeeld door een aantrekkelijke uitkoop regeling te introduceren voor oliemaatschappijen voor biobrandstoffen afzet boven de 2,5%. Het officiële doel blijft zo 5,75% maar in de praktijk zal er 2,5% worden bereikt. Bedrijven zullen deze uitkoop regeling gebruiken omdat deze ongeveer 25% goedkoper (€ 200 i.p.v. € 260 mln) is dan het bijmengen van biobrandstoffen. Zo'n systeem is eerder door de Nederlandse overheid gesuggereerd als een optie en werkt op dit moment al in Groot-Brittannië.

De opties in het alternatieve pakket zijn zorgvuldig geselecteerd maar aanpassingen zijn mogelijk. De criteria voor de selectie waren:
- maatregelen die extra zijn bovenop het huidige milieubeleid;
- focus op duurzame energie opties;
- geen relatief goedkope opties die waarschijnlijk toch wel uitgevoerd worden bijvoorbeeld door het ETS-systeem voor de industrie in Europa;
- steun voor innovatie.

De volgende opties zijn geselecteerd:
- efficiënte airconditioning, zuinige banden, elektrisch vervoer en inzet van hout in raffinaderijen in de transportsector (70 miljoen Euro per jaar);
- duurzame bio-elektriciteit, windenergie in zee en zonnespiegelscentrales in de elektriciteitssector (100 miljoen per jaar);
- investeren in onderzoek naar blue energy (energie uit het mixen van zoet en zoet water) en biotransportbrandstoffen uit lignocellulose biomassa (30 miljoen per jaar).

Tabel 2 Reductie van broeikasgassen en effect op landgebruik van het voorgestelde Nederlandse alternatieve scenario en het referentiescenario van 5,75% bijmengdoel in 2010

| Mitigatie scenario | $CO_2$-eq. reductie (Mt) | Land gebruik (ha) |
|---|---|---|
| **Referentie**: 5,75% biobrandstoffen doel | 1.5 of minder | 440.000 |
| **Alternatief voorstel**: 2,5% biobrandstoffendoel + alternatieve $CO_2$-reductiemaatregelen | 2.95 | 190.000 |

Het alternatief (2,5% biobrandstoffen en het pakket van alternatieve maatregelen) heeft de volgende voordelen ten opzichte van 5,75% biotransportbrandstoffen in 2010:
- op zijn minst 1,4 Mton meer reductie van broeikasgassen per jaar;
- 250.000 ha minder gebruik van landbouwgrond (vergelijkbaar met 12,5% van het Nederlandse landbouwareaal.);

- een lager risico op ontbossing;
- minder competitie tussen brandstof en voedsel;
- meer innovatie in duurzame energie (investering in tweede generatie biobrandstoffen, CSP en blue energy);
- Beperkt lagere kosten voor automobilisten.

**Europa**

De voor Nederland voorgestelde aanpak (2,5% biobrandstoffen en alternatieve maatregelen) is ook denkbaar voor heel Europa. Voor de 27 EU-landen zou het budget voor alternatieve maatregelen 6,2 miljard Euro per jaar zijn. Als dit budget wordt ingezet in elektrisch rijden, duurzame bio-elektriciteit, windenergie op zee, energie uit afval, zonnespiegelscentrales in noord Afrika en onderzoek naar tweede generatie biotransportbrandstoffen dan zou dit op zijn minst 30 Mton $CO_2$-emissie meer besparen dan het huidige biobrandstofprogramma dat mikt op 5,75% in 2010.

**Duurzaamheidcriteria**

Ook met een lager biobrandstoffendoel van 2,5% voor 2010 blijft het belangrijk om goede duurzaamheidcriteria voor biobrandstoffen in te voeren. De mogelijke snelheid van introductie van deze criteria is niet onderzocht in deze studie. Mocht het onmogelijk zijn om voor 2010 deze duurzaamheidscriteria in te voeren dan zou afschaffing of een nog lager biobrandstoffen doel voor 2010 overwogen kunnen worden. Dit zou het budget voor alternatieve kosteneffectievere klimaatmaatregelen verder verhogen en negatieve (indirecte) effecten van productie van biobrandstoffen voorkomen.

# 1 Biofuels, costs and greenhouse gas reductions

## 1.1 Introduction

Biofuels are an alternative for petrol and diesel produced from mineral oil. Three main arguments are generally cited in favour of their introduction:

- Reduced greenhouse gas (GHG) emissions from transport.
- Less dependence on fossil fuels.
- Support for agricultural regions.

On these three arguments biofuels are being supported by the European Commission and have been introduced in most European countries. The European Commission has set an indicative target of 5.75% biofuels for all European transport fuel in 2010. In the Netherlands this 5.75% target has been translated into an obligation for oil companies.

Today's biofuels are based on common agricultural products such as wheat, corn, sugarbeet, sugarcane, rape, soy and palm oil. As a result, there is now competition between the production of biofuels and food and there is presently widespread debate about whether biofuels are causing (at least part of) the current high food prices. FAO reports that 30% of the current rise in demand for corn is caused by biofuels (OECD/FAO, 2008). Earlier, IFPRI reported that a quarter to a third of increases in food prices are due to biofuels. Furthermore, various life cycle analyses have shown that the direct GHG reductions achieved with most of these first-generation biofuels are lower than may have been expected several years ago, with similar conclusions holding for the impact on fossil fuel dependency.

Apart from all this, there is another issue: the often indirect effects of biofuels on deforestation via food markets. Although there is still much uncertainty about the magnitude of this impact, two recent articles in *Science* indicate that it could be very severe (Searchinger, 2008; Fargione, 2008). In addition, the OECD (OECD, 2007) and JRC (JRC, 2007) have warned that it is uncertain whether current biofuels deliver any GHG reductions at all.

The EU and several of its member states have announced their intention to introduce sustainability criteria for biofuels. The Netherlands Environmental Assessment Agency (MNP, a Dutch government agency) has reviewed the criteria proposed by the European Commission (MNP, 2008) and concludes that these will not prevent loss of biodiversity and will not ensure a reduction of greenhouse gas emissions, in particular because indirect effects due to changes in land use are not included.

As a consequence, MNP recently concluded that 'Current biofuels do not add to the sustainability of transport'[1]. Many other organizations like the OECD, JRC, Friends of the Earth, Stichting Natuur en Milieu (Netherlands Society for Nature and Environment) and Greenpeace have come to the same conclusion. MNP suggests broadening the scope of the debate, thereby considering other options, too, such as bio-electricity instead of biofuels (MNP, 2008).

More innovative biofuels based on non-food sources (mainly cellulose) are currently being developed. These so-called second-generation biofuels are expected to perform better when it comes to GHG reduction. These will not be ripe for marketing in 2010, but may play an important role by 2020 (JRC, 2007). Often is suggested that first generation biofuels are necessary to develop second generation biofuels which will be produced from wood and have a better environmental performance. In the European REFUEL project (Refuel, University of Utrecht, ECN, Joanneum, IIASA, Chalmers and others) has recently been concluded for the roadmap for biofuels that first and second generation biofuels need different technologies, different resources and a different infrastructure. In this report is concluded that strong support for first generation biofuels can even hinder a quick development and implementation of second generation biofuels.

Despite the widespread debate on the sustainability of biofuels, the European Union and the Netherlands seek to triple the use of biofuels over the next three years. In 2006 biofuels accounted for around 1.8% of the transport fuel consumed in the EU (Eurobserver, 2007) and 0.3% of that used in the Netherlands. EU biofuel consumption data for 2007 are still lacking, but it is expected that the share of biofuels will be around 2.5%. In the Netherlands, the share of biofuels rose to 2.75% in 2007 (CBS Statline). This is higher than the 2% obligation for that year, but the additional sales can be compensated in the following year. The target for 2010 is still 5.75%, for the EU as a whole as well as for the Netherlands[2].

