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A strategy on climate-neutral fuels

Recommendations to the Dutch Environment Ministry (VROM)

Report

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Introduction

Transport CO_2 emissions continue to rise. If this tide is to be turned, all the available options to reduce them will eventually be needed. 'Climate-neutral' fuels are one such option, i.e. fuels causing less or (near-)zero greenhouse gas emissions in production and use. Before any truly significant percentage of the fossil fuels burned in motor vehicles is replaced by these kinds of fuels, however, major efforts will have to be expended. Against this background the Dutch Environment Ministry, VROM, commissioned CE Delft to draw up a series of recommendations on a robust medium-term government strategy on climate-neutral fuels.

At present, Dutch policy on biofuels consists of an obligation to oil companies to sell 2% of biofuels in the vehicle fuels they market. While this is a step in the right direction it is not enough, though. Under this obligation, oil companies and motorists will look for the cheapest solution, not for the most sustainable, and today's biofuels are still far from climate-neutral.

Key elements of the strategy

On the basis of desk studies and interviews with stakeholders we conclude that it is entirely feasible for the government to implement a policy package providing effective incentives for using climate-neutral fuels. If the government takes steps to create a market for these fuels, this will give industry the scope it requires to invest in the most promising climate-neutral options, thus ensuring continued development of the technology or technologies in question. It is then absolutely essential, however, that there is a perception that policies are stable and can be built on, providing long-term assurance to investors and others.

Against this background, any policy on climate-neutral biofuels needs to be constructed around the following pillars:

- Establish a **structural and stable market** for fuels with lower lifecycle carbon emissions (i.e. emissions during production *and* use). Such a market is essential if investments in the new fuels are going to be profitable. Industry will have to have an assurance that this market is going to survive for at least 10 to 15 years[1]. This will require development of a carbon calculation methodology or categorisation of biofuels according to their life cycle greenhouse gas emissions.
- Set **clear policy targets** for the short and medium term, such as CO_2 reduction targets for the transport sector, targets on global biodiversity, economic development, impacts on other sectors using the same raw materials, etc.

1 The average depreciation period for capital investment in production plants.

- Establish **sustainability requirements** for biofuel feedstocks and production. As the biofuels market grows, so too will worldwide pressure on wildlife, the environment and social welfare. In the absence of government regulation this will probably lead among other things to the clearing of rainforest, loss of biodiversity and undesirable social impacts. To avoid this, a certification system needs to be developed and implemented as a matter of priority, possibly along with other flanking policy.
- Ensure **international harmonisation** of policy, for the following reasons:
  a The investments required are so large that industry needs international markets for satisfactory returns.
  b With fuel and feedstock markets international, pursuing an independent Dutch policy would mean substantial additional costs.
  c The Netherlands is bound by international treaties and EU policy.
- Remove the **institutional barriers** holding back development of the biofuels market. Fuel specifications, import charges and vehicles not equipped for higher-percentage biofuel blends are among the main barriers in this respect.
- The tempo and cost of introducing climate-neutral fuels can be partly influenced by **good policy timing** and by ensuring that industry has **sufficient flexibility** as to how policy targets are secured (within sustainability constraints). Policy changes that are implemented too rapidly will mean higher costs for industry, while unduly slow policy progress will put a brake on developments. If market players are given the freedom they need, they can respond flexibly to changes without the need for policies to be continually modified.

The policy options examined
In this study we analysed a series of policy scenarios with which the government could elaborate this basic strategy. These were each evaluated to assess the extent to which they are in line with the key elements of the strategy cited above.

We first analysed a number of scenarios that feed directly into current policy, i.e. the obligation to fuel suppliers with respect to the amount of biofuels marketed, viz. obligation based on:

a Weighting: for example, one unit of a biofuel giving 80% carbon savings is equivalent to two units of a fuel with 40% savings.
b Mandatory percentages for fuel categories, with categorisation based on lifecycle carbon savings and percentages changing with time.
c A mandatory average carbon saving for all biofuels sold, with this percentage progressively tightened.
d A minimum requirement for the carbon savings of each biofuel, with this percentage progressively tightened.

All these policy scenarios assume there is a system of sustainability certification in place for biofuel supply chains as well as appropriate flanking policy to prevent unwanted impacts with respect to biodiversity, impoverishment and suchlike.

We then went on to examine three options for the longer term:
1 Continuation of the obligation.
2 Replacement of the obligation by a carbon tax.
3 Replacement of the obligation by an emissions trading scheme.

Short term
Each of the policy options examined has the ability to create a structural market for climate-neutral fuels, by requiring improvement of the net carbon savings embodied in new fuels. There are a number of clear differences, however. From our analysis we conclude that an obligation based on mandatory average carbon savings would dovetail best with current EU policy. In this scenario the Netherlands can comply with the EU biofuels directive while giving the market the flexibility it needs. The scenario with weighting offers the greatest scope for achieving a given CO_2 reduction through use of biofuels - the principal aim of Dutch policy. If so desired, an additional incentive can then be given to development and use of climate-neutral fuels by (temporarily) increasing their weighting factor. Under this policy the climate impact can be established beforehand, but not the volume of biofuels involved. In the European context, too, it is therefore recommended to switch from a volume-based policy target for biofuels to one based on carbon emission reduction targets.

Longer term
With respect to the longer-term policy options, we conclude that all three can be effective in reducing carbon emissions. There are again important differences, though. A carbon tax and emissions trading do nothing to regulate biofuel volumes, while an obligation does. With tax and trading it is left to the market to determine what CO_2 abatement measures are implemented. Any transition from an obligation to some other form of policy should therefore be carefully designed. If biofuels represent a more expensive route to emissions abatement than other options (as at present), this will severely depress demand for biofuels, with serious consequences for the industry. These kinds of market distortions can only be avoided by postponing any switch of policy track until such time as biofuels are competitive with other forms of carbon emissions abatement policy.

1 Introduction

1.1 Background

The Dutch government has, on repeated occasions, indicated its wish to develop more sustainable systems of transport mobility. It has done so by way of the 4th National Environmental Policy Plan, the Environment ministry's internal memorandum on sustainable mobility, the government's policy paper on Traffic Emissions, during the Dutch presidency of the EU in 2004 and, indeed, throughout its stated strategy with respect to managing the transition towards sustainable development. In the longer term this means drastic emission cuts, of course, but it also means improving the overall performance of mobility in terms of quality, safety, access and so on. Within the wider framework of sustainable development, transport CO_2 emissions are proving to be a substantial and intransigent bottleneck, as the historical record clearly shows: while carbon emissions have declined in just about every sector, transport emissions continue to grow.

If the Netherlands is to achieve any substantial reduction of its carbon emissions (by 50% in 2050, say) there will have to be major cuts in transport sector emissions, too. Besides more efficient vehicle engines and a rethinking of mobility demand, this will also require sustainable vehicle fuels with a zero or low carbon balance in terms of their overall lifecycle, i.e. production, distribution and use.

With respect to the last of these points, the Environment ministry (VROM) is currently elaborating a policy to increase the use of road vehicle biofuels, motivated directly by the need to implement the EU biofuels directive. A second aim of Dutch policy, however, is to improve the sustainability profile of biofuels and encourage innovation in this field.

Against this background, VROM commissioned CE Delft to draw up recommendations for a robust medium-term strategy for sustainable, climate-neutral fuels. What can the government do in the medium term to increase the use of such fuels and capture the potential they offer? What policies are available to encourage market innovation and what constraints should the government set on the playing field?

It is also important the strategy does not lose sight of the support required from stakeholders, nor of the international arena. One key element of this project was therefore a series of interviews with representatives of oil companies, biofuel producers, environmental organisations and others.

Any transition to renewable fuels requires more than just technological innovation. Far-reaching changes and indeed innovation are needed in other areas, too:

- In the economy: emergence or creation of new markets, for example, and new forms of global trade, etc.
- In consumer perceptions and acceptance: with respect to the safety of gaseous fuels, for example, and the sustainability of biofuels.
- In institutions and with respect to governmental intervention.

The envisaged transition, in short, is not just a programme of technological innovation to be analytically designed from an ivory tower, but nothing less than a broad transformation of society as such.

1.2 The current situation

As part of its efforts to reduce road transport CO_2 emissions, in the coming years the Dutch government will be taking steps to promote the use of transport biofuels. In doing so it is complying with EU directive 2003/30/EC. To this end a temporary fuel duty derogation has been introduced (2006), to be replaced in 2007 by an obligation to fuel suppliers. From then on oil companies will be obliged to ensure that 2% of the road vehicle fuels they sell consist of biofuels. In a recent policy memorandum to Parliament the government announced that this percentage is to be increased to 5.75% in 2010[2].

Today's biofuels are still expensive, though, and in some cases give only limited cuts in greenhouse gas emissions. Although biofuel production processes with lower costs and emissions are being developed, these fuels are not yet ripe for production on any major scale. In addition, growing use of biofuels is likely to lead to substantial expansion of large-scale biomass plantations, bringing with it the risk of unwanted ecological impacts such as clear-cutting of rainforest.

It is therefore essential - and this is indeed recognised in the cited policy memorandum - that any policy on biofuels must have sustainability as its core goal, as this will ultimately accelerate development and marketing of better biofuels and reduce the risk of unwanted impacts. In the course of 2006, the Dutch government therefore intends to elaborate a policy to that effect.

Looking to the longer term, it should not be forgotten that other climate-neutral fuels are also conceivable. Two cases in point are hydrogen produced using renewable energy sources and fossil-based energy with carbon sequestration. In the case of hydrogen, there are still a number of technical and economic problems standing in the way of widescale introduction, and expectations are that it will be several decades at least before it could be used as a transport fuel on any significant scale.

[2] Policy memorandum on biofuels from State Secretary Van Geel to Parliament dated 16.3.2006.

1.3 Goal of these recommendations

The Environment ministry commissioned a study aimed at providing recommendations on a **robust medium-term strategy for climate-neutral fuels,** with the focus on biofuels and 'medium term' taken to mean between about 2010 and 2020. Short-term policy (up to 2010) is already being elaborated and has been taken as the point of departure for the present study. Among the main external constraints on this strategy are that it should retain the support of the various stakeholders and make full use of any (economic) opportunities for the Netherlands.

1.4 Method

These recommendations are based partly on a study of the literature, but in addition we interviewed a large number of stakeholders, including representatives of oil companies, biofuel producers, feedstocks importers and environmental organisations. A list of those interviewed is provided in Annex A.

With respect to sustainability issues we also made grateful use of the results of discussions in the Cramer Commission, which is presently drawing up recommendations on a system of sustainability certification for biomass.

1.5 Reading guide

In Chapter 2 we first provide a brief description of the climate-neutral fuels with which this report is concerned. We then sketch the broader context into which any policy on climate-neutral fuels must fit and for which the strategy must make due allowance. Chapter 3, the core of the report, describes the key elements of a medium-term strategy. In Chapter 4 we consider the best kind of policy for implementing this strategy, analysing a series of policy options to that end. In Chapter 5 we present the conclusions and recommendations emerging from the previous chapters.

2 Climate-neutral fuels in a broader context

2.1 Introduction

This chapter sets out the background and basic premises of the biofuels strategy. First we briefly describe the current status of climate-neutral fuels and examine anticipated trends. We then set out the broader context within which the strategy is located and which it will have to take into due account.

2.2 Climate-neutral fuels

Although the biofuels available today can help cut carbon emissions, they still have their drawbacks. Various studies have shown that the emission reductions achieved with these fuels are often still relatively modest, averaging no more than about 30-50%. There is considerable variation around this average, however. On top of this, the additional costs of these biofuels are often such that the cost per tonne of CO_2 avoided is high compared with alternative abatement measures.

There is also concern about the potentially negative impact of large-scale cultivation of the biomass that will be needed for producing the far larger volumes of biofuels envisaged for the future. A familiar example are palm-oil plantations, which may involve clear-cutting of tropical rainforest. There is thus a risk of biofuels policy conflicting with another of the government's stated policy objectives: conservation of biodiversity. In addition, conversion of forest to biomass plantation may in itself lead to such massive releases of CO_2 that the carbon emissions of biofuels produced using feedstocks from these areas may even be higher than those of the fossil fuels they are replacing. NGO's have also voiced concern that the land rights of third-world farmers may be violated by western demand for biofuels and that labour conditions on some plantations are far from ideal. Finally, today's biofuels are produced from crops that can also be used as food or as animal fodder, as in the case of oilseed rape and similar vegetable oil crops, cereals, sugarbeet and sugarcane. Biofuel production is thus in direct competition with the food and fodder industries.

Meanwhile, efforts are underway around the world to develop biofuels and biofuel processes performing better than their current counterparts (CE, 2005a). Expectations are that these second-generation biofuels will embody carbon savings of around 80-90% and be able to be produced from woody biomass and/or wet biomass. These technologies will probably require several more years to mature, though some are already more advanced than others. The Canadian firm Iogen, for example, has advanced plans to build their first large-scale ethanol plant able to process straw. They are now looking for a suitable production site in the EU (UK or Germany), Canada or the United States. CHOREN Industries recently started construction of their first demo biomass-to-liquid (BTL) plant using the Fischer-Tropsch process in Freiberg, Germany. This plant, with a capacity of approx. 15,000 metric tonnes per annum, is seen as a stepping stone to the full-scale 200,000 mtpa plant envisaged. The latter facilities could then be operational by around 2009 or 2010. Both companies indicate that further development and expansion of production capacity depends very much on how the technology develops, but above all on the investment climate and the availability and costs of biomass feedstocks. A brief description of the various biofuels presently available and under development and their characteristics is provided in Annex B.

One of the longer-term options being considered for greening mobility is hydrogen, which can be used in fuel-cell vehicles. Hydrogen has a number of advantages, for example the fact that it can be produced from any conceivable energy source (renewable or fossil, with or without CO_2 storage), and that no air polluting emissions are associated with it use. At the same time, though, hydrogen is still very expensive and it is still far from clear whether costs can be reduced enough for it to be a cost-effective means of addressing the climate impact of transport (CE, 2006).

Summarising, we can conclude that the ideal climate-neutral fuel is not yet available, but that ongoing developments in this field do indicate that progress is being made on various routes to such fuels. In all these efforts it is important, though, that the government take measures to limit undesirable policy impacts - on biodiversity, social welfare and other industries, for example. It is not yet feasible to predict which climate-neutral fuels will eventually prove best, nor to what degree these will be able to meet transport energy requirements at reasonable cost and an acceptable burden to the global environment. At the moment it seems likely that any transition to climate-neutral fuels will be a gradual process, with no major sudden changes, and that this process will span several decades. If the aim of government policy is for the Netherlands to be using a substantial volume of climate-neutral fuels in 2030, we must embark on that process now.

2.3 The broader context

Dutch fuel policy obviously does not exist in a vacuum, but is part of a far greater whole. Any policy strategy must therefore take into account the following issues:

- The policy will have to be robust to oil price fluctuations arising from global economic and geopolitical developments.
- It will have to be similarly robust to the considerable uncertainties with respect to the price and availability of the feedstocks required for these alternative fuels.
- Dutch biofuels policy will also have to take into account the European policy setting and developments in other Member States. Although the Dutch government can exert some influence here, that influence is limited.
- In addition, large-scale demand for biofuel feedstocks impacts on (global) agriculture and on the food, fodder and energy sectors, with two main consequences. First, raw materials originally destined for the food industry, say, are now being used by biodiesel producers. For the food industry this not only pushes up costs; it also means reduced availability of suitable feedstocks. Thus, rapeseed oil is a suitable as well as healthy raw material

for margarine, for example, but it can also be used as a feedstock for biodiesel. Second, increased demand for agricultural products will engender a rise in (global) agricultural output. This may have unwanted impacts on environmental quality, biodiversity and social welfare. It goes without saying that any biofuels strategy should aim to keep such impacts to a minimum and that the government therefore needs a solid understanding of the broader implications of its policies in this area.
- It is also important to realise that the industries that will be shaping the envisaged developments (i.e. oil producers, feedstock suppliers, biofuel producers, vehicle manufacturers, and so on) are operating in international or global markets. This issue was mentioned by various stakeholders interviewed for this project. For most of these players a Dutch national policy will therefore be of only limited significance. In addition, independent Dutch policy will lead to higher costs to these industries.

Finally, it should not be forgotten that (bio)fuels are not an end in themselves. The primary objective of Dutch biofuels policy is to reduce carbon emissions. From this perspective it makes sense to weigh up the use of biofuels against:
- Other promising ways of reducing transport carbon emissions (or fuel consumption).
- Other biomass applications that substitute fossil fuels and cut carbon emissions.

In the next section we go into all these issues in a little more detail, looking specifically at the following:
- Other options to reduce transport carbon emissions.
- Other biomass applications (and other forms of renewable energy).
- Oil prices and supplies.
- International industry.
- International policy trends.

2.3.1 Other emission abatement measures

Biofuels are not the only route to reducing transport CO_2 emissions. More efficient road vehicles and behavioural change also have a contribution to make, and possibly also hydrogen and electricity from renewable sources. In the longer term, entirely new solutions may emerge of which we currently have no conception. Many of the interviewees from the oil industry as well as the Netherlands Society for Nature and Environment stressed that these other options should not be forgotten.

A scenario study carried out by the National Institute for Public Health and the Environment, RIVM (now the Netherlands Environmental Assessment Agency, MNP) shows that the potential of any of these individual measures is probably not enough to secure the targets envisaged by the government (RIVM, 2003). Other studies that have looked into the issue of global land use (e.g. (MNP, 2006)) have confirmed that the potential of biofuels is limited by the amount of land available worldwide. As things stand at the moment, then, it must be assumed that all the available routes to achieving large-scale cuts in carbon emissions will have to be utilised in the future and that all options should be left open.