**Costs per avoided tonne of $CO_2$**

A common way of comparing environmental options is to assess the cost to society of preventing one tonne of $CO_2$ emissions using the options in question. As the following data show, biofuels are relatively expensive compared with other GHG mitigation options.

| **Option** | **Cost per ton $CO_2$ saved (Euro)** |
|---|---|
| Biofuels | 400-4,000 (OECD, 2007 and 2008) |
| Concentrated solar power | 130-300 and falling |
| Energy from waste | 60-85 |
| Wind, offshore | 60 |
| Wind, onshore | 47 |
| Savings under the ETS system | 10 to 30 |

1 http://www.mnp.nl/en/service/pressreleases/2008/20080304Currentbiofuelsdonotaddtothesustainability-oftransport.html.

2 Note that all biofuel percentages cited in this report are based on energy content.

The OECD (OECD, 2007) has already concluded that biofuels are a far more expensive way of tackling climate change than other mitigation options. Biofuels cost between 400 and 4,000 Euro per avoided tonne of $CO_2$, other options between 20 and 200 Euro. The OECD recently concluded that despite the current high oil prices, this cost per tonne avoided $CO_2$ has risen to a minimum of € 600 (OECD, 2008) (partly because of the high food prices).

## 1.2 Goal of this study

In this report a scenario is presented in which the share of biofuels is not tripled in three years, but limited to 2.5%[3] (intermediate between the 2% of 2007 and the 3.25% of 2008). The money saved by society with this lower biofuel target is spent on several other $CO_2$ mitigation and renewable energy options and invested in the development of second-generation biofuels. This figure of 2.5% is similar to the 2.8% recently recommended in the Gallagher review in the UK (Gallagher, 2008).

**The Gallagher review advises 2.8% biofuels in 2010**

In the UK the government asked the Renewable Fuels Agency to investigate the indirect effects of biofuels. This led to the Gallagher review (Gallagher, 2008), which was presented in July 2008. The review recommends changing the biofuel policies drawn up in 2003 because of the rising food prices, the accelerating deforestation and doubts about the climate benefits of biofuels. In brief, the review concludes that:

- Use of existing farmland for biofuel production must be avoided.
- Biofuels should come from marginal/idle land, wastes and residues.
- Support should be given to advanced technology.
- Sustainability criteria must be introduced.
- Biofuel production must be boosted less than currently envisaged.
- The biofuels goal for 2013/14 should be 4%.
- The biofuels goal for 2010 should be 2.8%.
- For 2020 a goal of 5-8% biofuels should be set, depending on developments vis-à-vis sustainability.

Although this study is a case study for the Netherlands, the results can be translated to the entire European Union. In the final chapter we make a first, rough attempt at such a translation

## 1.3 The cost of biofuels in the Netherlands

In the Netherlands there is an obligation for oil companies to use biofuels, with no tax cuts introduced by way of compensation. This means the biofuels programme comes at no extra cost to the government: the extra costs of biofuels are paid by petrol and diesel consumers.

[3] The use of 2.5% in this study does not mean that 2.5% biofuels is the best solution. It is chosen as a pragmatic approach keeping some support for the biofuel industry. It could be argued that from an environmental point of view a lower percentage is even better especially if sustainability criteria for biofuels are not introduced.

In 2007 biofuels had a share of 2% in sales of Dutch road transport fuels (about 340 million litres)[4]. Most of these biofuels are sold in low-percentage blends, in the standard petrol and diesel sold at the pump. We anticipate that the biofuels currently sold in the Netherlands are mainly EU biodiesel from rapeseed and Brazilian bioethanol from sugarcane. Although the production cost of Brazilian ethanol is lower than the current price of petrol, the EU imposes a substantial import tax on this ethanol. The costs to oil companies and consumers are thus comparable to or somewhat higher than the more expensive EU ethanol from crops such as wheat or sugarbeet.

The exact costs and sources/origin of biofuels (incl. distribution and blending) are not currently monitored and are dependent on negotiations with suppliers and on the specific distribution and blending situation of oil companies. However, using the prices of E85 and B100 cited on www.fuelswitch.nl and comparing these to the average petrol and diesel price in the Netherlands in 2007, we estimate the additional cost of these 340 million litres to consumers at about 150 mln Euro, part of which is import duty on the Brazilian ethanol.

In 2010 the goal of 5.75% is expected to cost Dutch consumers between 418 and 485 million Euro, depending on:
- Oil prices.
- Feedstock prices.
- Biofuel production capacity versus demand.
- Import duties.
- Opting for biodiesel versus bioethanol.

In Table 3 the cost of biofuels in the Netherlands are presented for several biofuel targets.

Table 3 Costs of biofuels for Dutch consumers

| Year | % biofuels | Extra cost to consumer per litre diesel (Eurocent/litre) | Extra cost to consumer per litre petrol (Eurocent/litre) | Annual costs |
|---|---|---|---|---|
| 2007 | 2% | 1 | 1.3 | 147 |
| 2008 | 3.25% | 1.55 (1.2-1.8) | 2.1 (1.6-2.9) | 234-258 |
| 2009 | 4.5% | 2.15 (1.43-2.57) | 2.9 (1.9-4.5) | 323-371 |
| 2010 | 5.75% | 2.75 (1.67-3.38) | 4.2 (2.2-6.1) | 418-485 |
| Alt 2009 | 2.5% | 1.2 | 1.6 | 191 |
| Alt 2010 | 2.5% | 1.2 | 1.6 | 191 |

An alternative goal of 2.5% in 2010 will cost consumers 191 million Euros. Compared to 5.75% this saves consumers 260 million Euros per year[5].

[4] Recent data show that actual sales were in fact higher, 2.75%, but we expect these additional sales of biofuels in 2007 to be used by oil companies to count towards the 2008 targets. In our calculations for 2007 we therefore use the figure of 2%.

[5] Earlier, the Dutch government estimated that the extra costs for 5.75% rather than 2.5% would be 230 million Euro (VROM, 2006). This is in line with our own estimate.

The table shows, furthermore, that in the Netherlands 5.75% biofuels will cost diesel drivers about 2.75 Eurocents per litre diesel and petrol drivers about 4.2 Eurocents per litre petrol in 2010. These costs may vary, however, as oil companies are allowed to vary the share of biodiesel and bioethanol to some extent.

***Budget for the alternative***

To make the alternative financially attractive for petrol companies as well as motorists, we propose to spend only 200 million of the 260 million Euros saved in 2010 in the Netherlands (77%); 200 million is thus the budget for alternative policy options. These funds can be collected by government by introducing an interesting buy-out tariff for petrol companies for biofuel deliveries over and above 2.5%. Earlier, the Dutch government announced it would consider such a tariff as an option (VROM, 2006) and in the UK such a system is already up and running (cf. Section 2.4)

## 1.4 GHG savings due to biofuels

In Appendix B, calculations of the GHG emissions of biofuels are provided according to three methods:

- The calculation method of the European Commission.
- The calculation method of Searchinger, which includes the impact of changes in land use (Searchinger, 2008).
- The method of the Oeko Institute, again including an estimate of the impact of land use changes (Oeko, 2008).

The European Commission's biofuel calculations are the most optimistic[6]. According to the EC, biofuels reduce the GHG effect of transport per litre biofuel by between 34 and 75%, depending on the type of biofuel. Using these figures, lowering the target from 5.75 to 2.5% would result in 0.7 Megatonne (Mt) less $CO_2$ reduction. The remaining 2,5% biofuels would save 0,8 Megatonne $CO_2$ according to the calculation method of the EC.

In the Searchinger and the Oeko Institute methods, calculations include estimates of the effect of indirect land use change on GHG emissions. The conclusion now is that all today's first-generation biofuels apart from Brazilian ethanol result in additional GHG emissions.

[6] ILUC (indirect land use change) is not addressed in the Commission's proposed renewable energy directive currently going through the legislative process, or in its greenhouse gas calculator for biofuels. Since the renewable energy proposal was published, new research suggests that the ILUC from biofuel crops is in some cases so important that the resulting biofuels in fact have larger greenhouse gas emissions than fossil fuels. See for further calculations Appendix B.

Table 4 Greenhouse gas reduction by first-generation biofuels, including impact of indirect land use changes (for details and sources see Appendix B)

| GHG reduction | Conclusions |
|---|---|
| Bioethanol (Brazil, sugarcane) | The only first-generation biofuel delivering guaranteed GHG reduction even when indirect emissions are included: net effect between 15 and 88% reduction. |
| Bioethanol, corn | No reduction and probably additional emissions when indirect emissions are included. |
| Bioethanol, wheat | Possibly a small GHG reduction but also possibly extra emissions. |
| Biodiesel, rapeseed oil | Extra GHG emissions of between 35 and 200% if indirect effects are included. |
| Biodiesel, palm oil | Probably (large) extra GHG emissions if indirect effects are included. |
| Biodiesel, soy oil | Probably (large) extra GHG emissions if indirect effects are included. |

**What is the 'indirect land use change' effect?**
This best illustrated with an example. If we replace fossil fuel with biodiesel from rapeseed produced in Germany, there will be no direct change in land use, for the rapeseed is grown on existing farmland. Until recently, however, European margarine producers used this rapeseed for margarine. As demand for margarine is unaffected by the increased demand for biofuels, margarine producers now have to revert to other sources of vegetable oil, such as palm oil from Indonesia. This therefore leads to increased demand for palm oil, which may be produced on land that was formerly tropical forest. In this way biodiesel produced in Europe can lead indirectly to deforestation elsewhere. This so-called indirect land use change, or ILUC, may lead to loss of biodiversity and to very significant GHG emissions[7].

### No GHG reduction in studies including indirect land use change effects

GHG calculations that seek to include ILUC effects indicate there is only a small probability of biofuels leading to a net reduction in GHG emissions, and a large risk of emissions actually increasing. For the Netherlands the estimated range is from –11 to +120%. This is for the mix of Brazilian ethanol, which does deliver a GHG reduction (also if ILUC is included) and biodiesel from edible oil, which leads to extra GHG emissions if ILUC is included.

The situation is even worse for Europe as a whole, because less Brazilian ethanol is used than in the Netherlands. With ILUC effects included, the net GHG reduction is then likely to be negative. In other words, existing studies that include ILUC conclude that the European biofuels programme leads to no savings on GHG emissions.

### Conclusion for this project

This study is not a comprehensive study of GHG emissions and land use. Consequently, we conclude that the general opinion supported by the EC is that a biofuel target of 2.5% rather than 5.75% would result in 0.6 to 0.8 Mt less GHG emission reduction. We reiterate, though, that new studies which include the effects of indirect land use changes cast doubt on these figures, with the conclusion being that lowering the biofuel target may even be good for GHG emissions.

[7] Uncultivated land such as rainforest, but also grassland, can contain significant amounts of carbon in its vegetation and soil. When it is converted to farmland this carbon may be released as greenhouse gases.

## 1.5 Land use

The Dutch goal of 5.75% implies a need for about 23 PJ of biofuels in 2010 (734 PJ for the European Union as a whole). The area of productive land required for this purpose depends very much on the crops used as feedstocks for these biofuels, as there is substantial variation in yields in terms of GJ per ha; see Table 5.

Table 5 Yields of biofuels per ha and ha needed for Dutch biofuel target

| Crop | Yield (GJ/ha) | Required area with this crop to meet full Dutch target of 5.75% (23 PJ) | Percentage of Dutch agricultural land (2 mln ha) |
|---|---|---|---|
| Palm oil | 157 | 146,000 ha | 7% |
| Sugarcane | 122 | 188,000 ha | 9% |
| Sugarbeet | 105 | 219,000 ha | 9% |
| Jatropha | 63 | 365,000 ha | 18% |
| Corn | 63 | 365,000 ha | 18% |
| Wheat | 52 | 442,000 ha | 22% |
| Rapeseed | 38 | 605,000 ha | 30% |
| Soybean | 17 | 1,352,000 ha | 67% |

Source: Fresco, 2006.

The Netherlands has around 2 million hectares of agricultural land. Depending on the crop, between 7 and 67% of this area will be necessary, worldwide, to meet demand for biofuels in the Netherlands. If the crop mix in 2010 is the same as assumed for 2007 (mainly sugarcane and rapeseed and 60% diesel in the fuel mix) worldwide an area equivalent to 22% (440,000 ha) of Dutch farmland will be used to deliver 5.75% biofuels. A target of 2.5 instead of 5.75% would thus reduce this land claim by 250,000 ha.

**Biofuel land claims compared with solar power**

Biofuels require far greater areas of fertile land than is the case for other types of renewable energy. WUR (WUR, 2008), for example, have compared the land use requirements of biofuels with those of solar power and conclude that solar panels with 18% efficiency (the cheap systems) produce 50 times more energy per acre than the second-generation option of cellulosic ethanol produced from switchgrass. N&M (2008) calculate that acre for acre solar power (PV or CSP) delivers a 300 times greater reduction in GHG emissions than sugarcane ethanol and 3,000 times more per acre than biodiesel from rapeseed.

Figure 1 Acre for acre, concentrated solar power reduces GHG emissions by 300 to 3,000 more than biofuels

# 2 An alternative to 5.75% biofuels

## 2.1 Introduction

The alternative approach for 2010 consists of the following elements:
- A target of 2.5% biofuels for 2010 instead of 5.75%.
- Selection criteria and budget for alternative measures (Section 2.2).
- An alternative plan of other additional measures to cut GHG emissions (Section 2.3).
- A scheme for funding the alternative policies with the cost savings induced by the lower biofuels target (Section 2.4).

## 2.2 Criteria for selection of alternative measures

The following criteria were used to select alternative measures:
- Additional measures should be truly additional to current environmental policies.
- Focus on renewable energy and options supporting the transition to sustainable energy systems.
- No relatively cheap options likely to be introduced under existing policy arrangements such as the European emissions trading scheme (ETS).
- No controversial options like carbon capture and underground storage.
- Options than can be implemented between 2009 and 2012.
- Support for innovation.

**Budget for alternative measures**
Lowering the biofuel target for 2010 saves Dutch society about 260 million Euro per year (cf. Section 1.3). With the aid of an interesting buy-out tariff for petrol producers (cf. Section 2.4) we assume that around 77% of these funds can be collected by the government and used to finance the alternative policies presented here. This implies an annual budget of 200 million Euro in 2010. Of the money saved, 23% is direct profit for fuel consumers in the form of lower prices for petrol and diesel (around 0.5 Eurocent per litre).

## 2.3 The Dutch alternative

There are probably dozens of alternative policy options that could be financed with this budget. In designing our ‘alternative’ for the present study, we first drew up a rough selection comprising a manageable number of options and then made a final selection using the criteria listed above. In Appendix A this range of possible alternative GHG abatement options is described and assessed. From this list a policy package was deduced, presented here as the alternative package. There is obviously scope for altering this selection and we would certainly recommend a more detailed assessment before any decisions are made, but the package presented here is considered to be a realistic example of what could be done in the coming years.

The options selected are:

- More efficient vehicle air conditioning systems and tyres, electric vehicles and woody biomass for refineries serving the transport sector.
- Woody biomass, offshore wind and CSP in the electricity sector.
- Investments in research into blue energy (energy from mixing fresh and salt water) and second-generation biofuels.