In developing a medium-term strategy it is important to bear this in mind. For this reason, policies stimulating various options for cutting transport carbon emissions should perhaps even be given preference over policy geared solely to climate-neutral fuels. If the decision is taken to adopt a dedicated policy on (bio)fuels, this should at the very least be backed up by policies encouraging other measures, such as more fuel-efficient vehicles and behavioural change.

It is worth noting that current biofuels policy is concerned only with biofuels produced separately from fossil fuels, with which they are then blended or, alternatively, used as 100% biofuel. In the longer term these two routes could conceivably be integrated, though, particularly given the cost benefits that might well ensue. One of the oil companies interviewed cited the possibility of biomass or a biomass-based intermediate being fed directly to the refining process, for example. This would do away with the need for separate facilities to produce the desired quality of biofuels and mean substitution of crude oil by biomass. Refinery-produced petrol and diesel would thus become part-biological in origin[3]. This is not profitable at the moment and current biofuels policy gives no consideration to this option. In the future, though, policy-makers might well opt to promote this kind of integrated refining process, by giving this route to fossil fuel substitution equal treatment to separate biofuel production, for example.

2.3.2 Other uses of biomass and farmland

A second issue requiring consideration is the broader context in which biomass production and use take place and the key issue of land use. Many types of biomass can be used not only to synthesise transport fuels, but also for food or livestock production, electrical power generation or 'green' chemicals production. This holds for the current generation of biofuels as well as the next, it may be added, for woody biomass can also be burned in power stations as a coal substitute. Policy in one particular sector can thus affect the market (prices, supplies, etc.) in others.

One concrete example of the impact of current biofuels policy is given by recent developments in the oleochemicals sector. Uniqema, an ICI subsidiary based in Gouda (NL), is being affected by the biofuels industry's demand for tallow (waste animal fat). In Gouda this waste is used to synthesise a variety of chemicals, but it is now also serving as a (cheap) feedstock for biodiesel. This has pushed up the price of this raw material, and in the competitive market in which Uniquema operates the company is finding it hard to survive. If prices rise any further as a result of biofuels policy, the oleochemicals sector will probably switch to fossil-based production, so says Uniqema[4]. This is tangible evidence that greater use

3 Because refineries make a wide range of products, it would be difficult to ascertain the precise share of the biomass ending up in the fuels.

4 Personal communication, R. Soeterboek, Uniqema.

of transport biofuels may bring with it a risk of less biofeedstocks being used in the chemical industry.

The food industry, too, reports that the rise in demand for rapeseed oil for biodiesel has led to a rise in the price of this feedstock and massively reduced availability. Rapeseed oil is widely used in margarine, for example, and has a number of health benefits over other oils[5].

What is more, growing demand for land for biofuel feedstocks will be at the expense of other uses of this acreage, such as food cropping, animal fodder production, biomass for power generation, wildlife, etc. The response to rising demand for biofuels will be a growing amount of land devoted to biomass cropping, putting greater pressure on current farm acreage as well as on land that is now still virgin land. As the earth has only a finite amount of (productive) land and ever more food is required by the world's ever-growing population, there is a limit to the amount of land available for growing biomass for biofuels. A number of scenario studies have been carried out to assess where this limit lies. The results span a very broad range, however, depending as they inevitably do on how much nature and biodiversity is allowed to remain, for example - although no formal decisions have yet been taken on such issues.

In the more optimistic scenario studies on the potential of biomass (e.g. (Faaij, 2000)) one key issue is the assumption made of major improvements in world agricultural efficiency. These studies conclude that fairly substantial supplies of biomass will become available in the future, as calculations are based on the assumption of EU (or even Dutch) per-hectare agricultural productivity being attained worldwide.

A recent study by MNP, carried out in collaboration with UNEP and LEI (MNP, 2006), describes the estimated impact on global biodiversity of current and possible future biofuels policy. In this study the positive effects of reduced climate change on biodiversity (as a result of fuel carbon savings) are also weighed up against the negative impacts of biomass production. It is concluded that an increase in biomass cultivation and woody biomass plantations will, on balance, lead to a loss of biodiversity. Only after 2050 is this situation expected to improve, through a tempering of the greenhouse effect and greater overall use of biomass, solar and wind power. In the short term, the only way to achieve stabilisation or even a slight improvement of biodiversity is by expanding and conserving nature areas and continuing to enforce the associated legislation, so MNP concludes.

One important lesson from these scenario studies, to our mind, is that any EU policy on bio-energy or biofuels really needs to be backed up by a vision on global land use. If EU governments intend to create major incentives for biomass cultivation, this is the responsibility they have.

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5 Personal communication, W.J. Laan, Unilever.

Any strategy on transport biofuels should therefore take into due account the potential impact of that strategy on other sectors of the economy and seek to limit any unwanted side-effects of the large-scale cultivation of biofeedstocks that will ensue.

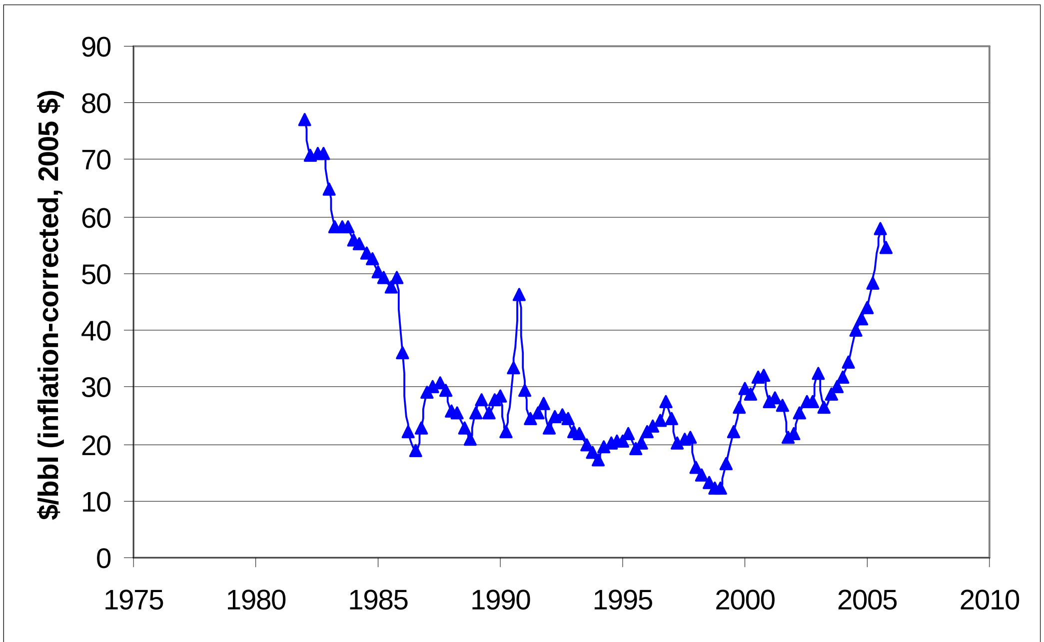
2.3.3 Oil prices and supplies

The transport sector is almost entirely dependent (>98%) on fossil oil (IEA, 2004). Consequently, any rise in the price of crude will mean a reduction in the additional cost of alternative fuels and an improvement in their cost effectiveness. The transition to climate-neutral fuels will then be facilitated, as costs decline and support for the transition rises (as a result). If oil prices show a downward trend, of course, the converse will hold, with the additional cost of the alternatives rising and support declining.

Broadly speaking, the price of oil is governed by three factors:
- Global oil demand.
- Global oil production.
- Geopolitical relations.

Demand for oil is still steadily rising, owing to growing demand from both the developing and developed world. Physical oil stocks are obviously finite, but until now (rising) oil output has always been offset by the discovery of new reserves, or through improved exploration and production methods. Experts disagree about exactly when oil output will start to decline, but according to the World Energy Outlook 2004 (IEA, 2004) the general consensus is that peak oil production will occur sometime over the next 25 years.

Figure 1 Average price of crude oil imports in European countries (quarterly, inflation-adjusted, $ of 2005)



Source: oil prices: IEA; inflation correction: Eurostat data on Consumer Price Indices.

Given these various factors, many experts expect the oil price to remain structurally high in the coming years, and perhaps even rise further still. In designing a strategy on climate-neutral fuels the government must nonetheless reckon with uncertainties when it comes to trends in oil prices.

2.3.4 International industry

If there is to be a major transition to climate-neutral fuels, there will have to be substantial changes within several key industries. New feedstocks and energy sources will need to be tapped, the emerging new fuels will require a suitable distribution network, existing production processes will need adapting and new facilities will have to be built. These are the changes that will be occurring over the next few decades.

In many cases the industries that will be doing all this will be large multinationals and other companies operating in international or global markets. For most of the companies concerned the Netherlands is just one of many markets and of limited significance internationally. On its own, then, the Netherlands can exert only little influence on global oil giants, biofuel producers or feedstock suppliers. The same holds for the automotive market, where the Netherlands is again only a minor player, most issues being regulated within a European framework and most vehicle makers being global operators.

In the interviews held, various companies therefore indicated that it will mean substantial added costs if the Netherlands 'goes it alone' and pursues a policy that clearly deviates from that of other countries. Separate feedstock and/or fuel streams would then have to be established, as well as separate production processes. This is seen as potentially problematical by the oil industry as well as by feedstock suppliers and biofuel producers.

On the other hand, though, the companies we talked to that are working specifically on developing 2nd-generation biofuels (Nedalco, Iogen, CHOREN) indicated they would in fact be very happy if the Netherlands (possibly in collaboration with other countries) were to take the lead on policy geared to these new products. As yet they have no major production capacity and therefore no need of huge markets. In addition, they need separate feedstock streams anyway.

2.3.5 International policy trends

The Netherlands is very much bound by European policy, particularly given the importance of European regulations in the fields of fuels, motor vehicles and international trade. There are also a number of international treaties of relevance for the policy leeway available to the Netherlands. Thus, any medium-term strategy on biofuels must make due allowance for at least the following international policy trends:

- EU (bio)fuels policy.
- EU climate policy.
- global post-Kyoto policy.
- international trade issues, EU import charges, etc.
- EU agricultural policy.
- EU state aid regulations.

It follows from the previous section, moreover, that the Netherlands will have to give due consideration to the policies of other countries, in particular:

- National (bio)fuels policies.
- Global trends in biofuels policy.

3 The basic strategy

3.1 Introduction

We are still almost wholly dependent on fossil fuels for transporting people and goods. The entire transport sector has been designed around these fuels and indeed optimised for them: the means of transport (cars, lorries, ships, aircraft, trains), the oil industry, the refinery sector and filling station infrastructure. Alternative fuels are only gradually finding their way onto the market, hampered as they are by factors like higher costs and their lagging behind in terms of development. If this situation is to be remedied and maximum substitution of fossil fuels by climate-neutral fuels achieved within the space of several decades, say, very substantial efforts will therefore have to be made. A whole new fuel production system needs to be created, new sources of energy tapped on a major scale and the distribution system and means of transport themselves re-designed.

At present biofuels are the most suitable alternative for fossil fuels in the transport sector. Biodiesel, bio-ethanol and ETBE can already be produced without any problems and a certain percentage added to traditional fuels. In the future it is entirely possible that other biofuels will be come onto the market, or even entirely different alternative energy sources like (sustainably produced) hydrogen or electricity.

In the following section we first of all consider the role of (the) government in this process of change. Although ultimately the changes will have to be shaped by the market, it is up to the government to create an appropriate playing field for that purpose. From these premises, the background set out in the previous chapter and the interviews held with stakeholders in the framework of this project emerge the key elements of a medium-term government strategy. These are described in Section 3.3. We then translate the strategy into a number of policy evaluation criteria, which we use in the following chapter to compare several conceivable policy scenarios.

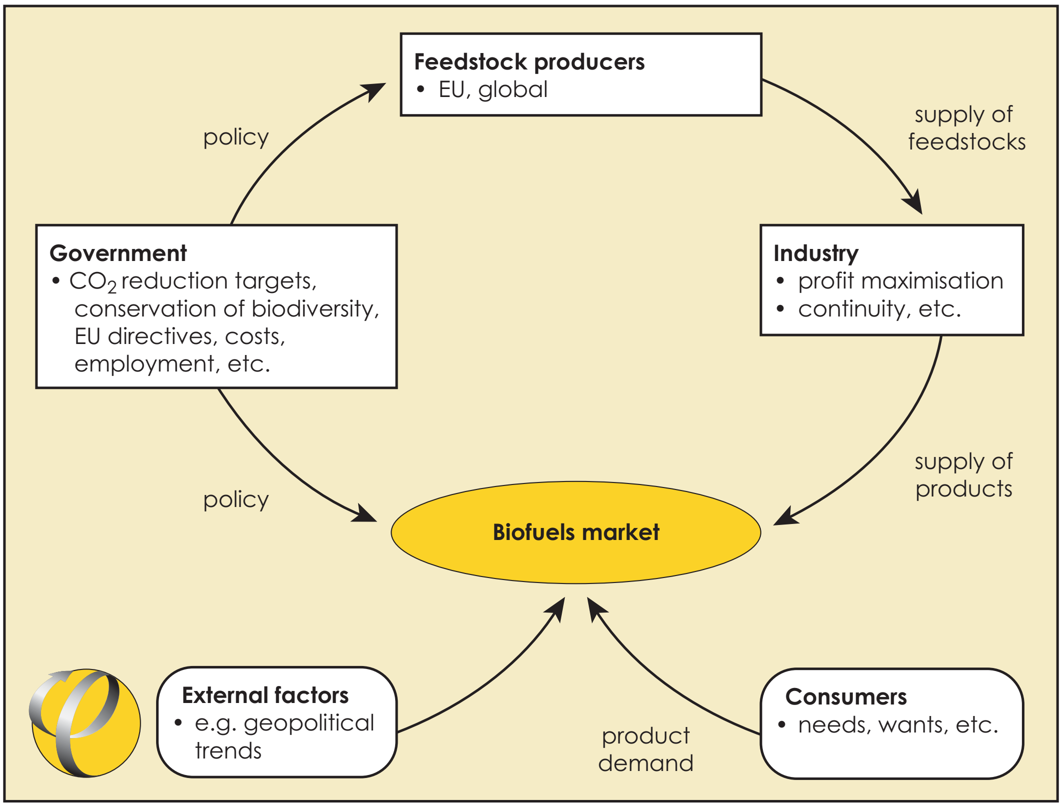
3.2 Creating a new market: the role of government

Biofuels are more expensive than (fossil) petrol or diesel, but deliver no improvement in engine performance. For most motorists the promise of reduced greenhouse gas emissions is no reason to dip deeper into their purse and opt for biofuels. At the same time, the price of fossil fuels does not yet reflect their environmental costs (including the cost of carbon emissions). Because it is important for society as a whole to reduce these emissions, however, the government has opted to give biofuels a helping hand, as it were, by implementing support measures. By making a certain use of biofuels mandatory, the government is creating a new market.

Under this new legislation, oil companies and motorists will once more seek the cheapest solution. The government has set its sights higher, though: it wants biofuels that perform better in environmental terms. It is therefore essential that extra incentives to that end are built into the government's policy. These should be geared specifically to improving the environmental performance of biofuels and encouraging further research into eco-friendly biofuels.

If the government's policy is effective, the market will respond by changing the fuels they have on offer, which consumers will then buy. The newly created market is then a consequence of a range of actions on the part of government, industry and consumers, as shown schematically in Figure 2.

Figure 2 A new market for biofuels emerging from the products supplied by market parties, consumer demand and government policy



In Annex D we provide an analysis of the role of government in promoting these developments. The government has a range of policy instruments at its disposal for creating a market for the new fuels:

- Regulation (i.e. standards), on mandatory blending of biofuels, for example.
- Pricing policy, including tax measures like reduced excise duty on biofuels or a lower purchase tax for vehicles equipped to handle high biofuel percentages.
- Emissions trading.

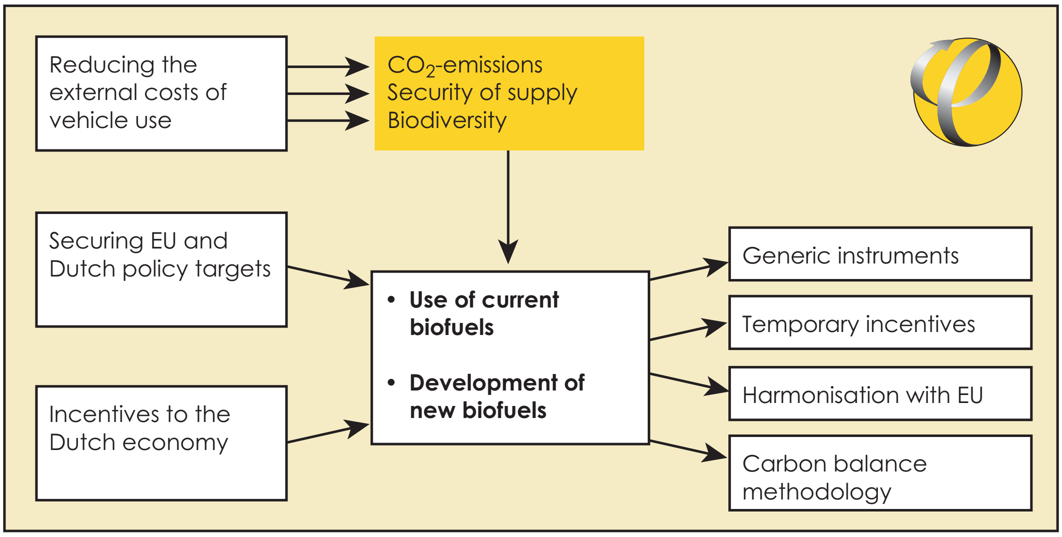
Innovation can also be encouraged by non-market means: by subsidising research or demonstration projects, capital investment in production plant, new infrastructure (for hydrogen, for example) and so on. Communicative processes (public information campaigns to improve people's understanding of biofuels, for instance) can play a (flanking) role in the policy.