Table 6 The options in the Dutch alternative (200 mln Euro per year)

| Option | Budget (mln Euro) | Cost (€/tonne $CO_2$) | GHG reduction (Mt) |
|---|---|---|---|
| 1 More efficient air conditioning and tyres | n.a. | n.a. | 0.25 |
| 2 Electric vehicles | 20 | 200 | 0.1 |
| 3 Woody biomass as refinery energy source | 50 | 135 | 0.4 |
| 4 Woody biomass in coal-fired power plants | 20 | 67 | 0.3 |
| 5 Offshore wind power | 60 | 60 | 1.0 |
| 6 Research on blue energy | 10 | n.a. | n.a. |
| 7 CSP, Morocco | 20 | 200 | 0.1 |
| 8 Research on second-generation biofuels | 20 | n.a. | n.a. |
| Total | 200 | | 2.15 Mt[8] |

Compared with current biofuels, the proposed alternative results in more GHG reduction, more investment in sustainable technologies for the future and less environmental risks.

## 2.4 Introducing the alternative in the Netherlands

This section describes how the alternative could be introduced in the Dutch policy process.

Current Dutch biofuel policies are based mainly on the of the Environment ministry's 'Biofuels Policy letter' of 15 March 2006 (VROM, 2006), the following elements of which are important for introduction of the proposed alternative:

- The Netherlands and other EU member states are not obliged by European law to use 5.75% biofuels in 2010. This a policy goal but not an obligation.
- 2% biofuels on the Dutch market means 3 mln hectolitres, 5.75% 9 mln hl.
- The letter mentions that 2% biofuels would reduce GHG emissions by 0.7 Mton and 5.75% by 2.1 Mton, and states that this is a very important reason for the policies. This figure presented by the Dutch government is calculated on the assumption that biofuels are completely carbon-neutral, even though it was well known at the time that the GHG emissions of biofuels may be significant. With the EC figures this GHG emission reduction is in fact at most 0.7 Mt.

[8] Some of these options affect the sectors participating in the EU GHG Emissions Trading Scheme (ETS). Government support for these options, which would not otherwise be used, makes it easier for the refinery and energy sectors to meet the ETS target. The targets for these sectors can consequently be lowered by the amount of GHG reduction delivered in these sectors by the alternative.

- The letter mentions that a 5.75% target would cost 230 million Euro more than current policies. (This is in line with our calculations of cost differences between 2.5% and 5.75% biofuels).
- The letter announces a Government Order (in Dutch, *AMVB*) obliging oil companies to sell biofuels to consumers.
- The letter announces that between 6 and 12 months after the obligation *AMVB* a second phase will be introduced, including stimulation of innovation and guarantees vis-à-vis sustainability. However, 18 months after the start of the obligation and 2 years after the first *AMVB* this second phase has still not materialized (apart from a subsidy programme for innovative biofuels), nor is not foreseen for the coming months.
- Not meeting the target is an economic offence.
- The government announced that it would give consideration to a buy-out option, as a means of preventing unforeseen problems. Under such an option an oil company would be able to choose not to comply with the obligation (for example, not to deliver 5.75% biofuels in 2010), but rather pay a 'buy-out' tariff to the government. This buy-out option is often used in obligation schemes for renewable energy to prevent excessively high costs to consumers in the event of unforeseen shortages or prices rises.

Although the Dutch government has not as yet introduced a buy-out option, neither has it stated it does intend to do so. A rather simple way of introducing the alternative is therefore to introduce an interesting buy-out tariff for biofuels over and above 2.5%. The official goal will stay 5.75% but because of this buy-out system in practice 2.5% biofuels will be used.

We estimated in section 1.3 that the alternative would save the consumers (and thus oil companies) about 260 mln Euro per year. A buy-out tariff which raises 200 mln Euro can then be expected[9] to be interesting enough for oil companies to opt for the buy-out option (15% cheaper than use of biofuels). This 200 mln Euro can be used to finance the alternative.

This 200 mln Euro means a buy-out tariff of 0.4 Euro per litre biofuel[10]. This is lower than the tariff of 0.44 Euro in the UK which is intended to force companies to meet the target. This buy-out price could be adjusted annually according to energy prices (of both fossil fuels and biofuels).

[9] The exact necessary discount rate for oil companies can later be further investigated.

[10] 200 mln Euro divided by 9 mln hl (5.75) minus 4 mln hl = 40 Euro per hl = 0.40 Euro per litre biofuel.

This would be in line with the aforementioned Dutch 'Biofuels policy letter' of 2006, from which a number of reasons can be deduced for introducing a buy-out option to finance an alternative option:

- The GHG reduction achieved under the Dutch biofuel programme will be much lower than stated in the letter (by 50 to 100%). Calculations that including the effect of indirect land use change expect no GHG reduction by biofuels in 2010 at all. Institutes like the OECD and JRC have clearly expressed their concerns.
- The government has still not introduced the sustainability guarantees for biofuels announced earlier to follow 6-12 months after the obligation.
- Much evidence has been put forward by NGOs and scientists that first-generation biofuels deliver meagre GHG reductions, use food crops and thus increase food prices, and create a risk of deforestation.
- The government has announced its willingness to consider a buy-out option.

**The UK situation**

In the UK the government has already introduced a buy-out option in the Renewable Transport Fuel Obligation (RTFO)[11]. In Chapter 5 of the 'Discharge of the obligation' this has been described (RTFO, 2007). We asked the RFA for the exact buy-out price.

*Response by the RFA (May 2008*): *The RTFO requires suppliers of road transport fossil fuel in excess of 450,000 litres in any obligation period (one year starting 15th April) that 2.5641% of the fossil fuel volume in excess of 450,000 should be made up of renewable fuel. They can do this by doing one or more of:*

*a Sell the appropriate volume of renewable fuel for each litre of which an RTF Certificate is awarded.*
*b Purchase the appropriate number of RTF Certificates from another company;*
*c Pay a 'buy-out' price for each litre.*
*d The buy-out price for the first two years (2008-9 and 2009-10) is 15p (35p minus duty incentive of 20p) and then 30p from 2010-11 when the duty incentive comes to an end.*

Because in the Netherlands there is no duty incentive (in the UK for every litre of biofuels 20 pence less duty is imposed) the buy-out price for 2008-2010 can be compared with the situation in the UK without duty incentive. This makes the net buy out prices 35 pence, which equals 44 Eurocents[12]. This UK buy-out price is intended to encourage oil companies to meet the target[13].

[11] http://www.opsi.gov.uk/si/si2007/pdf/uksi_20073072_en.pdf.
[12] 1 pound sterling equals € 1.26 (as of 4 June 2008).
[13] Our calculations indicate that with this buy-out price it could already be interesting for companies in the UK to use this option.

**Conclusion on introducing the alternative in the Netherlands**
A buy-out tariff of around 0.4 Euro per litre biofuel for not meeting the target between 2.5 and 5.75% is a fairly simple and effective way of ensuring that around 2.5% biofuels will be used and that funds will be generated for financing alternative measures instead.

This is in line with the 'Biofuels policy letter' published by the Dutch government in 2006. If the funds are then used to finance more cost-effective alternative GHG policies, as presented in the previous section, it will lead to more GHG emission reduction, at lower cost.

## 2.5 The alternative in the European context

In this section the Dutch alternative is transposed to the European level. This means much larger numbers and many more options. In this project it was not possible to bring together all the potential European policy options on GHG reduction and make a full assessment of their effects and costs. We therefore focused on a selection from among these options, based on our own experience and knowledge. These included:

- Offshore wind in northern Europe.
- Concentrated solar power (CSP) in southern Europe and North Africa.
- Energy from waste.

In addition, some of the other options included in the alternative package for the Netherlands are also feasible at the European level (energy-efficient vehicle aircons and tyres, woody biomass). It should be stressed that many more options are available in practice and that the package considered here serves merely as an illustration.

**How much biofuels in the EU in 2010?**
Assuming 50% bioethanol and 50% biodiesel (on energy basis), about 280 Million hl biofuels will be needed in the EU-27 in 2010 if the target of 5.75% is to be met. This is 31 times Dutch consumption (for calculations, see Appendix D).

**GHG reduction in EU-27 excluding indirect effects**
According to the GHG emission reduction figures provided in the proposal of the European Commission, these biofuels will probably save between 19 and 25 Mt $CO_2$ emissions (31 times 0.6-0.8 Mt)[14].

**GHG reduction in EU-27 including indirect effects**
If indirect effects are included, the GHG savings will be far less, as shown in section 1.4. All GHG calculations that include indirect land use change effects indicate there is a major risk of biofuels actually causing extra emissions relative to the fossil fuels they replace. Only in the case of Brazilian ethanol is a certain GHG reduction fairly well guaranteed. For the Netherlands the average range

[14] This is a very rough indication and probably quite optimistic, as the EU biofuels feedstock mix differs from that of the Netherlands.

(biodiesel and bioethanol included) is minus 11% to plus 120%. For Europe as a whole this range differs, because on the one hand the share of Brazilian bioethanol will be lower in the EU than in the Netherlands (which reduces GHG savings), but on the other hand the share of diesel in the fuel is also lower (53% rather than 63%, increasing GHG savings). Because of these two opposing effects, we assume in the following that the overall effect on emissions will be similar to that in the Netherlands.

*Studies including indirect effects conclude less biofuels = less GHG emissions*
Our rough calculations show that this means that 2.5% rather than 5.75 biofuels can at best save 31x1.4=43 Mt emissions or at worst could result in 31x0.2=6 Mt extra GHG emissions. On average, this lower amount of biofuels saves 31x0.6=19 Mt $CO_2$ emissions.

**Budget for the European alternative**
In all countries with a biofuels obligation, consideration might be given to introducing a buy-out tariff for biofuels over and above 2.5%. In countries with tax exemptions or a tender system, the level of exemptions or tenders can be reduced. In this way in all European countries funds could be generated for financing alternative options. On the basis of our rough calculations, the total funds raised could probably also be 31 times the Dutch budget, i.e. about 6.2 billion Euro.

**The European alternative**
Table 7 summarizes one possible alternative policy package for Europe. This leads to major investments in wind and solar and energy from waste, some GHG reduction in the transport sector and investments in R&D on second-generation biofuels.

Table 7 The options in the European alternative (5.6 billion Euro)

| Option | Budget (mln Euro) | Cost (€/tonne $CO_2$) | GHG reduction (Mt) |
|---|---|---|---|
| 1 Car options | n.a. | | |
| - energy-efficient air conditioning | | | 1 |
| - low-resistance tyres | | | 1 |
| 2 Electric vehicles | 500 | 200 | 2.5 |
| 3 Woody biomass in coal-fired power plants | 700 | 67 | 10.5 |
| 4 Offshore wind power | 1,000 | 60 | 16 |
| 5 Energy from waste | 1,000 | 60-85 | 14 |
| 6 CSP, North Africa | 2,000 | 200 | 10 |
| 7 Research on second-generation biofuels | 1,000 | | |
| Total | 6,200 | | 55 Mt |

As in the Netherlands, the funding for this alternative programme could be generated by means of a buy-out tariff for the biofuels obligations over and above 2.5% biofuels, or via less money for tenders or tax exemptions.

With this alternative, twice the GHG reduction is achieved compared with the figure calculated by the EC without indirect land use effects being included (55 Mt versus 19-25 Mt). Furthermore, the alternative results in less competition with food, less deforestation and more innovation.

# 3 Results and conclusions

An alternative programme with a biofuel target of 2.5% instead of 5.75% for the Netherlands is possible by introducing an interesting buy-out tariff for oil companies, valid over and above 2.5%. The funds thus generated can be used to finance alternative policy measures such as investments in development of second-generation biofuels. In this chapter we compare the alternative with the situation for a target of 5.75% biofuels.

The Dutch alternative proposed here thus assumes a share of 2.5% biofuels, in combination with the following elements (Table 8).

Table 8 The options in the Dutch alternative (200 mln Euro per year)

| Option | Budget (mln Euro) | Cost (€/tonne $CO_2$) | GHG reduction (Mt) |
|---|---|---|---|
| 1 More efficient air conditioning and tyres | n.a. | n.a. | 0.25 |
| 2 Electric vehicles | 20 | 200 | 0.1 |
| 3 Woody biomass as refinery energy source | 50 | 135 | 0.4 |
| 4 Woody biomass in coal-fired power plants | 20 | 67 | 0.3 |
| 5 Offshore wind power | 60 | 60 | 1.0 |
| 6 Research on blue energy | 10 | n.a. | n.a. |
| 7 CSP, Morocco | 20 | 200 | 0.1 |
| 8 Research on second-generation biofuels | 20 | n.a. | n.a. |
| Total | 200 | | 2.15 Mt[15] |

To compare the alternative with the 5.75% biofuels target, we took 2.5% biofuels as the reference, as both options have this included. The results of this comparison are shown in Table 9.

[15] Some of these options affect the sectors participating in the EU GHG Emissions Trading Scheme (ETS). Government support for these options, which would not otherwise be used, makes it easier for the refinery and energy sectors to meet the ETS target. The targets for these sectors can consequently be lowered by the amount of GHG reduction delivered in these sectors by the alternative.

Table 9 Comparison of 5.75% biofuels in 2010 with the alternative for the Netherlands (reference: 2.5% biofuels)

| | 5.75% biofuels | 2.5% biofuels + alternative |
|---|---|---|
| Annual cost to consumers | 260 million Euro | 200 million Euro |
| GHG reduction/year | Between 0.8 Mt reduction and 2.4 Mt extra emission | 2.15 Mt reduction |
| Use of arable land | --<br>250,000 ha worldwide (=12.5% of Dutch farmland) | ++<br>No extra arable land use |
| Energy security | + | + |
| Supporting agriculture | + | +/- (lower volume of biofuels) |
| Innovation | - (only first–generation biofuels) | + |
| Risk of deforestation | -- | ++ |
| Competition with food crops | -- | ++ |
| Stimulating innovative bio-options | - | + (money for bio-power and second-generation biofuels) |

Introducing a buy-out scheme (announced earlier by the Dutch government as an option in 2006) with a buy-out price of around 0.4 Eurocent per litre for all biofuel over and above 2.5% is anticipated to lead to oil companies opting for this buy-out option. The alternative measures can be financed with the funds thus generated. This buy-out price should be adjusted annually according to fossil fuel and biofuel prices.

To a considerable extent the alternative consists of power from woody biomass, both in refineries and in the power sector. A further 10% of the alternative is investment in second-generation biofuels. The alternative is thus also in line with the European biofuel directive, which gives member states scope for investing in other bio-options if they can present good reasons for doing so.

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# An alternative to 5.75% biofuels in 2010

## More sustainability at lower cost?

Annexes

**Report**

**Delft, September 2008**

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# A Alternative options for biofuels

## A.1 Introduction

In this appendix, we present a number of potential alternatives for biofuels. These can be divided into three categories:
- Alternative solutions in the Netherlands related to transport.
- Alternative solutions in the Netherlands not related to transport.
- Alternative solutions outside the Netherlands.