This analysis shows that successful and economically sound introduction of climate-neutral fuels will require the following steps:

- Create a market context, by making blended fuel obligatory, for example, or by internalising the external costs of *all* transport fuels. What is needed is a long-term policy package that is designed to be as generic[6] as possible. It is also important that legislation or pricing policy remains in force for a substantial period of time. A production plant is not built for the short term, but has to be utilised (profitably) for at least 10 to 15 years.
- To trigger initial change, develop a temporary system of incentives that is:
  - technology-neutral;
  - if necessary, temporarily in excess of external costs savings.
- Establish a carbon calculation methodology, mainly to provide incentives and for monitoring policy progress.

The overall scheme of things is illustrated in Figure 3.

Figure 3 Synopsis of the government's role in promoting use of sustainable biofuels



[6] Generic policies do not favour any one particular technology (or several).

3.3 Key elements of the strategy

From the background information provided in the previous chapter and section and the interviews held in the framework of this project (for a list of interviewees, see Annex A) emerge the principal pillars of a government strategy on climate-neutral fuels. If the future potential of climate-neutral transport fuels is to be maximally developed and captured, government policy will need to be built up around the following key elements:

- Creating a **structural market** for fuels with lower lifecycle carbon emissions.
- Setting **clear policy targets** for the short and medium term.
- Setting **sustainability requirements** on (global) biofeedstock production.
- Ensuring **international harmonisation** of policy.
- Removing **institutional barriers** to market development.
- Ensuring **good policy timing** and **business flexibility**.

These six tasks define the main contours of the government's role. If the policy is effective it will steer the market in the desired direction, at the same time limiting any unwanted side-effects.

A ***structural market*** is required if investments in the new fuels (and particularly in production plant) are to be profitable. In creating this market the government will have to make due allowance for a variety of factors, including EU policy directives, other forms of climate policy and external factors such as trends in oil prices.

Clear policy targets are obviously indispensable for shaping government policy. These may be environmental targets like transport CO_2 reduction targets and the objective of pursuing a climate policy that is cost-effective. However, they may also relate to such aims as retaining or establishing certain industries in the Netherlands and so on.

Setting of ***sustainability requirements*** on biomass feedstocks is essential to avoid unwanted environmental and social impacts such as the cutting of rainforest, biodiversity loss, increased poverty and so forth.

International harmonisation is essential for three reasons. First, the investments required for a transition to climate-neutral fuels are so substantial that industries will need a large, international market to guarantee satisfactory returns. International harmonisation of Dutch policy will therefore enhance its effectiveness. Second, fuel and feedstock markets are international and independent Dutch policy would therefore lead to unduly expensive changes having to be made. Third, the Netherlands is bound by international treaties and EU policy.

Institutional barriers such as fuel specifications, import charges and vehicles unable to handle biofuels may form an obstacle to developing the envisaged market. The government is in a position to remove some of these barriers.

To an extent, the tempo and cost of introducing climate-neutral fuels can be influenced by ***policy timing*** and the ***flexibility*** given to industry to secure policy targets. If changes are enforced too quickly, the market will be unable to deliver a timely response. If policies are tightened too slowly, though, development of the new fuels may be delayed, which means their carbon savings potential will be captured later than otherwise feasible. International policy trends (EU policy reviews, for example) can also play a important role in policy timing. The government should also give the market plenty of scope to respond to these developments. This will allow industries to respond flexibly to changes and means the policy will not need to be revised as external circumstances change.

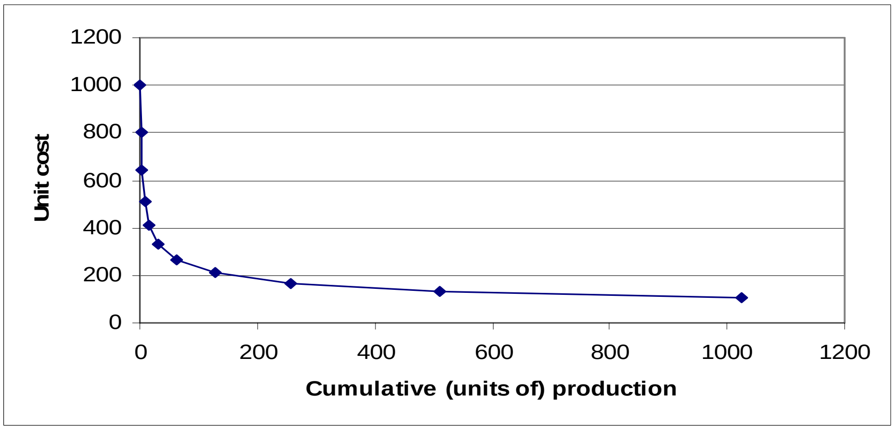
In the remainder of this section we look at each of these issues in greater detail. We then translate them into a set of evaluation criteria which we use in Chapter 4 to evaluate the various policy options.

3.3.1 Creating a structural market for new fuels

New technologies like biofuels and other climate-neutral alternatives do not emerge in the marketplace of their own accord. As long as they have only a non-existent or marginal share of the market, they are at a clear disadvantage compared with conventional technologies (Sandén, 2005). They will be unduly expensive, unfamiliar to market parties and consumers, and possibly plagued by teething troubles; in addition, the number of sales and maintenance points will still be limited. The investments required for further development of these technologies are relatively high-risk, because it still remains to be seen whether a market for the products will indeed materialise.

As production and sales volumes increase, costs will decline. In general this process will follow the kind of curve shown in Figure 4, with costs declining at a constant percentage rate for every doubling of production volume. Junginger (2005) has calculated this percentage for a number of renewable energy technologies and arrives at a figure of 15-25% cost reduction for every doubling of production volume. According to Goldemberg (2004), Brazilian ethanol has followed a similar cost curve. He found that every doubling of output in the period 1985-2002 was accompanied by an approx. 29% reduction in costs. The dynamics of new technology development are examined further in Annex C.

Figure 4 Typical cost curve for a new technology



Before a technology can be marketed on any significant scale, a number of problems must first be overcome. Companies, banks or governments will have to invest in the technology, for otherwise it will be stopped in its tracks immediately. They will only do so if they anticipate a satisfactory return on investment (ROI), generally through cost savings, sales growth or a rising market share. In their estimate, then, there must be a good chance of a market for the new product emerging. The greater the chance of success and the greater the market foreseen (and profits anticipated), the better the investment climate will be.

In the case of research institutes, decisions are based partly on different considerations. If research is (co-)funded by industry, the above considerations will again apply. When it comes to fundamental research, though, these institutes can also apply for funding under government programmes. In that case the perceived scientific importance of the research is likely to be the deciding factor.

The crucial importance of this issue - a certain assurance that a (profitable) market for the product will emerge - was also strongly reflected in interviews with parties involved in biofuel R&D. Nedalco and Iogen are currently taking a decision on investments in production facilities for bio-ethanol from straw, while CHOREN recently began construction of a plant for Fischer-Tropsch diesel from biomass. For funding these kinds of projects, industry is dependent on investors (often banks) who demand a certain ROI at what they deem an acceptable risk. Anticipated ROI and an assured market are consequently regarded by all market parties interviewed as the two principal factors governing investment decisions.

Given the level of investment required and the technological and financial risks involved in these new technologies, government policy is a key factor in funding decisions on new biofuels, so say these industries. Once investments have been made the market must then grow, reducing costs so that the new technology is eventually competitive with existing ones. In the early stages, government policy may in fact be a *sine qua non* for kick-starting the market, although as it develops the government can subsequently phase out these (market) incentives.

This market policy can then be effectively reinforced by flanking policy, in the form of investment subsidies, tax breaks and suchlike, as was confirmed by many of the companies we spoke to. In some cases these kinds of financial incentives may be a decisive factor, particularly when it comes to choosing a location for new production facilities.

3.3.2 Clear policy targets

Among the policy targets relevant to climate-neutral fuels are CO_2 emission targets, both officially pledged and indicative. In the short term, the Dutch government must meet its Kyoto commitments as well as secure the indicative targets set for the various sectors. In the longer term, expectations are that post-Kyoto negotiations will lead to agreements on further emissions reduction. The government's long-term ambition is to reduce carbon emissions to a level whereby global temperature rise is limited to 2°C above pre-industrial levels, with a maximum increase of 0.1°C per decade, and there is no more than 50 cm climate change related rise in sea level (NMP 4, 2000). If these targets are to be met, there will have to be substantial cuts in the carbon emissions of the transport sector too.

One immediate motive for the policy efforts we are concerned with here is the EU biofuels directive, which sets (reference) targets for the share of biofuels to be used by Member States. The quantitative figures for these obligations to fuel suppliers are 2% in 2005 and 5.75% in 2010 (based on energy density). In a policy memorandum to the Dutch Parliament, State Secretary for the Environment Van Geel indicated in March 2006 that he would also be adopting this latter target. Current expectations are that these percentages or reference targets will be raised still further after 2010.

Besides these core targets, the Dutch government has a number of other policy objectives and ambitions of relevance to biofuel policy. These are, in no particular order:

- Security of supply.
- Cost-effectiveness of climate policy.
- Limiting the additional burden to consumers.
- New opportunities for the Dutch industry.
- No shifting of environmental impacts (carbon emission cuts should not be at the expense of biodiversity, for example).
- Greater use of alternative energy sources for power generation.

In many of these areas no concrete targets have (yet) been set. It is still unclear, for example, what percentage decrease in transport emissions is to be delivered post-2012. Similarly, there are no concrete targets with respect to potential economic impact, nor has any decision yet been taken on the acceptable consequences for global or local biodiversity and healthy development of nature, among other things. Nonetheless, stated policies in all these areas will play an inescapable role in determining the optimum government strategy on climate-neutral fuels.

If so desired, the cost of biofuels can be kept within bounds, by tempering the rate at which the percentage obligation rises, say. This would allow the industry to achieve a stepwise increase in production capacity. A ‘safety mechanism’ could also be built into the obligation, with oil companies being given the option of paying a fine, or ‘redemption sum’, if they do not (entirely) meet their obligation. This could afford consumers some protection against high additional costs and would be used, for example, in situations where there is a shortfall in biomass supplies, a deficit in production capacity or low oil prices. There are risks involved, though, because it may detract from the need to invest. Companies might choose to pay a fine rather than taking the risk of investing in new technology. For biofuel producers it will also breed uncertainty, because in this scenario their market is not guaranteed. What is more, targets will not be met. It is therefore essential that the fine be set sufficiently high to avoid this kind of effect, but low enough to avoid extreme fuel cost increases.

As already set out in the previous chapter, biofuels policy may impact negatively on other sectors for which the government also has policy objectives, owing to biomass feedstocks rising in price or coming into short supply. This can be avoided by harmonising policies across the various sectors and by maximising the biofuel price (as described in the previous section, with a fine or ‘redemption sum’), since this indirectly limits the price that will be paid for the feedstock.

As these examples show, although it is sometimes feasible to pursue a range of different goals concurrently, in other cases they may prove to be in conflict. There will then be a need to weigh up the various pros and cons of a given policy option, or implement flanking policy to control its side-effects.

3.3.3 Sustainability requirements

Widescale use of biofuels implies a need for substantial quantities of biofeedstocks. To a certain extent, residues from the food and/or fodder industry can be used for this purpose, while the next generation of biofuels will be able to use materials like forestry pruning waste. In part, though, dedicated biofeedstock cultivation will be required.

Once dedicated biofeedstock crops are being used, any increase in biofuel volume will lead either to an increase in agricultural acreage or to agricultural intensification, or to both. After all, demand for biomass in other sectors will not decline. Even if residues from other industries are used, the effect will be essentially the same. Many of these residues would have otherwise been used as fodder, soil conditioners or a source of local energy, necessitating cultivation of additional crops if these materials go to the biofuel industry.

This increase in large-scale biomass cultivation can create economic opportunities for farming and forestry regions, but there are also undeniable risks to ecology and biodiversity. Two familiar examples in this context are Indonesian palm-oil plantations and the South American soya industry. Because of the local population’s need for food and fodder, cultivation of these crops is currently leading to the rapid destruction of valuable rainforest, and local and international NGOs are becoming increasingly vociferous in their protests. Additional demand for these crops, for both biofuels and bio-electricity, will probably accelerate this process of destruction. This is not just bad news for global and local biodiversity. It will also have a severe impact on the lifecycle carbon balance of the biofuels, for conversion of forest to farmland is accompanied by massive carbon emissions that will only be offset decades later after many years of biofuel use.

Biodiversity is not the only sustainability issue. If biofuel feedstocks are grown in the developing world, particularly, there are issues of labour conditions, local environmental protection, land rights and pesticide use, for example. If a suitable certification system is introduced and robustly enforced, these issues can hopefully be satisfactorily regulated.

One of the important tasks of government is therefore to define the playing field for growing the required biofeedstocks by establishing sustainability requirements aimed at achieving certain minimum standards with respect to conservation, environmental protection and so on. Explicit criteria might also be set with respect to labour issues: no child labour, for example.

A major risk in all of this, particularly when it comes to biodiversity, is that there will be a shifting of impacts. If the production of biomass for biofuels is subject to requirements that do not apply to other uses of that biomass, the 'good' biomass will simply be used for biofuels and the 'bad' for all the other applications. An obligation might be introduced, for example, that no rainforest be felled for the cultivation of fuel biofeedstocks. Yields from existing plantations used originally for other applications will then be used for biofuels, with new plantations being created where rainforest once stood to supply these other applications.

If the government is serious about encouraging far greater use of biofuels it is therefore essential that the issues of environmental and biodiversity impacts and competition with food crops are duly addressed by means of dedicated policy that addresses the macro level. Earlier this year the government set up the Cramer Commission to draw up recommendations on sustainability certification. This commission's brief is to come up with minimum requirements with which to prevent the worst problems. It is essential that the commission's recommendations are assessed to see whether they also address the issue of impact shifting.

3.3.4 International harmonisation

International harmonisation is not an end in itself, but an important and probably essential part of securing the above objectives. Many of the parties we spoke to cited this as being crucial for the effectiveness of any government policy on climate-neutral fuels. Their reasons can be summarised as follows.

The market
The Dutch fuel market is relatively small and a larger market will justify considerably greater investments in 2nd-generation biofuels research and production capacity. A bigger market is also needed to push down costs, as was illustrated in Figure 4. Feedstock suppliers, biofuel producers and oil companies are all international players operating in global markets. These industries serve more than just the Dutch market and feedstocks are imported on a large scale for many different applications and from and to many different countries simultaneously. If feedstocks and production plant for the Dutch market deviate from those used in the international (EU) market, this will mean a substantial increase in costs to producers and others.

Institutional barriers
Most legislation on biomass, fuels, biofuels and vehicles is drawn up at the European level. If the Netherlands intends to deviate from the EU's path or introduce its own regulations, it will have seek approval within the EU.

Sustainability requirements
Although criteria with respect to the sustainability of biofeedstock production can perhaps be regulated at the Dutch national level (by incorporating them in the basic biofuel obligation to suppliers, for example), this will lead to a shifting of impacts as well as greater costs (see Section 3.3.3). Particularly on this point, then, international harmonisation is important.

3.3.5 Institutional barriers

Existing regulations, administrative systems and organisational structures are geared mainly to today's fuel supply system and traditional uses of biofuel feedstocks. In the context of a transition to climate-neutral fuels these therefore constitute a barrier to new technologies. In this situation it is the government's task to adapt the regulations accordingly, to the extent that this is indeed desirable. In addition, the government can play a role in promoting or facilitating the required changes in society as a whole.

In our interviews with stakeholders the following issues were cited:
- Today's fuel specifications need to be amended or extended to accommodate and regulate the various blends that may come onto the market - with due allowance obviously being made for any unwanted impacts of such changes (such as an increase in air polluting emissions). This applies only to ethanol, ETBE and biodiesel, it may be added; the fuel delivered by the Fischer-Tropsch (FT) process has no trouble meeting the specifications.

- Today's vehicle fleet is only equipped to handle low-percentage blends and higher blends may therefore lead to engine problems. In the coming years the incoming fleet will therefore have to be re-engineered to retain compatibility with trends in fuels. Again, FT diesel is an exception here, as this can also be burned in today's diesels. Higher biodiesel blends do require engine modification, though, and ethanol requires a switch to flex-fuel vehicles.
- Biofuels and blends need to be readily tradable on international markets. All the biofuel producers and oil companies interviewed indicated this is still problematical at the moment.
- Fuel duty is levied per litre of fuel, independent of energy density. As particularly bio-ethanol has a significantly lower energy density, it is consequently at a disadvantage. This was cited as a barrier for so-called E85 fuels, which are considerably more expensive than they would be if duty were indexed to energy content.
- Import charges on ethanol distort the market and push up costs. In addition, excise duty rules for denaturalised and undenaturalised ethanol lead to additional transport and financial risk for ETBE producers and other ethanol processors.
- Other institutional barriers may arise if policy in other areas has consequences for biofuels. If there is greater subsidisation of biomass-based electricity, for instance, biofuel feedstock supplies and prices will be affected.

These barriers are not specific to climate-neutral fuels, it may be added, but also hold for the current generation of biofuels. It therefore already makes sense to remove them in the short term.

In the stakeholder interviews all these barriers were cited. In many cases the precise extent to which existing regulations need to be adapted will require careful (political) deliberation. Less stringent fuel specifications for ethanol-petrol blends would facilitate use of these blends, for example, but may at the same time lead to greater VOC emissions. Lowering ethanol import charges may lead to cost savings, but would have an adverse impact on the (economic and technological) performance of European ethanol producers and their suppliers.

3.3.6 Policy timing and business flexibility

Although government policy is a key factor in encouraging the use of climate-neutral fuels, so too are industry's response to that policy and the success of technological development, i.e. R&D programmes. These three factors therefore need to be properly aligned, in terms of substance as well as timing.