The following criteria were used to select alternative measures:
- Measures additional to current environmental policies.
- Focus on renewable energy and options supporting the transition to sustainable energy systems.
- No cheap options likely to be triggered by instruments like the EU emissions trading scheme (ETS).
- No controversial options like carbon capture and underground storage.
- Options that can implemented between 2009 and 2012.
- Support for innovation.

## A.2 Netherlands, transport-related (non-ETS)

**Woody biomass as a refinery energy feedstock**

Refineries use both fuel oil and natural gas to supply the energy needed for the refining process. Fuel oil is a by-product of the refining process and has a fairly low market value. Natural gas, on the other hand, is bought on the market. Instead of using woody biomass to make bio-petrol and bio-diesel, it is energetically more efficient to use this woody biomass to supply the energy needed for the refining process. For this biomass option woody biomass can be used which does not compete directly with food and which has a better GHG performance and is also accepted by NGOs as a sustainable source (SNM, 2008). This biomass would replace fuel oil or natural gas (most likely natural gas, as this is bought on the market, and not a by-product of the refining process). Previous research (CE, 2003) has shown that approximately 20 PJ of fuel oil or natural gas could be replaced by woody biomass. In the case of natural gas, this would be equal to 0.7 to 1.1 Mt $CO_2$[16].

The costs for this options are estimated as 135€/tonne $CO_2$. This is a conservative assumption. This is twice the price for woody biomass in coal-fired power plants, because in this case the woody biomass replaces natural gas.

[16] Assuming that FSC wood residue is used for the energy supply. Other types of biomass would lead to different numbers.

**Low-emission air conditioning in cars**

The general emissions of passenger cars are regulated at the European level (target: 120 gram/km). However, this goal does not include extra vehicle appliances such as chair heating and air conditioning systems. Aircons are common in new cars and lead to substantial extra emissions. Supporting the use of economic aircons in new cars saves an extra amount of $CO_2$ over and above current policies. This can be regulated by subsidizing high-efficiency aircons or by introducing minimum standards for the efficiency of these units in new cars.

Although policy to address these extra aircon-related emissions is already under development, there is scope for additional measures. A lower vehicle purchase tax on new cars fitted with efficient aircons and/or an additional tax on vehicles with an inefficient system could be effective in this respect. TNO (TNO, 2006) has done the calculations and concludes that for the EU-15, there is a potential of 0.5 Mt/year savings in 2010/2011, rising to 1.35 Mt/year in 2015 and 2.5 Mt/year in 2020. With current oil prices, abatement costs are negative[17]. Considering that the Netherlands is responsible for about 3.6% of car use in the EU-15 (Eurostat), the reduction potential for the Netherlands would be 0.02 Mt/y in 2011, increasing to 0.05 in 2015 and 0.09 Mt in 2020.

**Low-emission tyres for cars**

Another option to reduce car emissions would be to use energy-saving tyres instead of standard tyres. This would lead to about 3% less fuel consumption. Policy to stimulate energy-saving tyres is currently being developed, but again there is scope for additional measures. A lower vehicle purchase tax on cars fitted with efficient tyres and/or an additional tax for non-efficient tyres could encourage such introduction. Estimates are that emissions reduction would be 6 Mt/y from 2015 onwards for the EU-15, or 0.2 Mt for the Netherlands alone.

**Small electric buses in inner cities**

Although there is plenty of debate on electrically powered vehicles, most options are fairly long-term. One option that is immediately available is use of medium-sized (32 persons, flat-floor) electric buses in the centres of old cities. The company Spijkstaal (www.spijkstaal.nl) has sold several such buses to cities in Italy as well as to Rotterdam in the Netherlands. It is ideal for cities with year-round tourism such as Amsterdam, Volendam or Delft.

[17] TNO used an oil price of $73.8/barrel.

This 6-metre bus (costing 180,000 Euro, including one battery pack), which can transport 32 people including one disabled person, has a low flat floor. It is not easy to compare with other options. A Mercedes Sprinter (100,000 Euro) can transport 20 people but has no low flat floor. Conventional buses (250,000-300,000 Euro) are larger (12 metres) and can transport 80 people, but are too large for old cities.

Spijkstaal reports the following data:
- Max speed: 40 km/h.
- Action radius: 80 km (or 120 km with more expensive Lion battery).
- $CO_2$ emission: 160 gram/km (electricity) = 8 gr/pkm compared with 60 gr/pkm for normal diesel buses (Connexxion).
- 50,000 km/year in Italy, in 25-person buses for tourism (first sales in 2001).
- 16,000 km in Rotterdam, in 20-person buses for commuters.
- Recharging for 80 km costs 5 Euro (50 kWhe).
- Battery can be changed in minutes (1,500 kg).
- Low maintenance costs.
- Designed to operate 400,000 to 500,000 km.
- Extra investment: 50,000 to 80,000 Euro.

In Rotterdam the project has been subsidized by the municipality, the EU and the Port of Rotterdam (25,000 Euro each; total: 75,000 Euro).

Calculating on the basis of the Italian situation and assuming 8 years (400,000 km) the annual figures will be:
- Extra costs: 9,375 Euro per year, excluding lower maintenance costs.
- Distance: 50,000 km per year.
- $CO_2$ savings: 1,200 gram (160x60/8) – 160 gram/kg = 1 kg /km.
- $CO_2$ savings: 50,000 kg = 50 tonne.
- $CO_2$ costs per tonne: 190 Euro.

Not included are lower noise levels and no direct air pollution.
Source: (Mr. Heiboer Spijkstaal and www.spijkstaal.nl).

Introducing 1,000 such electric buses in the Netherlands would cost 10 million Euro (500x10,000) a year and save 50 kt $CO_2$ a year. In practice, other electric vehicles could also be included in such a programme to promote electrically powered transport.

## A.3 Netherlands, non-transport related

### Co-firing of woody biomass in coal-fired power plants

Woody biomass could replace part of the coal burnt in power plants. The potential $CO_2$ savings of this option are approximately 0.6-1.7 Mt (ECN, 2006). However, the costs of burning woody biomass are higher than those of burning coal: the uneconomic top is around 66-68 €/tonne $CO_2$ (ECN, 2006).

**Onshore wind power (via current 'SDE' scheme)**
In the Netherlands several types of sustainable energy generation are currently subsidized under the so-called 'SDE' scheme: land-based wind power, small-scale PV, biomass, waste incineration and green gas. The amount of subsidy depends on the uneconomic top of the technology: the subsidy for land-based wind power is 2.8 Eurocent/kWh, (SenterNovem, 2008). This amounts to a price of 47 €/tonne $CO_2$ for land-based wind power. As the SDE budget will be spent before the closing date, increasing this budget will lead to greater $CO_2$ reductions.

**Large scale offshore wind power**
Apart from land-based wind energy, offshore wind power also has major potential. According to ECN (ECN, 2006), 7.7 to 10 Mt of $CO_2$ emissions could be prevented by generating electricity in large-scale offshore wind farms. Total costs would range from 465 to 605 million Euro, equivalent to 60 Euro/tonne $CO_2$. Other studies (Ecofys, 2005) estimate the societal benefits of 6,000 MW offshore wind power in 2020 to be in the range of 180 to 5,260 million Euro[18].

Despite these benefits to society, however, large scale off-shore wind energy would need government support to compensate for the uneconomic top of approximately € 0.05/kWh (€ 85/ton $CO_2$).