One risk the government runs is burdening industry with an obligation it cannot yet fulfil - because technical development is taking longer than anticipated or because there has been insufficient time to build the required production capacity. This will lead to higher costs and a risk of the government's 'obligation' simply being unfeasible.

This may be the case if the government imposes an obligation on industry to deliver 2% biofuels from woody biomass in 2010 while the technology is only sufficiently advanced to invest in large-scale production plant in 2008. To secure the 2% target, a crash programme of plant construction will ensue, leaving no time for a gradual extension of production capacity *and* process know-how. Again, this will lead to extra costs that could have been avoided (by increasing the obligation more slowly) and to the risk of targets not being fulfilled (through problems with the new technology, lack of financial backers or feedstock shortfalls).

If the government proceeds too slowly in its programme of incentives for better performing fuels, however, there will be over-extended investment in fuels that are no longer useful in the longer term. The upshot will be less reduction of carbon emissions than was in principle feasible.

Because of the major investments that will have to be made by the various industries, it is important the government gives them sufficient time to anticipate future policy. Companies first need several years for plant construction, then sufficient assurance their facilities will remain profitable for 10 to 15 years - the period cited by several of the parties interviewed as the minimum term within which the policy package must engender such confidence. That package therefore needs to be fixed in advance for a specific number of years, setting reasonable timetables for any changes that are required (plant construction, development of new technologies, introduction of certification, increased biofeedstock volumes and so on).

The future is full of uncertainty - and here one need only consider oil and biomass prices - and it is also difficult to predict how fuel and engine technology will develop. It is therefore wise to ensure the policy package gives the market the scope it needs to respond to these developments. This will allow industry to adapt flexibly to changes and obviate the need to keep tinkering with policies as external circumstances change. The oil companies we spoke to were particularly in favour of this kind of flexibility, as this would allow them to seek the most cost-effective solutions. For the government's part, developing robust policy that is scheduled well in advance requires considerable insight into likely future trends in all relevant areas. Erroneous estimates today may lead, a decade hence, to high additional costs and far from optimal solutions. If policies are continually adjusted in response to external trends, this will be at the expense of security of investment.

Market parties are in a far better position to respond to external trends. The options available at any given time will therefore be better utilised if the government steers by means of generic policy, with industry being given the opportunity to respond to emerging situations as they best see fit.

3.4 What kind of policy best serves this strategy?

The strategy outlined above still has little to say about the actual instruments that would need to be used to create a structural market for climate-neutral fuels. There are a variety of instruments that could be elaborated in such a way as to fulfil the main terms of the strategy.

For the coming years, the government has already opted for an obligation on the use of biofuels. It is from within the context of this obligation, then, that further development and use of climate-neutral fuels can best be pursued. In the longer term, once biofuels have gained a firm footing in the market, there may be reason to opt for a different kind of policy. In the following chapter we examine a series of policy scenarios for the medium and longer term and assess the extent to which they might be able to achieve the strategic goals set out above.

3.4.1 Evaluation criteria

One way to assess the merits of the various policy options is to translate the key elements of the strategy into evaluation criteria. In the next chapter we shall therefore analyse the alternative policies with reference to the following criteria:

a Volume effectiveness (with respect to both carbon savings and biofuel volume).
b Costs and cost effectiveness.
c Market assurance (essential to encourage investments in new fuels).
d Business flexibility (in response to fuel and feedstock costs, technological developments, fuel types, etc.).
e Compatibility with EU policy, scope for international harmonisation.

As will be seen, these criteria do not cover all the pillars discussed above.

In the first place, some of the institutional barriers are not specific to the next generation of climate-neutral biofuels but are already relevant for current policy. These therefore need to be removed as a matter of priority.

Second, although sustainability requirements are a pivotal element of the overall strategy, they have not been included in the evaluation criteria because the policy variants all score the same in this respect. The most obvious way to operationalise these requirements is by means of certification and elaboration of such a scheme is therefore another matter of priority. Again, risks with respect to the sustainability of biomass-for-biofuel cultivation and the shifting of impacts are not specific to climate-neutral fuels but may also arise with today’s biofuels.

Lastly, good policy timing will need to be an important feature of the policy package as it is further elaborated and translated into concrete terms. In this document, though, we restrict ourselves to the main thrust of the strategy and associated policy package.

4 The policy options analysed

4.1 Introduction

There are potentially a range of policy options available for operationalising the key pillars of the strategy set out in the previous chapter. It may well be that the biofuel obligation is initially shaped using one set of policies, but that as time progresses a different package is adopted as circumstances dictate.

In this chapter we elaborate a number of policy alternatives for the medium term, which we then assess against the concrete criteria that emerged from the key elements of the strategy. In the process, we demonstrate that introduction and, ultimately, widespread use of climate-neutral fuels can be achieved using a variety of policies. Each of these options has its benefits and drawbacks - in terms of costs and rate of change, the freedom afforded to industry and the degree to which policy targets are secured. In one scenario, policy efficacy may be guaranteed, for example, while another will be steering on the compass of cost minimisation. A choice for one particular option is therefore always in part political: how are the various policy targets to be weighed up against one another, and how can the Netherlands best respond to the present European and global policy context?

Below, we are generally concerned specifically with biofuels. The analysis applies equally, though, to other fuels delivering lifecycle carbon savings, such as hydrogen produced using renewable energy sources. A key requirement for inclusion of any fuel in the policy package, however, is that lifecycle carbon savings can indeed be calculated.

4.2 The policy options considered

In the following we examine a series of policy scenarios, in each case outlining the government's playing field. For each of these options we indicate how it can be elaborated so as to best achieve the strategic goals set out in the previous chapter. In the following chapter we assign each policy option an (approximate) score as to how it performs in strategic terms, using the set of criteria described at the end of the previous chapter.

In Section 4.3, below, we first of all examine a number of policy scenarios that dovetail directly with standing policy, i.e. the government's decision that fuel suppliers have an obligation to market a certain percentage of biofuels, viz. 2% in 2007. Within the terms of this obligation, there are a number of options available for gearing policy to improving the carbon balance of the biofuels sold. Here we examine the following:

An obligation with:

a Weighting: for example, one unit of a biofuel giving 80% carbon savings is equivalent to two units of a fuel with 40% savings.
b Mandatory percentages and fuel categories, with categorisation based on lifecycle carbon savings (for example, specifying that 5.75% biofuels are to be sold in 2010, with at least 1% from woody biomass).
c A mandatory average carbon saving (for example, the average saving embodied in all the biofuels sold must be at least 50% in 2010).
d A minimum requirement for the carbon savings of the biofuels, with this percentage progressively tightened.

All these policy scenarios assume there is a system of sustainability certification in place for biofuel supply chains as well as appropriate flanking policy to prevent impacts in the realms of biodiversity, social welfare and suchlike.

The last of these options (d) might possibly be combined with one of the first three. This possibility will be discussed along with the general conclusions presented in the Chapter 5.

In the longer term, once the biofuels have gained a firm foothold in the market, it is not inconceivable that the standing obligation will at some stage be revoked and a different form of policy adopted. In the second half of this chapter we therefore examine the following options for the longer term:

1 Continuation of the obligation.
2 Replacement of the obligation by a carbon tax.
3 Replacement of the obligation by an emissions trading scheme.

The last two of these options for the longer term dovetail well with climate policy trends in other sectors.

4.3 'Obligation scenarios'

4.3.1 Obligation with weighting

In this scenario the obligation is designed such that one unit of 'high-performance' biofuel, in environmental terms, is equivalent to more than one units of a 'standard' biofuel. This can be done in several ways:

- The various fuels are divided into a (limited) number of categories, which are then assigned a weighting factor. This categorisation can be:
  - By 'default' (for example, biofuels from woody biomass in category A, biofuels from residues in category B, other biofuels in category C). Or;
  - Based on proven environmental performance (for example, biofuels achieving >80% carbon savings in category A, those with 50-80% savings in category B, others in category C).
- The weighting factor is indexed to lifecycle carbon savings (on a linear scale, for example, with a factor of 1 for 40% savings, 1.5 for 60% and 2 for 80%. Here again, either a default value can be assigned or the calculated savings of the biofuel.

If so desired, the total percentage of biofuels can be gradually increased. The categories and weighting factors can also be adjusted as new fuels are developed. For the first few years, category B could be defined as a biofuel with 50-80% carbon savings, say, being tightened to 60-80% savings in 2012.

Volume effectiveness (with respect to both carbon savings and biofuel volume)

- This policy scenario can above all be effective in pursuing a certain reduction in carbon emissions. The carbon savings to be delivered using biofuels is specified in advance and weighting factors assigned to the fuels on the basis of the savings embodied. It is then up to the market to determine whether the obligation is fulfilled using relatively large quantities of poorer performing biofuels or a smaller volume of better performing alternatives.
- Over and against this, however, stands the fact that the aggregate volume of biofuels sold cannot be established beforehand: if more biofuels with greater carbon savings are marketed than originally anticipated, this will be at the expense of volume.
- Nor does this scenario give the government any assurance that 2nd-generation biofuels will indeed be marketed, for the market can comply with the obligation using only 1st-generation fuels. Such will be the case if the latter are in sufficient supply, if they are sufficiently low-priced, and if the weighting factors create insufficient incentive for 2nd-generation fuels.
- If weighting is based on calculated carbon savings, there is a better guarantee that the aggregate savings targeted will indeed be achieved than if fixed fuel categories are employed. In the latter case there is a major likelihood of some biofuels scoring better, or worse, than initially assumed - LCAs have demonstrated that the carbon balance of a given biofuel may vary considerably, depending on cropping methods and specific local circumstances, among other factors.
- The government can vary the weighting factors and thus respond to trends in the cost of new technologies. The weighting factor for 2nd-generation biofuels could be set relatively high in the first few years, for example, and reduced later on as the market develops.

Market assurance (essential for investment in new fuels)

- This policy scenario has advantages for producers seeking to market better performing biofuels, as any additional costs incurred will be offset by the need to blend in a lower quantity of biofuels.
- In this scenario the government can give industry the assurance it requires if the weighting factors and categorisation or carbon savings calculation method are fixed for a number of years in advance. This kind of solid platform will allow industry to judge for itself whether investment in R&D on low-carbon processes or production plant for better performing biofuels are profitable.
- Some uncertainty will always remain, however. If biofuels with low carbon savings are relatively cheap (in other words, if the weighting factors are not high enough), the market will give preference to these fuels.
- Given the current status of research on 2nd-generation biofuels and the reality of production plant taking at least 10 to 15 years to be written off, government policy will have to give industry the assurance that there will still

be sufficient incentive to market 2nd-generation biofuels in 4 or 5 years' time and that market opportunities in the period thereafter are also such that production capacity can be gradually expanded.

Flexibility (fuel and feedstock costs, technological trends, fuel types, etc.)

- This policy scenario is relatively flexible: the market determines which biofuels are used to comply with the obligation. If certain feedstocks become prohibitively expensive, the market can switch to cheaper alternatives. It also means that 2nd-generation biofuels can be marketed the moment the technologies in question are sufficiently advanced.

Costs and cost effectiveness

- The additional cost of biofuels is incurred initially by producers and will lead to consumers paying more for their fuel. There is an important role for government here, as the higher the mandatory percentage of biofuels, the higher the additional costs will be. Beyond this, of course, these additional costs will also be governed by the market price of the biofuels already available.
- The market will seek the biofuel mix with which to comply with the obligation at lowest cost.
- The cost effectiveness of the policy, in Euros per tonne of carbon saved, is determined by the cost of the biofuels and the carbon cuts achieved. In this policy scenario there is no way that cost effectiveness can be directly controlled: even if biofuels become substantially more expensive, they will still have to be marketed, for otherwise suppliers will fail to comply with the obligation. The government could easily build in a 'safety mechanism', though, putting a ceiling on maximum additional costs. In the current Dutch policy setting this is achieved by means of a fine. This is detrimental for investment security, however.
- The obligation will encourage the market to deliver cost-effective biofuels: the weighting factors enable higher costs to be accepted for biofuels embodying greater carbon savings.

Compatibility with EU policy, scope for international harmonisation

- While current biofuels policy is geared to a specific volume of biofuels being marketed, this scenario also aims specifically at CO_2 reduction. As set out above, the volume of biofuels sold will depend on the carbon savings of the specific biofuels coming onto the market. The government is obviously in a position to influence these volumes, via the mandatory percentages and weighting factors.
- Under EU biofuels policy, member states are free to make their policies as sustainable as they see fit and provide extra incentives for 2nd-generation biofuels if so desired.
- International harmonisation is of crucial importance for policy effectiveness as well as costs, as discussed in Section 2.3.4. Incentives for biofuels with greater carbon savings would therefore be considerably more effective if they were in force not only in the Netherlands but throughout the EU. The greater production volumes and ensuing economies of scale in both production and

distribution will reduce costs, moreover, and new products and technologies will likewise become cheaper, quicker. The government should therefore pursue international harmonisation of the categorisation system or carbon calculation methodology and its biofuels policy as such.

4.3.2 Obligation with mandatory percentages

In this policy scenario the government lays down the percentages of various types or categories of biofuel, specifying, for example, that of the 5.75% biofuels to be sold in 2010 at least 1% point must consist of fuels with over 80% carbon savings and 2% points of fuels with 60-80% savings. These percentages are then raised as time progresses. Percentage carbon savings can be set using the methods outlined in Section 4.3.1. If so desired, the total percentage of biofuels can also gradually be increased.

Volume effectiveness (with respect to both carbon savings and biofuel volume)
- This policy scenario is geared to securing a certain reduction in carbon emissions as well as a certain volume of biofuels.
- This scenario can also guarantee that biofuels achieving the high percentage carbon cuts required are indeed marketed - regardless of trends in the cost of today's biofuels.
- As in the previous scenario, the carbon savings are better guaranteed if weighting is based on calculated carbon reductions rather than on a set of fixed categories. In the latter case there is a major likelihood of some biofuels scoring better, or worse, than originally assumed.
- The government can vary the percentages of the various categories to give industry the time it needs, thereby seeking to achieve gradual, staggered market introduction of the new technologies.

Market assurance (essential for investment in new fuels)
- If the percentage obligations are laid down for several years in advance (preferably with the intention of continuing further down the road taken), this policy can provide the assurance that investments in better performing biofuels will be deemed worthwhile.
- This policy gives industry a good measure of assurance there will be a market for the biofuels they may be launching in the future, for any higher costs will be acceptable. Within each category the biofuels will be competing with one another, but between categories there will be no such competition.

Flexibility (fuel and feedstock costs, technological trends, fuel types, etc.)
- This policy scenario is relatively rigid. It is the government that determines when a particular category of biofuels comes onto the market and in what quantities. Only within the categories is there any free choice.
- As a result, there will be only limited scope for the market to absorb developments in feedstock costs, technologies and so on.
- Faced with these kinds of (unforeseen) developments, the government could obviously simply adjust the percentages. This will have a negative impact on

market assurance, though, and thus on returns on earlier investments. It may also reduce willingness to invest any further.

Costs and cost effectiveness

- Because this scenario affords market parties little flexibility, it gives them only limited scope for seeking least-cost solutions. Compared with the previous option, costs may therefore be higher.
- Although the government can allow for anticipated cost trends when setting the percentages, it cannot do anything to directly control the costs or cost effectiveness of the biofuels. If there is a substantial rise in costs, they will still have to be marketed, for otherwise there will be a failure to comply with the obligation. Here, too, the government can build in a ‘safety mechanism’ by putting a figure on maximum costs, as is the case in current policy. This will reduce investment security, however.

Compatibility with EU policy, scope for international harmonisation

- This kind of policy is geared to achieving both carbon savings and a specific biofuel volume. In this respect, then, it is entirely compatible with current EU policy.
- Under EU biofuels policy, member states are free to make their policies as sustainable as they see fit and provide extra incentives for 2nd-generation biofuels if so desired.
- Once again it holds that incentives for biofuels with higher carbon savings will be considerably more effective as well as cheaper if introduced not only in the Netherlands but across the EU. The government should therefore pursue international harmonisation of the categorisation system or carbon calculation methodology and its biofuels policy as such.

4.3.3 Obligation with mandatory average carbon savings

In this policy scenario the government lays down the average minimum carbon savings of the biofuels marketed, specifying, for example, that in 2008 the average savings embodied in all biofuels sold must be at least 40%. This percentage can be raised in subsequent years.

In this case the obvious approach would seem to be to determine the lifetime carbon savings of the various fuels fairly accurately, using a carbon calculation methodology similar to that outlined in Section 4.3.1. Although categorisation is another possibility, there would then have to be at least three categories, for otherwise this option is equivalent to mandatory percentages in each category. If so desired, the total percentage of biofuels can also be progressively increased.

Volume effectiveness (with respect to both carbon savings and biofuel volume)

- This policy scenario is geared to securing a certain reduction in carbon emissions as well as a specific volume of biofuels.
- This option provides guarantees on the average carbon savings embodied in the biofuels sold. There will only be an incentive to market (more expensive) fuels with greater savings than the mandatory average if biofuels with lower percentage savings are available at lower cost. After all, industry will seek the cheapest way of meeting its obligation. Depending on costs and feedstock supplies, it may then be the case that all biofuels end up somewhere around the mandatory average. However, oil companies may also opt for a mix of cheap biofuels with low carbon savings and dearer fuels with higher savings.
- As with the previous options, carbon savings will be better guaranteed if the percentages are based on calculated CO_2 savings rather than a fixed set of categories. In the latter case there is a major likelihood of some biofuels scoring better, or worse, than initially assumed.
- The government can increase the mandatory average percentage savings according to a staggered schedule, giving the industry time to anticipate future developments and take steps to ensure the desired (mix of) biofuels are available on schedule.

Market assurance (essential for investment in new fuels)

- If the government announces several years in advance what figures it is attaching to the mandatory overall volume and average carbon savings (preferably with the intention of continuing further down the road taken), this policy can provide assurances that investments in better performing biofuels will eventually be profitable.
- In this scenario it is unclear, however, when biofuels performing better than the mandatory average will eventually be marketed, as this will depend on the cost of the other fuels being used at that time (see previous point).
- This policy gives industry a good measure of assurance there will be a market for any biofuels they may be launching in the future, for any higher costs will be acceptable. Within each category the biofuels will be competing with one another, but between categories there will be no such competition.

Flexibility (fuel and feedstock costs, technological trends, fuel types, etc.)

- This policy scenario gives the market plenty of scope as to how to comply with the volume obligation and mandatory carbon savings. Within these constraints, the market will be able to absorb developments in feedstock costs, technologies and so on.
- The average carbon savings to be achieved are obviously a constraint and may lead to problems if biofuels with the (high) savings required are available in insufficient quantity.

Costs and cost effectiveness

- Within the given constraints, the market can seek least-cost solutions, as described above. Compared with the previous scenario, costs may therefore be lower.
- When putting a figure on the average percentage savings required, the government can allow for anticipated cost trends, but cannot do anything to directly control the costs or cost effectiveness of the biofuels. If there is a substantial rise in costs, they will still have to be marketed, for otherwise there will be a failure to comply with the obligation. Once again, the government can build in a 'safety mechanism' by putting a figure on maximum costs, as is the case in current policy. This will reduce investment security, however.

Compatibility with EU policy, scope for international harmonisation

- This kind of policy is geared to securing a certain reduction in carbon emissions as well as a certain volume of biofuels. In this respect, then, it is entirely compatible with current EU policy.
- Under EU biofuels policy, member states are free to make their policies as sustainable as they see fit and provide extra incentives for 2nd-generation biofuels if so desired.
- Once again it holds that incentives for biofuels with higher carbon savings will be considerably more effective as well as cheaper if introduced not only in the Netherlands but across the EU. The government should therefore pursue international harmonisation of the categorisation system or carbon calculation methodology and its biofuels policy as such.

4.3.4 Obligation with progressive tightening of mandatory savings

In this policy scenario the requirements set on the biofuels used to meet the obligation are progressively tightened. For example, biofuels giving less than 50% lifecycle carbon savings are no longer allowed after 2010, with this threshold being increased to 60% in 2015, say. The required percentage savings can be established using the method outlined in Section 4.3.1. If so desired, the total percentage of biofuels can also be progressively increased.

Volume effectiveness (with respect to both carbon savings and biofuel volume)

- This policy scenario is geared to securing a certain (minimum) reduction in carbon emissions as well as a certain volume of biofuels. Both can therefore in principle be guaranteed.
- In addition, this scenario can provide an assurance that biofuels will (ultimately) be marketed with which the high percentage carbon reductions we need are indeed achieved.
- There is no incentive to market biofuels performing better than the minimum, however, as these will only be used if they are cost-competitive with the biofuels performing around the minimum, or if the mandatory minimum is raised to 80 or 90%, say. In this scenario, then, the average carbon savings achieved with the biofuels is not likely to be much above the mandatory requirement.

- The industry cannot change from one biofuel to another at the flick of a switch. Although the requirements are being steadily tightened, then, we expect only a gradual rise in the carbon savings achieved.
- For the same reason, the government will only be able to raise the minimum specifications gradually, since the entire volume of biofuels sold must meet these requirements.
- As in the previous scenarios, the carbon savings will be better guaranteed if weighting is based on calculated carbon savings rather than a fixed set of categories. In the latter case there is a major likelihood of some biofuels scoring better, or worse, than initially assumed.
- The government can increase the mandatory average percentage savings according to a staggered schedule acceptable to industry.

Market assurance (essential for investment in new fuels)
- If the schedule for tightening the requirements as well as the carbon calculation methodology to be used are fixed for a number of years ahead (again, preferably with the intention of continuing further down the road taken), this policy can provide assurances that investments in better performing biofuels will eventually be profitable.
- This policy gives industry a good measure of assurance vis-à-vis the market for today's biofuels as well as for any that may emerge in the future.
- If the carbon calculation methodology used is reasonably accurate, though, the industry may well run the risk of supplying biofuels with carbon savings that prove lower than required (owing to disappointing per-hectare feedstock yields due to the weather, for example). These will then no longer be eligible for the scheme and would have to be sold for the going price of fossil fuels.

Flexibility (fuel and feedstock costs, technological trends, fuel types, etc.)
- At the outset (when the minimum requirement is still relatively low) this policy scenario is reasonably flexible, as the market has considerable scope for choosing which fuels it uses to secure carbon savings. As the requirement is tightened, though, this flexibility will decrease, as feedstocks or production processes that are no longer up to the standard will have to abandoned.
- The market will have an incentive to pursue the cheapest biofuel that complies with the standard. This will make it difficult for the industry to market new fuels and expand production capacity (which would lead to cost savings). It is only after the standard has been tightened that the market value of these fuels increases.
- As the standard is tightened, biofuels no longer up to requirements will lose their value, as there will no longer be a market for them (unless they are competitive with fossil fuels). This policy option may therefore lead to destruction of capital, as production facilities cannot simply be readjusted to produce a fuel meeting the new standard. In addition, certain feedstocks or biofuels may lose their value if unexpected circumstances lead to them no longer meeting the standard (due to the weather, for example; see above).
- This means the market has only limited scope for responding to trends in feedstock costs and quality, technology and so on.

- Faced with these kinds of (unforeseen) developments, the government could obviously simply adjust the standards. This will have a negative impact on market assurance, though, and thus on returns on earlier investments. It may also reduce willingness to invest any further.

Costs and cost effectiveness
- This scenario gives the market reasonable scope for seeking least-cost solutions, although that scope declines progressively as the standards are tightened. This may mean higher costs than in the first scenario.
- Although the government can allow for anticipated cost trends when setting the standards, it cannot do anything to directly control the costs or cost effectiveness of the biofuels. If there is a substantial rise in costs, they will still have to be marketed, for otherwise there will be a failure to comply with the obligation. Once again, the government can build in a 'safety mechanism' by putting a figure on maximum costs, as is the case in current policy. This will reduce investment security, however.

Compatibility with EU policy, scope for international harmonisation
- This instrument is geared to achieving both carbon savings and a specific biofuel volume. In this respect, then, it is therefore entirely compatible with current EU policy.
- Under EU biofuels policy, member states are free to make their policies as sustainable as they see fit and provide extra incentives for 2nd-generation biofuels if so desired.
- Once again it holds that incentives for biofuels with higher carbon savings will be considerably more effective as well as cheaper if introduced not only in the Netherlands but across the EU. The government should therefore pursue international harmonisation of the categorisation system or carbon calculation methodology and its biofuels policy as such.

4.4 Long-term scenarios

The obligation on biofuels being introduced in 2007 may be a good way for the government to get new technologies onto the market. In terms of development, biofuels have long way to go before they catch up with their fossil counterparts and an obligation of this nature is a robust government incentive for encouraging use of alternative fuels. Although costs will be high at the start, they will fall as progressively greater volumes of the fuels are produced and consumed.

It is the government's intention that this obligation will be in force for some time to come, with scope for adjusting the percentage of biofuels and required carbon savings to moving targets and circumstances. The EU has also recently indicated its preference for a biofuels obligation, among other things to ensure that targets are indeed secured and that policies are internationally harmonised.

It is perfectly feasible to adopt one of the above policy variants in the coming years and continue to pursue that course over the longer term. In each of the above scenarios the policy can be shaped such that the biofuels complying with the obligation are eventually climate-neutral. Each of the variants then retains its particular qualities and the pros and cons outlined above. This option will not therefore be discussed any further here.

In the course of time, however, it is by no means inconceivable that alternative policy options will emerge. Once biofuels have gained a market foothold and institutional barriers have been removed, there may no longer be a need for regulatory policies of the kind we have been considering. Below we therefore examine three scenarios for the longer term:

1 Continuation of the obligation.
2 Replacement of the obligation by a carbon tax.
3 Replacement of the obligation by an emissions trading scheme.

In doing so, we assume these policies will not be introduced for some time to come, and not until there is a clear trend towards biofuels that perform better environmentally. By that time, biofuels will already be widely available and initial barriers (technical, legal, costs, etc.) will have been removed.

What we do not consider here are the modalities of the switch from one policy to the other. This will require a prudent and possibly staggered approach, to provide industry sufficient security of investment[7].

4.4.1 Obligation superseded by a carbon tax

If the government opts for a financially based instrument as a means of getting a major volume of biofuels on the market *and* moving towards a more sustainable economy, it could impose a tax on fuel producers proportional to the carbon density of the fuel in question. Reducing fuel duty in proportion to embodied carbon savings is a similar instrument, the difference being that in the former case of a carbon tax it is consumers, ultimately, that will pay an additional charge, while lower excise duties mean less revenue for the government. For an honest comparison of fuels, and because it makes no difference to the climate where greenhouse gases are emitted, carbon emissions in the recovery, transport and production phases of the fuel lifecycle must all be included.

The level of the charge and/or subsidy can be established in various ways. One way is by internalising certain external costs, including the cost of carbon emissions. At a macro-economic level, internalisation of external costs leads to efficient allocation of resources and thus to a minimum burden on the economy as a whole (for further consideration of this issue, see Annex D). This charge would not have to be restricted to the transport sector, it is worth noting, but could be implemented economy-wide to create a level playing field. It would lead to a

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7 If a far smaller volume of biofuels were to be marketed under the new policy than under the old, for example, many companies in the biofuels business would face financial problems .

substantial increase in the price of fossil fuels (provided fuel duty is not reduced by way of compensation).

In internalising external costs, the government faces the challenge of putting a figure on these costs. This is by no means straightforward, as we set out in Annex D. An additional complicating factor is the wide variety of sources from which biofuel feedstocks can be drawn. When it comes to carbon emissions it makes a great deal of difference whether the sugar used in ethanol production, say, comes from sugar beet or cane, and that difference will be even greater if and when ethanol from woody biomass comes onto the market. That wood can originate from anywhere in the world, in principle, with major implications for carbon emissions during transport.

A different approach to establishing the level of a carbon tax is to create equal or comparable prices at the pump. In that case the government needs to have a thorough understanding of the cost price of fossil fuels and various kinds of biofuel, as well as any other alternatives. Market parties may have strategic motives for withholding information on certain aspects of their cost price, however, or providing a less than honest picture, indeed, so as to hold back part of the difference in charge as profit. Under this scenario, moreover, the charge should ideally be indexed to trends in the prices of the various (fossil and bio-) fuels.

With time, the additional cost of biofuels is anticipated to decline. On the one hand, costs will fall as production volumes grow (see Section 3.3.1) and on the other it is expected that the switch to 2nd-generation biofuels will, for a broadly similar volume output, also involve cost reductions (see Annex B). With this policy instrument, the government can provide additional incentives for new technologies, by (temporarily) introducing a subsidy on low-carbon fuels along with the charge on high-carbon fuels.

Volume effectiveness (with respect to both carbon savings and biofuel volume)
- The impact of a carbon tax (in terms of both carbon cuts and biofuel volume) depends on its level and on market circumstances. Only if fossil and alternative fuels have a similar price at the pump will such a tax lead to biofuels gaining a significant market share.
- Under this scheme, least tax is paid on biofuels embodying the greatest lifecycle carbon savings. This gives a clear incentive to continue to reduce carbon emissions. The precise impact will depend, however, on how the charge level compares with any additional costs.
- A carbon tax will lead to a decline in fuel demand (unless compensated by a reduction in fuel duty, say, leaving pump prices unchanged). This will also reduce carbon emissions. Higher fuel prices also create an incentive to develop and market fuel-efficient vehicles.
- An important element of this policy, and possibly decisive for its effectiveness, is the methodology used for assessing fuel carbon emissions.
- The effectiveness of the tax can be improved if the government uses the revenues for climate policy in other sectors of the economy.

Market assurance (essential for investment in new fuels)

- If the carbon tax is implemented as a long-term policy that can be relied on, it will give market parties the assurance they require, for industry can then assess whether investment in particular trends or production methods make business sense.

Flexibility (fuel and feedstock costs, technological trends, fuel types, etc.)

- This policy scenario gives the market plenty of flexibility. It does not regulate biofuel volumes or characteristics, nor the types of fuel to be marketed. Within the constraints of the carbon tax, the market will seek the cheapest fuels for meeting consumer demand. If oil prices rise, the market can respond by selling more biofuels, with the opposite happening if biofuel prices rise. If climate-neutral fuels can be profitably marketed (at a lower carbon tax rate), that will happen.
- If the government is unhappy with the outcome of the tax (because too little climate-neutral biofuel is being marketed, for example) it can adjust the charge level. This will be at the expense of market assurance, though, and thus on returns on earlier investments. It may also reduce willingness to invest any further.
- This carbon tax is not technology-specific. In principle, the embodied emission of any fuel can be calculated and the supplier charged accordingly.

Costs and cost effectiveness

- This policy scenario is geared specifically to cost effectiveness. Emission abatement measures costing less than the tax will be implemented, while those costing more will not[8].
- The charge level thus also determines the maximum costs that industry will be prepared to incur for a given CO_2 emission reduction.
- The cost to government is low, as most costs will be borne by fuel consumers.
- Administrative costs need not rise substantially. Oil companies will have to provide detailed reports on the fuels they sell, as they already do at the moment. The system can be straightforward and dovetail with fuel duty administration.

Compatibility with EU policy, scope for international harmonisation

- The Netherlands is at liberty to introduce a carbon tax.
- It is as yet unclear how international/EU (bio)fuels policy will develop, and whether the Dutch government will eventually opt to replace the current obligation by some other form of policy.
- Once again, it holds that incentives for biofuels with higher carbon savings will be considerably more effective as well as cheaper if introduced not only in the Netherlands but across the EU.

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[8] This holds in a perfect market. In practice, however, other considerations will also play a role, such as risk avoidance, anticipated long-term trends, convenience, etc.

4.4.2 Obligation superseded by emissions trading

In 2005 the European Union launched a CO_2 emissions trading scheme (EU ETS) for the industrial and energy sectors and in the meantime plans are emerging to include the aviation sector, too. It is not inconceivable, then, that the ETS will eventually be extended to encompass certain other modes of transport (including road transport) or perhaps even to the sector as a whole.

If at some time in the future it is indeed decided to pursue this path, the biofuel obligation could in principle be phased out. After all, the trading scheme would then ensure that carbon emissions do not exceed the set target (i.e. emissions cap). Below we examine the implications of this for a transition to climate-neutral fuels. It should be noted, though, that it is also possible to implement both these policies, in which case there would be even greater incentive for (and regulation of) climate-neutral fuels.

If the government decides to use carbon emissions trading as a means of getting a substantial volume of climate-neutral fuels onto the market, it will first of all have to introduce an obligation for relevant parties to dispose over CO_2 allowances. There are two options here: the obligation could be imposed either on oil companies or on consumers. In the first case, the oil companies would have to surrender allowances for the carbon emissions of the fuel they sell. In the second case, consumers would have to pay for their fuel at the pump financially as well as in terms of allowances (using a special electronic card, say). The allowances can either be auctioned to oil companies or allocated on the basis of their historical market share ('grandfathering') or, alternatively, gradually allocated to car owners. Whichever party is endowed with allowances, emission allowances can obviously be traded.

It is to be queried whether a system of emissions allowances for the transport sector should be tied to the current European ETS. One argument in favour is that it increases the allocative efficiency of the European economy, with emissions reduction taking place where costs are lowest. According to current estimates, under this scenario it will be mainly the transport sector that buys allowances from industry, for example, where emissions can be reduced at lower cost. The drawback here, though, is that European industries may consequently become less competitive than industries in countries without an emissions trading scheme.

A separate scheme for the transport sector (or road transport alone) does not have this drawback, because this sector is scarcely exposed to international competition, if at all (and certainly not from outside the EU, ocean shipping and aviation excepted). On the other hand, a separate scheme for transport would push up the price of emission allowances.

A wide-ranging exploration of the options available for this kind of policy for the transport sector can be found in (CE, 2006b). For a description of emissions trading schemes, including the ETS, the reader is referred to (OECD, 2005).

As in the case of a carbon tax, the government would have to determine the carbon emission embodied in each fuel in order to establish how many allowances must be surrendered for each litre of fuel. The procedure for this would be similar to that to be developed for use with the obligation in the coming years.

Volume effectiveness (with respect to both carbon savings and biofuel volume)

- An emissions trading scheme like the ETS limits the total carbon emissions of all the sources included in the scheme. In that respect, then, effectiveness is guaranteed.
- Provided the carbon emissions of various fuels can be accurately calculated, a trading scheme is an effective way of reducing emissions. The magnitude of the impact is determined largely by the government, the party deciding the number of allowances allocated.
- This policy gives the government no means of controlling the market share of biofuels (or other alternative fuels). If climate-neutral fuels become a more expensive, or otherwise less attractive, means of securing carbon savings than alternative abatement measures, consumers will opt for the latter[9]. It holds equally, of course, that the volume of biofuels or climate-neutral fuels marketed will rise as they improve their competitive edge over other abatement measures. It should be added that 2nd-generation biofuels *will* probably be competitive, this already being the case for Brazilian ethanol, for example (excl. import charges).
- If the emissions trading scheme is trans-sectoral (if transport is included in the EU ETS, for example), consumers and industry are even at liberty to achieve the carbon emission cuts required of them in other sectors. The transport sector will then be co-funding those reductions, because additional emission allowances will have to be bought.
- Under a scheme of this nature it is also in principle possible to take as a basis the *lifecycle* reduction in carbon emissions embodied in the fuel. In this variant, fewer emission allowances would be required for fuels with high lifecycle emission cuts than for those with less. The scheme thus creates an incentive to improve the carbon performance of the biofuels still further. The impact will depend, however, on the price of the emission allowances compared with any additional costs incurred. A key element of this policy is therefore the methodology used for calculating fuel carbon balance.
- Another option, however, is to design the scheme such that no allowances are required for biofuels (and also possibly hydrogen). After all, it is in other sectors of the economy that *lifecycle* carbon emissions occur, where other policies are in force (or which may also perhaps be included in the ETS), while vehicle tailpipe emissions are merely equivalent to the amount of carbon absorbed by the feedstock crops during cultivation. This makes the system more straightforward, but at the same time means the policy can no longer be used to stimulate innovation and R&D on climate-neutral fuels.