**Blue energy**
Blue energy refers to electricity generated by mixing salt and fresh water through a membrane. According to Redstack (REDstack, 2006), the potential is large: instalkling so-called RED technology along the length of the 'Afsluitdijk' enclosing dam could generate 200 MW, while the total capacity for the Netherlands as a whole is 3,000 MW. Assuming this energy replaces fossil electricity, fitting out the Afsluitdijk in this way would save 1 Mt $CO_2$[19], and the full potential for the whole of the Netherlands would be 15 Mt/y. Costs are currently high, but are expected to decrease sharply in the future: in 2005, costs were 1.40 €/kWh, but a better performance of the RED technology should lead to a price 0.14 €/kWh between 2005 and 2010, while lower membrane prices could decrease prices to 0.05 €/kWh after 2010, which is competitive with fossil fuels.

[18] The lower estimate is based on a 'Global economy' scenario with a low oil price ($ 45/barrel) and small learning effects, the upper estimate on a 'Strong Europe' scenario with a 'high' oil price ($ 65/barrel) with large learning effects. The current oil price of $ 125/barrel would lead to an even higher estimate of societal benefits.

[19] 200 MW means 24*365*200=1,752,000 MWh per year. Assuming a $CO_2$ emission of 0.6 kg $CO_2$/kWh, this results in 1 Mt $CO_2$/year.

## A.4 Outside the Netherlands

### Municipal waste incinerators

In the Netherlands most of the municipal waste is burned in incinerators, while in many other EU countries it is landfilled. The potential emission reduction for the EU-15 has been estimated at over 80 Mt/year (Gemeente Amsterdam, Afval Energie Bedrijf). Other sources (SenterNovem, 2006) estimate the reduction potential at 45 to 113 Mt/year. Costs are estimated at 60 to 85 €/tonne $CO_2$. This reduction is due partly to municipal waste replacing fossil fuels in power stations and partly to the avoidance of the methane emissions associated with landfilling of municipal waste.

### Concentrated solar power

Concentrated Solar Power (CSP) is the technique used in solar thermal power stations. In this kind of power station the rays of the sun are concentrated by an array of mirrors onto the boiler of a conventional power plant. This produces high-pressure steam, which drives a steam turbine connected to an electric generator. The costs of this technology depend on the location: in places like California, with fairly intense solar irradiation, costs are 0.12-0.14 €/kWh (Gezen, 2008), while in southern Spain and other locations with lower levels of insolation they are around 0.22 €/kWh. This means the costs of $CO_2$ reduction are in the range of 130 to 300 Euro/tonne $CO_2$. CSP is at the beginning of its learning curve, however, and costs are expected to decline in the coming years. In North Africa the costs are estimated at around 200 Euro/tonne $CO_2$.

The efficiency of CSP is around 18%. This means that saving a tonne of GHG emissions using CSP requires 300 times less acreage than bioethanol from sugarcane (the best biofuel) and 3,000 times less than biodiesel from rapeseed. Additional advantages are that a CSP station does not need to be sited on fertile soil and that the waste heat from the station can be used to produce fresh water.

DLR has described a concrete scenario for introducing CSP in Europe with the support of North African countries (DLR, 2007).

Table 10 Summary of potential options for the alternative

| | Capacity (Mt) | Costs (€/tonne $CO_2$) | Short, medium or long term? |
|---|---|---|---|
| More efficient air conditioning in cars | 0.05 | | medium |
| More efficient tyres | 0.2 | | medium |
| Electric vehicles | 0.025 to ?? | 200 | short/medium |
| Woody biomass as refinery energy source | 0.7-1.1 | | short |
| Co-firing of woody biomass in coal-fired power plants | 0.6-1.7 | 66-68 | short |
| Land-based wind power | | 47 | short |
| Large scale offshore wind power | 7.7-10 | 60 | short/medium |
| Blue energy | up to 15 | 2,000 (current) – 0 (future) | long |
| Energy from waste EU | 80 | 60-85 | short |
| CSP | Very substantial | 130-300 | medium/long |

## A.5 Other options which might also be considered

The list of options in this appendix is not complete and is provided merely by way of illustration. There are obviously many other options worthy of (further) stimulation. For some of these, (weak) incentives are indeed in preparation. Greater encouragement might be considered for:

- Solar domestic heating.
- CHP for industry.
- Waste heat distribution.
- Extra insulation for buildings
- Climate-neutral housing.
- Aluminium recycling.
- Methane emission reduction in dairy farming.

**Aluminium recycling**

The aluminium manufacturing process requires large amounts of energy and more recycling of aluminium could therefore lead to considerable energy savings. Estimates by ECN (ECN, 2006) show that the potential $CO_2$ reduction is between 0.8 and 3.1 Mt $CO_2$, at a price ranging from -40 to -33 €/tonne (the minus sign indicating that the costs are negative, i.e. that it is cheaper to recycle aluminium than not to do so). As a first step in realizing these emission cuts, the government could introduce a programme to make companies aware of these economic GHG reductions.

**Methane reduction in dairy farming**

The digestive processes of dairy and other cows produce methane. Methane emissions from cattle have been estimated at 125 kg of methane per cow per year. Given that there are around 1.4 million cows in the Netherlands (CBS data) and that the Global Warming Potential of methane is 23 times higher than that of $CO_2$, this means greenhouse gas emissions of about 4 Mt $CO_2$-eq. a year. Other estimates (CLM, 2007) cite an emission of 6 Mt/year. These methane emissions depend on what the animals eat, however, and shifting to a different diet might reduce the climate impact of dairy farming (CLM, 2007). Reducing cows' methane emissions by 5% would lead to a reduction of 0.2 to 0.3 Mt $CO_2$-eq./year[20].

Other options to reduce GHG emissions would be to reduce the percentage of nitrogen in cow manure, again by means of a shift to a different diet, or by prolonging cows' productive lifetime (CLM, 2007).

[20] Unfortunately, a cost estimate is not available.

# B Greenhouse gas reduction of biofuels

**Calculation of GHG savings in 2007 and 2010 according to the EC method**
We base our optimistic estimate of GHG savings on the assumption that in the Netherlands the biodiesel target will be met with biodiesel produced from rapeseed oil and with bioethanol (via ETBE) produced from wheat/corn (10-30%) and sugarcane (70-90%). Using the GHG reduction figures of the European Commission (allocation by energy value, and with no inclusion of indirect land use change effects), this results in a annual emission reduction of 0.34 to 0.49 Mt $CO_2$ in 2007, and 1.0 to 1.4 Mt $CO_2$ in 2010. Using the same figures, a target of 2.5% would result in 0.43 to 0.61 Mt $CO_2$ reduction.

Calculating with the EC figures, lowering the goal from 5.75% to 2.5% would result in 0.6 to 0.8 Mt less $CO_2$ reduction.

To compensate for this using the 180 mln Euro funds calculated in the main report, the (average) cost of the alternative measures need to be lower than 225 Euro per tonne of $CO_2$ avoided.

**Alternative views on the GHG reduction of biofuels**
The figures presented by the European Commission are generally considered to be optimistic. In reality, the net GHG reduction achieved with the biofuels in question will probably be lower, for the following reasons:

- The GHG allocation method (allocation to by-products with energy value) used by the EC is simple, but results in higher GHG reductions than when substitution is used (which is generally considered to be more realistic and accurate)
- Indirect land use changes (ILUC) due to biofuels are not been taken into account in the EC's calculations, but are a serious issue, as demonstrated in a range of recent publications (incl. OECD, 2007; JRC, 2007, Gallagher, 2008). Earlier, the German Oeko Institute proposed a risk methodology (the Risk Adder approach) for predicting the GHG effect associated with the risk of deforestation due to indirect land use changes.

Both the effects of the indirect land use change calculated with the Risk Adder approach and the effects of allocation by energy value or substitution are summarized in Table 11.