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9 Consumers do not always opt for the cheapest solution, with factors like comfort, status and so on also often playing a role. A good example is the purchase of a new car, with many people not going for the cheapest or most efficient vehicle, but keen to pay more for a bigger, more powerful model with all the latest trappings.

- As allowances cost money, emissions trading in the transport sector may increase the average price of fossil fuels. The precise increase will depend on the price of an allowance, which will in turn depend on the level of the emissions cap, the costs of carbon abatement measures and how allowances are allocated. As already mentioned, any fuel charge will depress fuel demand (unless it is compensated by a fuel duty derogation, say, leaving consumer fuel prices unchanged). This in itself will also reduce carbon emissions. In addition, higher fuel prices create an incentive to develop and market more fuel-efficient vehicles.

Market assurance (essential for investment in new fuels)

- An emissions trading scheme for the transport sector, or inclusion of the sector in the EU ETS, gives the market the assurance that emission abatement is financially attractive. This obviously means the policy has to stand for a good length of time.
- The price of an emission allowance will always be uncertain, though, because the costs of the required abatement measures are themselves unclear. Industries seeking to invest in sustainable fuels will have to factor this uncertainty into their calculations. There will be plenty of experience with this in the years ahead in the context of the EU ETS[10].
- The government can give added market assurance by being as clear as possible about how the scheme is to be shaped and how it is to evolve, in terms of the allowance allocation method to be used and the level of the cap, among other things. Because emission reductions are not achieved overnight (particularly, in our present context, given the time required to build biofuel facilities) a lead time of several years is desirable.

Flexibility (fuel and feedstock costs, technological trends, fuel types, etc.)

- Emissions trading gives the market plenty of flexibility. As with the carbon tax, it does not regulate biofuel volumes or characteristics, nor the types of fuel to be marketed. The market simply gravitates towards the cheapest means of respecting the emissions cap. Emissions can then be reduced by using climate-neutral fuels, by driving fewer kilometres or transporting goods more efficiently, by using more efficient vehicles, and so on.
- If the transport sector is included in the EU ETS, there will be even greater flexibility and it can be opted to seek greater emission cuts in other sectors within the ETS.
- In its allocation of emission allowances and by setting the emissions cap, the government has some scope for steering developments.
- The scheme is not technology-specific. In principle, the embodied emission of any fuel can be calculated, so all fuels might be included in the scheme.

[10] From recent reports of EU Member States it has transpired, for example, that a number of countries have issued more emission allowances than necessary. When this news broke at the end of April 2006, the going price for an allowance fell from € 30 to € 16 per tonne within a few days (www.endseuropedaily.com).

Costs and cost effectiveness

- An emissions trading scheme provides a strong incentive to reduce carbon emissions at lowest cost, thus optimising cost effectiveness. Abatement measures that are cheaper than the price of emission allowances will be implemented, while more expensive ones will not[11].
- The (anticipated) price of an emissions allowance therefore determines the maximum costs that will be incurred to achieve a given emission reduction.
- Transaction costs depend very much on the choice of the active party. If it is consumers that are doing the trading, costs will be considerably higher than if this is the oil companies. In the latter case, there will be fewer parties burdened with the business of day-to-day administration and the costs to government of administration, allocation, enforcement, etc. will also be lower. The oil companies will have to report accurately on the fuels they sell, as they already do under fuel duty legislation.
- Under the current ETS, allowances have been distributed free of charge in the Netherlands according to a negotiated allocation method. Alternatively they might be auctioned, though. The cost of additional allowances and of emission reductions (such as any additional costs of climate-neutral fuels) are paid by the party trading. If this is the oil companies, these costs will be passed on (in large measure) to consumers.

Compatibility with EU policy, scope for international harmonisation

- The Netherlands is at liberty to implement a CO_2 emissions trading scheme for the transport sector. Linking up with the ETS means agreement will have to be reached with other EU member states.
- It is as yet unclear how international/EU (bio)fuels policy will develop, and whether the Dutch government will eventually opt to replace the obligation by some other form of policy.
- Once again, it holds that incentives for biofuels with higher carbon savings will be considerably more effective as well as cheaper if introduced not only in the Netherlands but across the EU.

4.5 Other key issues

All of the scenarios examined above can, in principle, be used to shape a generic policy package to encourage development and (increasing) use of climate-neutral biofuels. We now discuss a number of aspects important for policy effectiveness and implementation that have not yet been explicitly discussed.

Carbon balance methodology

If the biofuel obligation is to be used to achieve rising carbon savings in the fuels marketed, it is essential to know, for every biofuel (or any other fuel from renewable sources), the lifecycle carbon savings it embodies. This can either be done precisely, using some form of carbon calculation method, or less precisely, by categorising each biofuel according to its basic class and the kind of biomass used to produce it, for example. In the first variant, specific localities and

[11] This holds in a perfect market. In practice, however, other considerations will also play a role, such as risk avoidance, anticipated long-term trends, convenience, etc.

circumstances can be included, creating an incentive to produce the fuel with a minimum of greenhouse gas emissions (minimum fertiliser usage, energy-efficient fuel production, etc.). In the second variant there will be no such incentive, but this is offset by there then being lower transaction costs, because there will be less need for companies to file reports, and enforcement and verification will also be easier, for example.

Whichever approach is adopted, though, the results it yields will only be realistic if two conditions are met:

- A macro-approach must be adopted that considers not only the specific area from which the biomass in question is sourced, but also the bigger picture, including any shifting of impacts that is likely to occur. Does the additional demand for this particular biomass mean an expansion of aggregate farmland acreage, for example, and thus to the felling of forest elsewhere? If so, these impacts must be allocated to the biofuel.
- Cascading must also be included. If waste streams are employed that would otherwise have been used for animal fodder, for example, extra fodder will have to be grown, as demand for the latter will remain unchanged.

It is also wise to examine more closely the precise objectives being pursued. It may, for example, make sense not to focus on (and seek to influence) carbon savings per litre or energy unit of fuel replaced, but to do so for savings *per hectare*. The first indicator is geared to achieving maximum carbon savings, while the second seeks as efficient as possible use of the acreage available for biofeedstock cultivation.

Development of an appropriate methodology is beyond the scope of the present project. For the transition to climate-neutral fuels it is important, though, that a well functioning carbon calculation method be implemented as a matter of priority, because it is a precondition for any policy pursuing a reduction of carbon emissions.

Ensuring biofeedstock production sustainability

As mentioned earlier, the Cramer Commission is currently working on recommendations for sustainability certification of biomass. We advise the government to await these recommendations and then elaborate them for the specific case of biomass for biofuels.

To ensure consistency of government policy, it would seem wise to adopt similar criteria for biomass used in power generation and for biofuels production. For industry, harmonisation with other sectors as well as with other EU nations is also important. Feedstocks are bought on international markets and supplied to a wide range of buyers, while intermediates and end products are resold to various sectors and shipped to numerous countries. For the parties in these supply chains, unambiguous, uniform criteria are therefore of the essence.

As far as we can judge at the moment, any certification developed can be incorporated into the obligation. Biofuels lacking the required certificate could then be marketed in the Netherlands, but would not count towards the obligation.

WTO
The Netherlands is bound by international trade agreements. It is not yet entirely clear whether all the policy options examined earlier in this chapter are indeed feasible under the terms of these agreements, or whether the setting of sustainability requirements on biomass cultivation will be deemed acceptable. Legal experts are currently examining this issue, in the Netherlands as well as the UK.

Innovation subsidies
Subsidies for innovative research on climate-neutral fuels may be an important means of stimulating technologies that are not yet ripe for the market or are still in the demonstration phase. This will be particularly the case with technologies still so expensive that market incentives are insufficient.

From the interviews held with potential biofuel suppliers it was evident that it is above all the smaller firms that would benefit from such subsidies. Larger companies have sufficient funds to finance projects of this scope, in such cases basing investment decisions on projections as to the likely market for the new technology or fuel. Smaller firms are unable to make this kind of investment without incurring major financial risk, which is why government subsidies can be so crucial here.

The effectiveness of government subsidies also depends on the technology concerned and particularly the manner in which it will have to be invested in. Does an entirely new facility have be built, or can existing plant be extended step by step or re-engineered? In the case of ethanol, for example, it is relatively straightforward to extend existing facilities (for ethanol from sugar or cereal feedstocks) by adding a unit for processing woody biomass. In such cases a government subsidy may be an attractive option. The same holds for research programmes. In the case of large-scale plant for Fischer-Tropsch diesel production, the investments are many times higher, however. Existing subsidy schemes then no longer suffice.

Separate treatment of biofuels in petrol and diesel?
In the short term there are a number of advantages in having separate obligations for blending biofuels into both petrol and diesel. This will prevent only biodiesel being blended, which is presently cheaper than ethanol. It is precisely the ethanol route that offers scope, in the years ahead, for a gradual transition from cereals and sugar to straw and woody biomass. In the case of biodiesel, by contrast, there are (as yet) no prospects for developing it further into a (near-) climate-neutral fuel, with 80-90% carbon savings, say. In addition, this policy restricts demand for biodiesel feedstocks, limiting distortion of this market (where the food industry also procures its raw materials).

Whether or not separate targets will also be needed in the longer term cannot be judged with any certainty at the moment, although we do expect the above arguments to retain their basic validity. Petrol and diesel substitutes are produced from a variety of feedstocks using a variety of processes and so in all likelihood there will remain a price differential, too.

Economic impact and assurances to 1st-generation producers

Over the next few years, 1st-generation biofuels will represent the only way of fulfilling the obligation. Initially, then, producers will be investing heavily in such fuels, to build up sufficient production capacity to satisfy growing consumer demand. Industry generally reckons with investments in production plant making business sense if they on stream for at least 10-15 years (at a profit). As a result, they may get into serious trouble if after 5 or 8 years it transpires there is no longer a market for their product. This may be the case if the government drops 1st-generation fuels from the obligation too soon.

This is above all a problem with biodiesel facilities, which will probably not be able to be converted to 2nd-generation plant. In the case of ethanol capacity this may well often be possible, however.

Vehicle fleet

With the vehicle fleet as it stands today, the maximum amount of biofuels that can be marketed is about 10%. Current fuel specifications even limit the maximum percentage in standard fuels to 5%. To replace higher percentages of petrol and diesel, the fleet will therefore have to be slowly but surely replaced with vehicles re-engineered to handle higher biofuel percentages. If the government sticks to its plans for a target of 5.75% in 2010, this process will have to be started as soon as possible.

In the case of 2nd-generation biofuels, it may be added, it is only necessary to equip petrol vehicles to burn higher ethanol percentages, as Fischer-Tropsch diesel can be used in existing diesels without any problem.

To this end the Netherlands can implement its own, national policy or, alternatively, pursue a change in EU policy. In the first case, the government could introduce financial/fiscal incentives for flex-fuel vehicles. Consumers could be induced to buy such a car by reducing the vehicle purchase tax paid (which would dovetail with current differentiation, based on tailpipe carbon emissions) and/or a lower annual vehicle circulation tax. This is the approach that has been adopted in Sweden, for example. Because these cars can also run on conventional petrol or low-percentage ethanol blends, this means it is no longer necessary to wait until E85 is on the market.

EU policy could also target the automotive industry directly. The current ‘integrated approach’ seeks to induce car makers to introduce vehicles equipped to handle biofuels. This kind of policy can be designed flexibly, with producers being given the option to manufacture and sell either biofuel-driven or fuel-efficient cars. As noted earlier, though, in the longer term this is not a wise strategy, because optimum use will probably have to be made of both routes if road transport carbon emissions are to be reduced. Car makers might also be obliged to market a (growing) share of flex-fuel vehicles, for example, and equip new diesel vehicles for burning biodiesel. As already mentioned, the latter consideration does not apply to FT diesel, which is of high quality and suitable for today’s diesels.

Biomass at refineries

As discussed briefly in Section 2.3.2, in technological terms it is also perfectly feasible to process biomass directly in refineries (after suitable pre-treatment of feedstocks), just like crude petroleum at the moment. This would also mean substitution of crude, although it is then difficult to say with any precision what proportion of the petrol or diesel is ultimately of biological origin.

This route might have cost benefits, because it obviates the need for several of the processing steps normally required in biofuel production. Under today’s biofuels policy this route is not being rewarded or encouraged, though. We therefore recommend that its potential be investigated and consideration be given to whether this route can eventually also be included in the policy, or a separate policy be established to that end.

Support to Dutch industry

Many of the potential producers of climate-neutral biofuels we spoke to stated or intimated they would be willing to locate in the Netherlands if two conditions were satisfied:

a Sufficient, and sufficiently reliable, feedstock supplies (straw, wood waste, etc.)[12].
b A guaranteed (and profitable) market, preferably combined with flanking policy such as tax breaks.

With respect to the first point, the foreign companies we interviewed (CHOREN and Iogen) did not see the Netherlands as their first choice of location, because of the limited farmland acreage. If the government were to create a market for their product, though, by means of one of the policies examined above within the context of the current obligation, for example, the Netherlands may well become more interesting as a production location, so say both companies. Feedstock supplies must then be a feasible affair, though, with logistics being such a major cost item. Perhaps the port of Rotterdam can serve a purpose here.

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12 These kind of facilities require huge amounts of feedstocks. Iogen, for example, is working on a feasibility study for a cellulose ethanol plant with a capacity of about 200,000 mtpa, which will need to be supplied with about 120 lorry loads of straw a day.

For many of the other companies we spoke to (oil companies and biodiesel producers, for instance) the most important thing is that Dutch policy remains in step with the policies in force in other, larger EU markets (Germany and France, particularly). These companies operate on a bigger scale, for the European market.

The policy process
Given the crucial role of industry (oil companies, biofuel producers, car manufacturers, etc.) in R&D, production and marketing of climate-neutral fuels, the government cannot afford to retreat within an ivory tower when shaping policies in these areas. Consumers will want their questions answered and NGOs will be defending the interests they stand for. The policy process itself is therefore another issue that needs to be given priority status in policy development and implementation.

Market parties should therefore be closely involved in policy development, so that hands-on knowledge and experience is incorporated at all stages of the process. NGOs should be involved so that other interests are represented. This will benefit the quality of policies, improve the practicability of implementation and create the required support among all the various stakeholders. In our view the interviews held in the context of this project, many of them with representatives of the Environment Ministry present, indeed lived up to this expectation. These communicative exercises were also highly appreciated by stakeholders and ministry alike. It is recommended to maintain these communications in the period ahead.

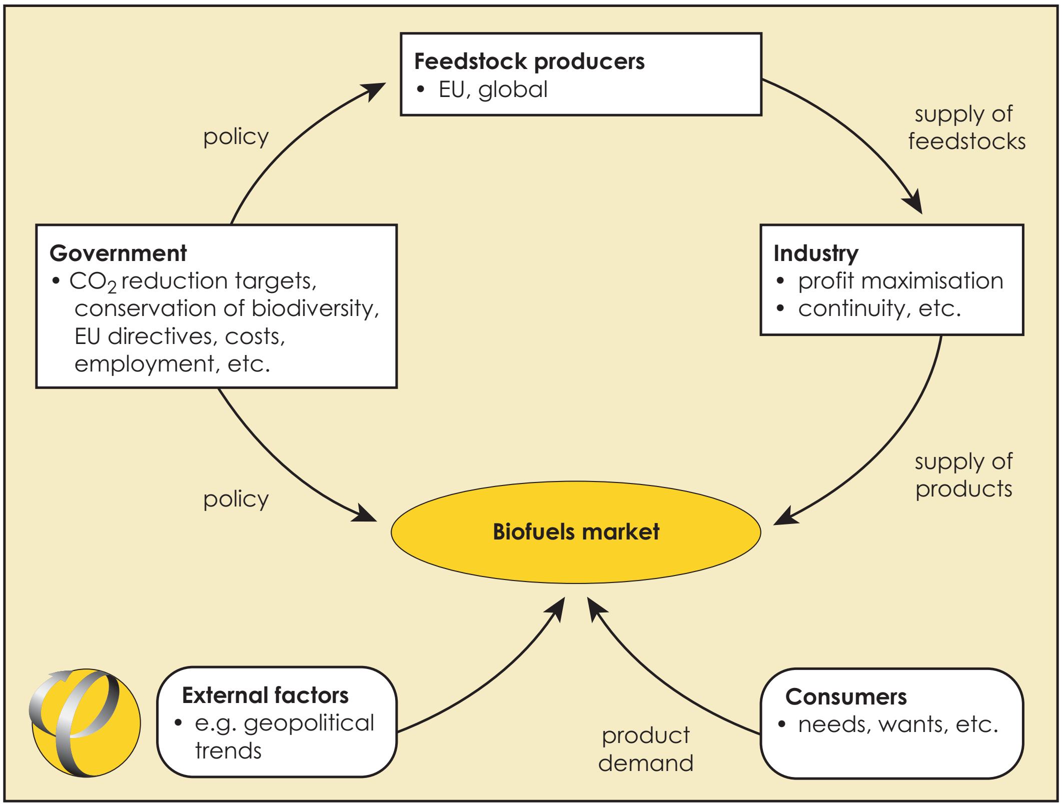
Other institutional barriers
In Section 3.3.3 a number of institutional barriers were cited that have not been discussed above. In many cases these are not specific to climate-neutral fuels, but apply equally to the present generation of biofuels. Where possible, then, these should already be removed in the short term. We are concerned here with the following specific barriers:
- Fuel specifications.
- International tradability.
- Fuel duty indexed to energy density.
- Import duties, excise duty rules for naturalised/denaturalised ethanol.
- Biomass policy in other sectors.

5 Conclusions and recommendations

5.1 Conclusions on strategy

Climate-neutral fuels will not penetrate the market simply of their own accord and the government will only be able to secure its environmental targets if it plays an active role in the fuels market. The government's position in all of this is shown schematically in Figure 5.

Figure 5 A new market for biofuels emerging from the products on sale by market parties, consumer demand and government policy



Any strategy to develop a market for climate-neutral fuels must therefore take as its point of departure not only the government's own objectives but also the empirical behaviour of industries and consumers. In the case of climate-neutral fuels it is industry, above all, that is important, because this the party that will have to invest in R&D and production capacity. Consumers will probably play less of a role, as they will probably not have to alter their behaviour unduly as this new market emerges[13].

[13] In due course, consumers will probably have to switch to a car that can burn climate-neutral fuels. In the medium term, though, it seems unlikely there will be any really substantial changes to vehicles. The greatest changes in this respect will be within the automotive industry.

From our analysis we conclude that any government strategy on climate-neutral biofuels should be constructed around the following pillars:

- Creating a **structural market** for fuels with lower lifecycle carbon emissions.
- Setting **clear policy targets** for the short and medium term.
- Setting **sustainability requirements** on (global) biofeedstock production.
- Ensuring **international harmonisation** of policies.
- Removing **institutional barriers** to market development.
- Ensuring **good policy timing** and **business flexibility.**

These issues were explained and elaborated on in Section 3.3.

5.2 Conclusions on policy options

'Obligation scenarios'

In Chapter 4 we assessed the strengths and weaknesses of four policy options within the framework of the current obligation; the results are summarised below in Table 1. For the purpose of this synopsis we have rated each of them on the evaluation criteria that follow from the strategic 'pillars' just cited (see Section 3.4.1). The scores presented in this table are relative and are based on one and the same reduction in carbon emissions being achieved with the biofuels marketed. What the table shows, in other words, is how the policy scenarios compare if the aim were to get biofuels on the market that achieve, say, 70 or 80% carbon savings.

Table 1 Approximate evaluation of the four 'obligation scenarios', assuming achievement of the same carbon savings

		Obligation with weighting	Obligation with mandatory percentages or categories	Obligation with mandatory average carbon savings	Obligation with progressive tightening of mandatory savings
Volume effectiveness	Carbon savings	++	++	++	+
	Biofuel volume	-	++	++	++
Market assurance		+	++	++	++
Business flexibility		++	-	+	-
Costs and cost effectiveness		+	+/-[a]	+/-[a]	-
International	Compatibility with current EU policy	-	+	+	+/-
	Scope for international harmonisation	+	+	+	+

a Costs depend very much on the precise standards set and may rise steeply if industry sees itself compelled to market fuels too soon in technical and economic terms, for example.

Each of the policy variants can be used to pursue progressive improvement of the carbon savings embodied in the fuels marketed. Equally, they can all be used to create incentives for climate-neutral fuels in terms of R&D and/or final consumption.

There are nonetheless a number of clear differences:

- An obligation with mandatory percentages or minimum mandatory carbon savings can be relatively effective as a means of improving the climate performance of biofuels and has the advantage of allowing the government to steer market developments. It also provides industry a fair amount of assurance with respect to future market trends. The drawback of these options is that they leave industry relatively little scope for using the optimum fuels, from their perspective, for fulfilling the obligation. This will lead to higher costs and there is moreover a risk of the market being unable to meet the set requirements, because technologies are not yet ripe for scaling up, for example.
- In the case of minimum requirements, biofuels performing better than that minimum will have an added advantage. If the standard is set relatively low, this will stand in the way of better performing fuels penetrating the market, as their market value will only rise if the mandatory requirements are tightened.
- In other policy options, more expensive, better performing biofuels do have added value. In the second option in Table 1 the market and thus the added value of these fuels is guaranteed, while in the other options these both depend on the cost and availability of poorer performing biofuels.
- The first variant will probably entail the least overall costs. In this scenario, oil companies can opt to fulfil (part of) their obligation with a limited volume of biofuels embodying higher carbon savings than required. They will then need to sell less of these fuels, implying that total additional costs may end up lower than in the other scenarios.
- An obligation with weighting is thus the only variant in which the volume of biofuels is not specified beforehand. If relatively well performing biofuels are marketed, their total volume will be lower than if their embodied carbon savings are less. Conversely, if the fuels marketed perform poorly in this respect, more of them will (have to) be sold. For this reason this option does not dovetail well with current EU policy, which seeks to achieve a specific biofuel volume.
- The last variant, too, with minimum mandatory carbon savings, scores worse on the criterion 'compatibility with current EU policy'. In this scenario the minimum requirement will have to be set relatively high to ensure that biofuels with certain (relatively high) carbon savings are marketed. This means that some of the biofuels allowed in other EU countries will not be eligible as a means of fulfilling the obligation.
- Weighing up the various strengths and weaknesses, we conclude that an obligation with mandatory average carbon savings scores best, for in this variant the terms of the EU directive can be complied with while still giving the market sufficient flexibility.

- If the cost aspect is held to be more important than a certain volume effectiveness, a variant with weighting can best be adopted. The government can then oblige market players to achieve a certain reduction in carbon emissions, by assigning weights proportional to embodied fuel savings. This policy also allows the government to vary the weighting factors, to create an additional (temporary) incentive for climate-neutral fuels.

The option of an obligation with mandatory minimum savings could possibly be combined with one of the other options. This could be done to prevent biofuels being marketed that embody very little carbon savings or even lead to an increase in emissions, as in the case of biodiesel from palm oil grown on peaty soils, for example. It is the first two options that are most eligible for combination in this respect. In the case of an obligation with weighting, a mandatory minimum is a useful way of preventing that it is only relatively inferior biofuels that are marketed. If some form of categorisation is employed, it makes sense for similar reasons to set a minimum standard for the lowest category, for otherwise it may well be bulked out largely with (very) poorly performing fuels. In the case of an obligation with mandatory average carbon savings, there is less need of a minimum standard, for there will then be a guarantee that relatively inferior fuels will be offset by sales of an equal amount (energy content) of fuel embodying higher carbon savings, ensuring the reduction target is still met.

Long-term scenarios

We now move on to the long-term scenarios analysed in the previous chapter. These too were assigned an approximate score on the various evaluation criteria, as shown in Table 2.

Table 2 Approximate evaluation of the long-term scenarios

		Continuation of obligation	Replacement of obligation by carbon tax	Replacement by emissions trading
Volume effectiveness	Carbon savings	++	+/-	+
	Biofuel volume	++	-	-
Market assurance		++	+	-
Business flexibility		-	+	+
Costs and cost effectiveness		-	+	++
International	Compatibility with current EU policy	?	?	?
	Scope for international harmonisation	+	+	++

With respect to these policy options we conclude as follows:

- All three long-term policy options examined can be very effective for reducing carbon emissions.
- The main difference between a carbon tax and emissions trading is that the former puts a cap on the cost of abatement measures rather than on the emissions themselves, while the latter caps emissions rather than costs.
- Both these policy instruments create a level playing field with respect to other potential routes to emissions abatement. This leaves it to the market to decide whether cuts are achieved by means of efficiency measures, for example, or low-carbon fuels. These instruments will therefore only lead to successful market penetration of climate-neutral fuels if they represent a route that is competitive with other measures.
- Continuation of the current obligation for climate-neutral biofuels does provide assurances with regard to the volume of such fuels consumed. To an extent, the pros and cons will depend on the policy route adopted, as set out above.
- Any far-reaching policy change can have major consequences for industry and must therefore be managed extremely carefully. It is more than likely that a policy change will be followed by a sea change in demand for biofuels and ditto in their price.
- This kind of unwanted market distortion can be avoided by postponing any policy switch until such time as biofuels are competitive with their fossil counterparts or with other emission abatement measures.
- A carbon tax or emissions trading might also be combined with an obligation to producers to market a certain percentage of climate-neutral fuels. This would reduce the cost effectiveness of emissions abatement, however, thus going against the very grain of these policy instruments.

The cited policy instruments can help create a structural market for climate-neutral fuels. That in itself is not enough, though. It is also vital that the government establishes sustainability requirements, to prevent any shifting of impacts. In particular, constraints need to be set on the origin of biofeedstock supplies and the cropping methods used to produce them. Only in this way can it be ensured that whatever policy is implemented - the core aim of which will remain carbon emissions reduction - it does not create new problems with respect to the environment, biodiversity or social welfare. This issue is not specific to future climate-neutral fuels, it may be added, but already needs to be suitably regulated for the biofuels coming onto the Dutch fuels market now and in the near future.

Whichever policy variant is adopted, industry will only invest in new technologies if it has an assurance there will be a continued market for them throughout the period the production facilities are being written off (10-15 years on average). A policy that is seen as stable and reliable, creating assurances for a good many years ahead, is therefore of the essence. From the perspective of industry it is also important to be able to anticipate policy changes. It takes several years to set up an R&D programme or build a production facility and it is important the government duly allow for this fact when scheduling policy changes.

This last issue we consider the single most important element of any strategy, because only if this goal is assured can a truly structural market be created. It makes good sense, though, to back up any of these policy measures with suitable flanking policy. Thus, subsidies for innovative research on climate-neutral fuels are an important way of supporting technologies that are not yet ripe for the market, i.e. technologies that are still so expensive that market incentives on their own do not suffice. Developments can also be accelerated by ensuring the Dutch vehicle fleet is equipped to handle the new fuels, by means of a tax break for vehicles that can burn higher-percentage biofuels, for example. In the longer term, though, the most productive course of action is to create new EU legislation revising the standards for new vehicles, passenger as well as freight.

5.3 Recommendations

Based on the analysis of this study, we make the following recommendations:

- As a matter of priority, a methodology should be developed for calculating the lifecycle carbon emissions embodied in biofuels or, alternatively, a fuel categorisation scheme. This is absolutely essential for implementing *any* of the above policy variants. In due course, this methodology could be extended so that other climate-neutral fuels can also be promoted under the same policy.
- As a matter of priority, a set of sustainability requirements should be developed to prevent any unwanted shifting of impacts. If things go wrong in this respect, consumers may well turn their back on biofuels.
- International harmonisation increases policy effectiveness and reduces the costs that industry will have to incur in complying with Dutch policy. In addition, companies will be keener to build production facilities in the Netherlands if Dutch policy is in line with that of other EU nations. It is therefore recommended to seek international partners to argue at the EU level for whichever strategy is adopted. The forthcoming review of EU biofuels policy provides a good opportunity in this respect, while the follow-up directive is also to be discussed at some stage in the future.
- Once a decision has been reached on which form of policy is to be adopted, it will obviously have to be elaborated in terms of substance as well as the modalities of implementation. One pivotally important element, though, are the quantitative values adopted for biofuel or carbon savings targets or weighting factors, and their evolution over the years, As these form the cornerstone of the government's ability to steer developments, they should be addressed with the greatest of care.
- Throughout further policy development and implementation, it is also important to make an explicit point of maintaining contact with the various stakeholders. It is therefore recommended to keep up the good communications with stakeholders that have been built up over the past few years.

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A strategy on climate-neutral fuels

Recommendations to the Dutch Environment Ministry (VROM)

Annexes

Report

Delft, July 2006

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A Parties interviewed

For the purpose of this study the following stakeholders were interviewed:

BP	Mike Sharrock, James Primrose, Jacoline Poldervaart
CHOREN	dr. C. Uhle
ExxonMobil	Adrie Teurlings, Nelo Emerencia
Iogen	Christophe Bourillon
Lyondell	Willemien Terpstra, Wiebe Schipper
Nedalco	Martin Weissmann
Netherlands Platform for Sustainable Mobility *(Platform Duurzame Mobiliteit)*	Frits Hermans, Remco Hoogma, Ewald Breunesse, Martin Weissmann
Netherlands Society for Nature and Environment *(Stichting Natuur en Milieu)*	Ron Wit, Jan Fransen
Sabic	Cees Hettinga
Shell	Gerard Fiolet, Leo Petrus, Ewald Breunesse
VERNOF and MVO	Jan van Dril, Coen Blomsma, Henk Kant, R. Macnack, Frank Bergmans, Marieke Leegwater

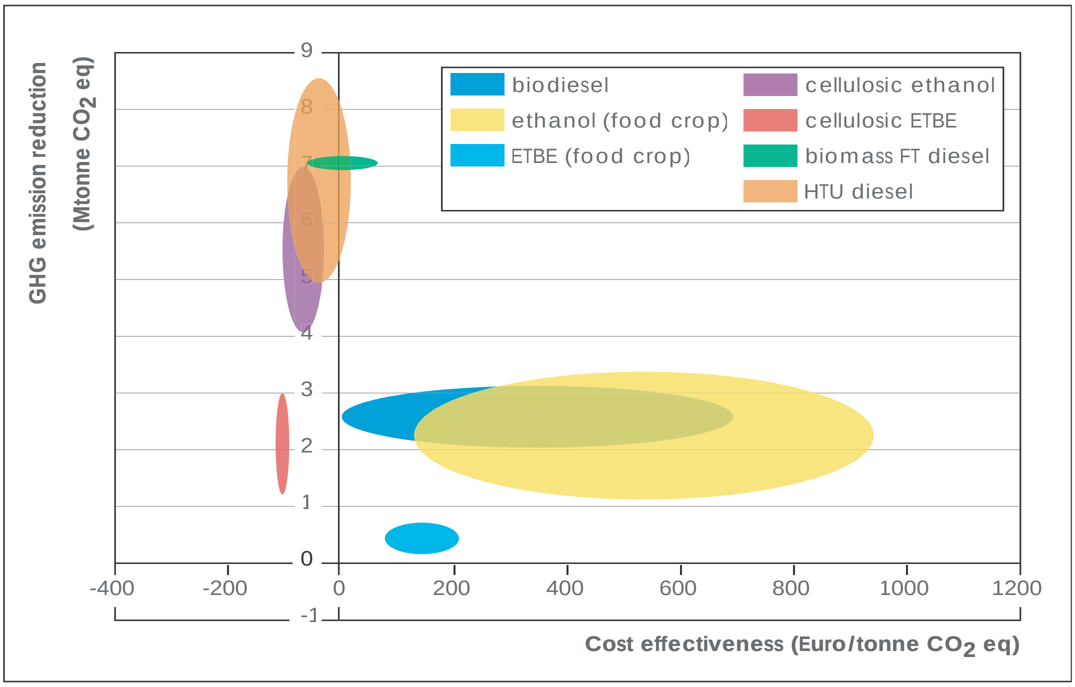
B On current and future biofuels

B.1 Background information

Figure 5, based on data from (CE, 2005) but adjusted to the current oil price, plots the CO_2 reduction potential[14] of current and future biofuels against their cost effectiveness. Biodiesel, bio-ethanol and ETBE from food crops are already on the market, while the other fuels are still under development.

Figure 6 provides a visual picture of the amount by which CO_2 emissions would be reduced in the hypothetical scenario of the respective biofuels replacing 20% of Dutch transport fuels in 2020[15]. Biodiesel and today's bio-ethanol would then lead to a reduction of 1-3 Mt CO_2-equivalent, while FT diesel from biomass, ethanol from woody biomass and HTU diesel would save 4-8 Mt CO_2-eq. To be clear, these last three biofuels are not yet commercially available. In terms of potential carbon savings, ETBE clearly scores somewhat worse than the other biofuels. The reason form this is that ETBE is produced partly from fossil fuels.

Figure 6 Comparison of greenhouse gas reduction potential of the various biofuels in 2020, in the (hypothetical) scenario of them replacing 20% of Dutch road transport fuels by that date



NB: Cost effectiveness is based on average petrol and diesel prices as of September 2005.
Source: (CE, 2005a), with data adjusted to later oil price. The width and height of the coloured 'blobs' indicate the uncertainties in the data.

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14 Although we here use the term CO_2 for the sake of legibility, we are actually concerned with *all* greenhouse gases, expressed as CO_2-equivalents.

15 'Hypothetical', because this scenario would require extremely substantial investments in biofeedstock cultivation, biofuel production, fuel distribution systems, vehicle fleet and so on.

The cost effectiveness plotted on the x-axis is here defined as the ratio between the additional cost of the biofuel - compared with the fossil fuel it is replacing - and the emission reduction it secures. Owing to the anticipated cost reduction and greater carbon savings achievable with the next generation of biofuels, they also perform considerably better on cost effectiveness than their current counterparts. While emissions reduction with the latter still costs several hundred Euro per tonne CO_2-eq., future biofuels are expected to cut this figure to below 100 Euro. ETBE scores relatively well on cost effectiveness, one reason being the fairly high cost of MBTE. ETBE from woody biomass might even become cheaper than MTBE. In Figure 6 this is expressed as negative cost effectiveness.

Because the cost effectiveness of an alternative fuel depends on the cost differential compared with the fossil fuel it is replacing, these data depend on two factors that are difficult to predict at the moment: biomass costs and fossil fuel price. If the first of these rises, the additional costs of these alternatives will likewise rise and their cost effectiveness will decline. If the price of oil rises, on the other hand, the cost differential will be reduced and cost effectiveness improved. The figure thus only shows the situation under the chosen assumptions, including, in this case, the fossil fuel price of September 2005 (the crude oil price is that month was about $60/barrel).

If development of these second-generation biofuels is brought to a successful conclusion, they will score considerably better than their current counterparts, both economically and in terms of carbon emissions reduction. There are other benefits, too, though. With this next generation of biofuels, based on woody biofeedstocks, there will be less risk of competition with the food and fodder industries (today's biofuels consuming potential food crops and agricultural residues from the oilseed, sugar and cereal sectors). In addition, their per-hectare yield (expressed as litres of fuel) is substantially higher than that of some of the current biofuels.