Table 11 Greenhouse gas reduction of biofuels without en with indirect land use change

| % GHG reduction | (EC, 2008) allocation by energy value | (EC, 2008) allocation by subsititution (policy pref) | (Searchinger, 2008) (incl. land use change spread over 20 years acc IPCC) | (OEKO, 2008) including ILUC low estimate | (OEKO, 2008) including ILUC high estimate |
|---|---|---|---|---|---|
| Bioethanol (Brazilië, sugarcane) | 74% | 88% | 15% | 59% | 44% |
| Bioethanol corn | 56% | 34% | -140 to -365% | 16% | -50% |
| Bioethanol wheat | 45% | 20% | | 11% | -67% |
| Biodiesel rape | 44% | 34% | | -35% | -200% |
| Biodiesel palm oil | 32% | 37% | - 330 to – 2000% | 48% | 3% |
| Biodiesel soy oil | | | -85 to -1495% | 41% | -17% |

** A positive figure means a reduction compared with fossil fuels and minus figures means extra emissions.

In the table various estimates of GHG reduction by first generation biofuels are presented: the EC JRC figures (allocation by energy and by substitution), the figures presented by Searchinger in Science including indirect land use change effects and draft figures of the German Oeko-institute. The land use change of Searchinger have been spread over 20 years. This timeframe has been recommended by the UK, NL, Germany and the EC for biofuel GHG calculations. The indirect land use change of Searchinger seems more specific than the German calculation.

From the table it can be concluded that only bio-ethanol from sugarcane results in a reliable GHG reduction. The amount of GHG reduction by biofuels from sugarcane is being debated and lies between 15 and 88% reduction. The other biofuels do not necessarily lead to GHG reductions, which is mostly caused by indirect land use change effects. For all other first generation crop biofuels it is very unclear if they deliver an actual GHG reduction and there is a risk that they worsen the climate problem substantial.

In Table 12 we summarize the general impression.

Table 12 Greenhouse gas reduction by the most important first generation biofuels (conclusions)

| GHG reduction | Conclusions |
|---|---|
| Bioethanol (Brazilië, sugarcane) | The only first generation biofuel with a GHG reduction effect also when indirect emissions are included. Net effect between 15% and 88% reduction |
| Bioethanol corn | No reduction and probably an extra emission when indirect emissions are included |
| Bioethanol wheat | Possible a GHG reduction but also possible an extra emission |
| Biodiesel rape | Extra GHG emissions if indirect effects are included between 35% and 200% |
| Biodiesel palm oil | Probably (large) extra GHG emissions if indirect effects are included |
| Biodiesel soy oil | Probably (large) extra GHG emissions if indirect effects are included |

*GHG reduction in the Netherlands with indirect land use change included*
As mentioned above, in the Netherlands probably a large part of the ethanol is currently imported form Brazil. According to the sources above this delivers an GHG reduction but the amount is debated (-15 to -88%). For all biodiesel options, calculations including indirect effects result in significant extra emissions (+35 to 2.000%). Biodiesel from rape which is mainly used also results in higher emissions but not so extreme (+35 to +200%) Combined (63% biodiesel from rape, and 37% ethanol from sugarcane like the fossil distribution over this fuels) the range is -11 to +120%. This is the range for the Dutch biofuel program.

This means that the 2% in 2007 have had an impact of between – 0.1 Mton to + 0,84 Mton $CO_2$. On average there is an extra emission of 0,55 Mton. Note that this is very different from the figures presented by the Dutch Ministry of Environment (VROM, 2006) in their policy documents, where biofuels are presented as completely climate neutral and in which a reduction of 0,7 Mton is predicted for the year 2007.
For 2.5 % this would be between - 0,1 and +1,0 Mton.
For 5.75% this would be between - 0,3 and +2.4 Mton.

**Conclusion**
All GHG calculation indicate that there is a small chance that biofuels lead to a net reduction of Greenhouse gas emissions and a large chance that there is a net extra emission. For the Netherlands this range is –11 to +120%. This means that 2.5% biofuels in stead of 5.75 biofuels can at best save 1.4 Mton emissions or at worst could result in 0.2 Mton extra Greenhouse emission. On average this lower amount of biofuels saves 0.6 Mton $CO_2$ emissions.

*GHG reductions in the EU including Indirect land use change*
In the EU the share of bioethanol from sugarcane is much lower than in the Netherlands This means that also for the bio-ethanol the GHG reduction including indirect effect will probably be negative. For the EU biofuel GHG effect including indirect effects the current scientific estimates conclude that the net effect will be negative.

# C GHG emission reduction of alternative measures in ETS regulated sectors

Greenhouse gas emissions by the large industry and the electricity production sector in the EU is regulated by the Emission Trading System. If this system would work ideally an extra emission reduction in a sector under the emission trading system could result in an extra emission of the same size elsewhere because only the total emission of the sector is regulated. In this view (perfect working ETS) the alternative measures should be chosen in sectors which are not regulated by ETS like the transport sector, the waste sector, the building sector and the gas use by consumers.

In practice, however, the ETS system is still not perfect. One important leak is the effect on import and export of energy intensive materials like aluminum, steal, fertilizer and cement. If the ETS $CO_2$ price rises this may lead to extra import of this materials into the European Union. (This extra import can also be realized in the form of choosing an other location for new production plants). Lowering the price for example by alternative measures of this alternative could reduce this effect. The magnitude of this leak is still unknown.

A second leak could be a change of the cap by policy makers if the price of $CO_2$ becomes high. Some politicians have indicated that they are willing to rise the amount of emissions allowed if the $CO_2$ price becomes higher than 30 euro's per ton. This makes the real cap between 2012 and 2020 unpredictable.

Besides the direct Greenhouse gas emission reduction many investments in renewable energy also result in a long term reduction of GHG emission and in the transition to a more sustainable energy system.

Because of the possible leakage of the ETS system in the alternative system both options in and outside ETS are considered.

Special attention will be for options in the Transport sector (also outside ETS).

**Policy options for ETS and this alternative**

There are several options to combine this alternative with the ETS system:

1 See this alternative as a help for lowering the leakage of ETS
  If you expect a high $CO_2$ price in the ETS system with a high risk of leakage through energy intensive materials and politicians which may rise the cap then the alternative has a good direct $CO_2$ reduction effect.

2 Lower the cap with the amount of $CO_2$ save by the alternative
Because the Alternative focuses on options which are to expensive for ETS (>40 Euro per ton $CO_2$) the measures are extra and in principal the Cap of ETS could be lowered with the $CO_2$ saved and this will have no effect on the companies who are in the ETS system.

# D Amounts of biofuels in 2010 in Europe

**Source: EC, 2006**
European Energy and Transport, Trend to 2030, Update 2005, DGTREN, Brussel 2006.

**Liquid fuels for transport**
EU-27 energy demand in transport 2010 (EC, 2006 page 81).
- Public road transport 7,472 ktoe.
- Private cars and motorc 173,934 ktoe.
- Trucks 123,331 ktoe.

Therefore the EU-27 liquid fuels consumption 2010 for road transport is 305 Mtoe.

**Biofuels in EU-27 in 2010 based on 5.75%:**
5.75% of 305 Mtoe = 17.52 Mtoe biofuels = 17.52 M x 41.868 GJ = 734 PJ
This equals:
35.9 x $10^{15}$ liter diesel (35.9 MJ/liter) = 204 Million hectoliter diesel
Or
225 million hectoliter petrol (32.5 MJ/liter)
Or
218 Million hectoliter biodiesel (33.6 MJ/liter)
or
344 million hectoliter bioethanol (21.3 MJ/liter)

The Diesel market share in Europe was 53% in 2007.
(http://www.cairns.com.au/article/2008/06/02/4291_motoring.html)

Assuming 50% bioethanol and 50% biodiesel on an energy base this leads to (218+344)/2= 281 Million hl biofuels in the EU-27 in 2010 for 5.75%. This is 31 times the Dutch consumption of 9 million liters biofuel in 2010.