C On the development of new technologies

C.1 Introduction

As discussed in Section 2.2, a number of climate-neutral biofuels are currently under development. Various pilot plants are operational that can convert cellulosic biomass into a biofuel, and research regarding hydrogen as a transport fuel in onging.

The development of new technologies typically follows an established pattern, in which a number of stages are passed through. As the development progresses, more and more experience and knowledge is gained, and the scale of the processes or production is increased. Learning effects and economies of scale then lead to cost reductions. The following description of these developments is taken from (CE, 2006).

C.2 Drivers of trends in cost effectiveness

Most future reductions in CO_2 emissions, in the transport sector and elsewhere, are expected to come from new technologies and from improvements to the technologies available today. Some of these options are already on the shelf, but not yet marketed on any substantial scale. Others are still at the R&D stage, still too immature for market introduction.

Past experience with technological development shows that the cost of using a new technology follows a learning curve that slopes downward with time. If technological development is successful, costs will progressively decline through optimisation of the technology, efficiency gains in production and economies of scale in the production process, among other factors.

As long as the technologies in question are immature, then, new technologies will generally remain unattractive in terms of both cost and cost effectiveness. Once they have been developed further, though, and large-scale market access is secured, they may become more competitive and even outperform more conventional technologies. Deriving a long-term strategy for CO_2 reduction in the transport sector thus requires insight into potential trends in the cost and cost effectiveness of the various abatement options. In arriving at that insight, constraints on improved cost effectiveness that are unlikely to alter over time must be kept separate from those that are susceptible to improvement in this respect.

C.3 Technological development and learning

Various phases can be identified in a technology's life-cycle. In the literature a variety of schemes and stages have been defined for that purpose, one of which is shown in Table 3. Each stage typically takes several decades. However, they are not always well-defined and tend to overlap. Clearly, not all technologies will reach all stages, but only the successful ones.

Table 3 Stages of technological development and typical characteristics (from (Junginger, 2005))

Stage		Mechanism	Cost	Commercial market share
1	Invention	Seeking new ideas, breakthroughs, basic research	High	0%
2	Research, development and demonstration (RD&D)	Applied research, research development, demonstration projects	(Very) high	0%
3	Niche market commercialisation	Identification of niche applications, investment in field projects, learning by doing	High, but declining	0-5%
4	Pervasive diffusion	Standardisation and mass production, economies or scale, building or network effects	Rapidly declining	Rapidly rising (5-50%)
5	Saturation	Exhaustion of improvement potentials and scale economies, arrival of more efficient competitors on the market	Low, sometimes declining	Maximum
6	Senescence	Domination by superior competitors	Low, sometimes declining	Declining

In each of these stages, there are different learning mechanisms and scale effects at work that may work to reduce costs. Utrecht University (2005) has identified the following mechanisms behind technological change and cost reduction:

- Learning-by-searching.
- Learning-by-doing.
- Learning-by-using.
- Learning-by-interacting.
- Upsizing (or downsizing).
- Economies of scale.

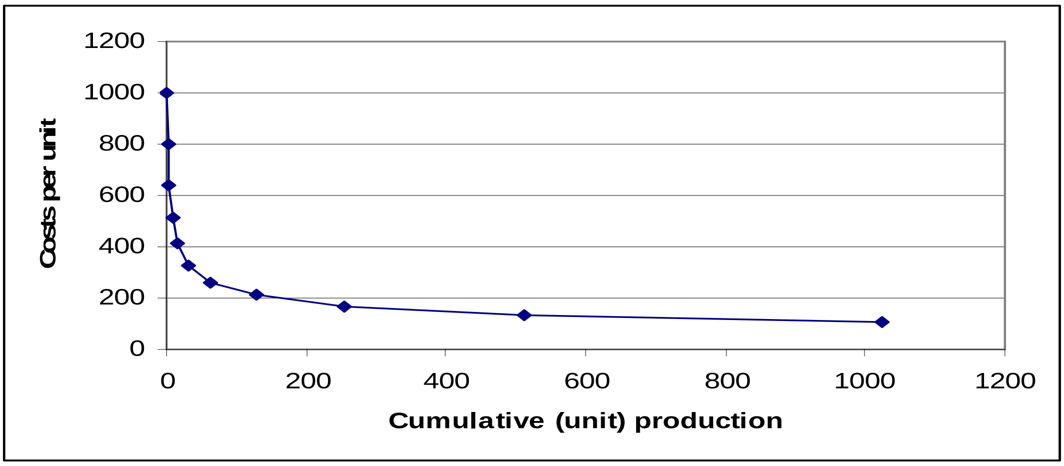
Often, combinations of these factors occur at each stage, although not all of them may apply to all technologies. Competition among manufacturers eventually brings the price of new technologies down sharply.

It should be noted that these learning and scale effects are not limited to technological development and production itself, but also occur at the user level (Sandén, 2005). For example, growing adoption of a technology will decrease the uncertainty of its merits, and service costs will decline with user experience. The appeal of using a new technology may also improve once its market share is on the rise because complementary goods, services and spare parts will then become more widely available at lower cost.

C.4 Effect of experience and economies or scale

Clearly, cost reduction can be achieved both by experience (learning) and by increasing the scale of production. But while the various stages and mechanisms are familiar, predicting the unfolding cost curve for a specific new technology is very difficult. In order to learn from the past, these cost curves have been derived for various technologies with hindsight. Often, a relationship is found between the cost development of a product or technology and its cumulative production. In the literature, the parameter progress ratio (PR) is often used to describe this relationship. PR describes the rate at which costs decline for every doubling of production. For example, a PR of 0.8, or 80%, equals a 20% cost decrease for each doubling of cumulative capacity. To illustrate these effects, a typical cost curve is shown in Figure 7, for PR = 80%. In this example, the cost of one unit starts at 1,000, but falls sharply once production and sales volumes increase.

Figure 7 A typical cost reduction curve, with PR=0.8: unit costs fall sharply as (cumulative) production volume grows



Junginger (2005) has analysed cost trends in various renewable technologies over the past few decades. For onshore wind farms, PR values were found to lie between 77-85%. For electricity from biomass-fuelled CHP plants, PR values of 91-92% were found. For biogas production, the PR was 85% from 1984 to the beginning of the 90s. Between the early 90s and 2002, cost reductions were insignificant, leading to a PR of approximately 100%. (Goldemberg, 2004) analysed the cost trend of ethanol production in Brazil. They found a PR of 93% in the timeframe 1980-1985 and 71% in 1985-2002.

For each technology, the cost reductions were found to be due to different types of learning. In the case of biogas plants, for example, a local, small-scale technology, learning-by-using and learning-by-interacting were found to be the most important learning mechanisms. For CHP plants, upscaling was probably the main mechanism behind cost reduction.

D On market instruments and innovation

D.1 Introduction

The Dutch Environment ministry, VROM, is keen to see climate-neutral fuels playing a key role in reducing the greenhouse gas emissions of the transport sector. As things stand at the moment, biofuels offer the greatest potential in addressing this task, with those available today representing an initial step in the right direction. Cost-effective use of biofuels requires next-generation technologies, however, and these are still not yet mature in commercial terms. The question addressed in this Annex is what framework of incentives is required for the medium term to ensure that these 2nd-generation biofuels establish a firm market foothold.

D.2 Policy objectives

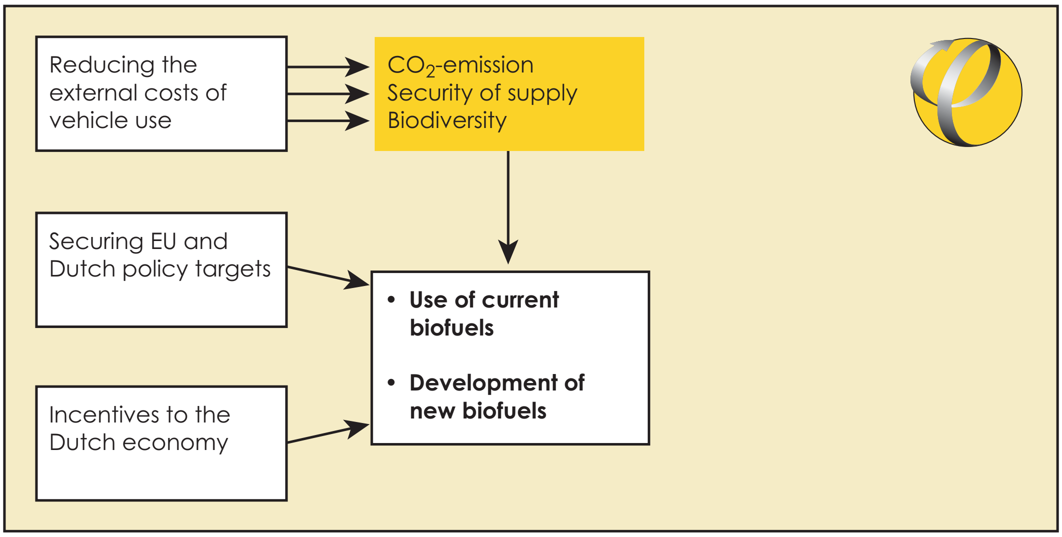
There are three main motives for pursuing greater use of biofuels:

- To reduce the external costs of traffic:
  - By minimising CO_2 emissions.
  - By improving security of supply.
  - By reducing negative impacts on biodiversity.
- To secure the Dutch and EU government's policy targets:
  - Through a substantial share of new biofuels.
- To stimulate the Dutch economy.
  - Through new opportunities.

A first step towards greater use of biofuels can be taken using existing technologies. Before there is really widespread use of such fuels (more than the 2% target set by the Netherlands for 2006), however, it is essential that new technologies become available that reduce the carbon footprint of these fuels substantially further. This is because today's biofuels are relatively expensive and do not always lead to any serious reduction of carbon emissions.

The government has therefore set the country the dual challenge of using technologies already available to the national economy and developing new technologies.

Figure 8 Purpose of climate-neutral fuels



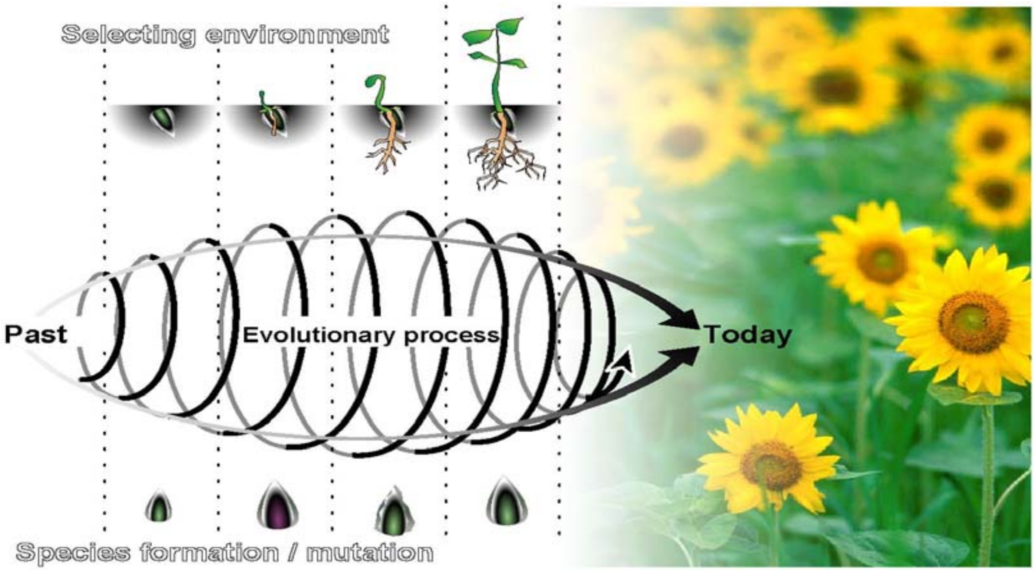
Technological development and diffusion are familiar processes. Innovation is indeed one of the hallmarks of modern economies (Beaumol, 2002). In today's competitive markets, companies cannot survive unless they are innovative. By means of such innovation they aim to enhance their competitiveness, increase their market share and boost their profits.

In a truly free market, producers have little or no opportunity to make a profit on environment-friendly innovations, which have very little added value for consumers. The environmental damage embodied in consumer products is not reflected in their price, after all, and eco-friendly articles are consequently no cheaper (and oftern a lot more expensive) than their polluting alternatives.

The issue of climate change is now challenging society to find ways of ensuring that at least some of the innovative efforts of industry are directed towards successfully reducing greenhouse gas emissions and, in our present context, towards developing cost-effective biofuels and getting them onto the market (Jaffe, 2002). This requires two things: an attractive **market context** and suitable support of the **innovation process** (Jaffe, 2004). In this Annex we shall endeavour to show why both of these are essential.

The situation can be compared with the evolution of biological species, which is achieved through the unending development of new variant life forms, some of which prove to be better equipped for survival than their predecessors. Because the environment selecting them is also changing, life forms with no chance in the old context may suddenly become successful. In the case of biofuels, the 'selecting environment' is the market context and the process of 'species formation' - engine fuels based on the Fischer Tropsch process, HTU, ethanol from woody biomass, and so on - can be hastened through innovation.

Figure 9 Evolutionary process of mutation and environmental selection of successful life forms



D.3 Market context

In and of itself, the market cannot supply public goods like a clean environment. This is because the costs of environmental damage are external costs borne not by consumers (or to a very minor extent only) but by society as a whole. As a result, external costs will play no part in consumer decisions on whether or not to buy a particular product. It is only the government that is in a position to encourage, or compel, consumers to take external costs into account in their purchasing decisions.

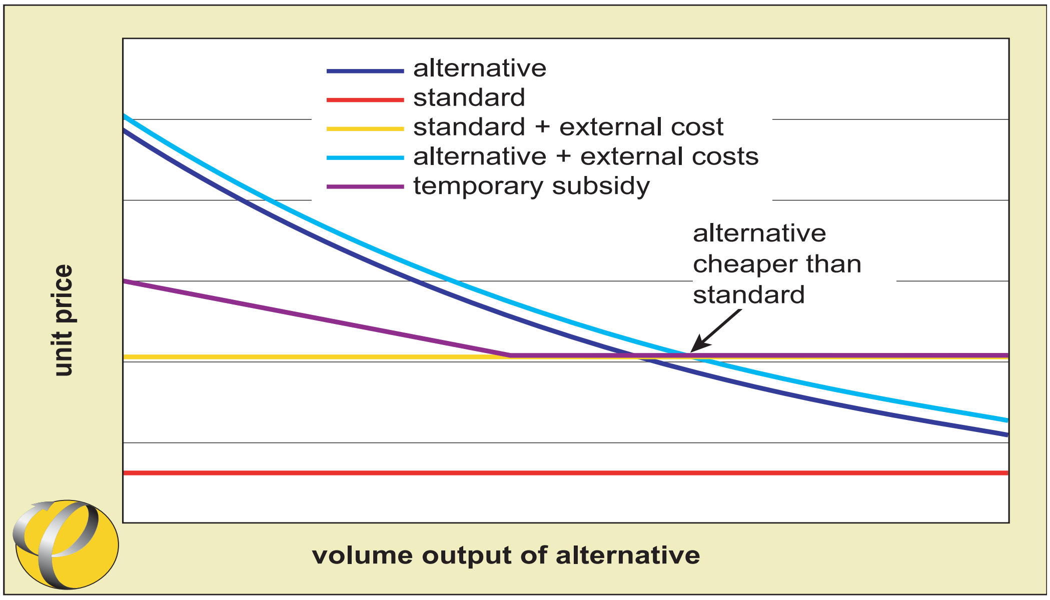
The external costs of fossil engine fuels are higher than those of most biofuels. The direct costs of these fossil fuels are lower, however[16]. Because biofuel production processes are more expensive than conventional technologies and consumers themselves enjoy no benefits by using the fruits of these more expensive technologies, there is currently no market perspective.

> The basic premise is therefore clear: without government action there will be no market for climate-neutral fuels.

16 If oil prices rise any further, a situation may arse in which fossil fuels become more expensive than biofuels. Even in the current market context this would create a strong incentive to use the latter. That incentive would be insufficiënt, however, to get biofuels consumption up to a level at which the overall benefits to society (the net balance of *all* direct and external costs and benefits) is maximum. To achieve this kind of efficiency in fuel consumption patterns, the government must find a way to induce consumers to take the external costs of the various fuels into proper account.

This is illustrated in Figure 10, which shows the hypothetical market prices and external prices of a standard product (unleaded petrol, say) and a number of alternatives of equal value to consumers (petrol-ethanol blends, say). Under normal market conditions the standard product is far cheaper than the alternatives and will therefore have a higher share of the market[17]. Unit for unit, however, this product also has the highest emissions. This means the external costs of the conventional product are higher than those of the alternatives. If consumers took both the direct and the external costs into account in their decisions, they would not opt for the conventional product but for alternative 2a or 2b.

Figure 10 Competition between several fuels with different external costs



In the case of current biofuels (alternative 1) internalising the external costs does not yet mean they become cheaper than conventional vehicle fuels. Only when alternative 2 becomes commercially available (2nd-generation biofuels) can biofuels gain a slice of the market.

Internalising external costs will move companies to develop and introduce environment-friendly technologies and subsequently fuels in the same way that a rise in wage costs moves companies to save on labour, say, or a rise in oil prices creates an incentive to save on fuel (Jaffe, 2004; Hicks, 1932).

17 It should be noted that although a small number of consumers *are* willing to pay more for eco-friendly products, experience shows that this group is never larger than about 5%. In this report we are looking at a (far) greater share of the market than 5%.

External costs

The external costs include, first, the cost of CO_2 emissions, reduction of which is the prime aim of Environment ministry policy. Security of supply also has its external costs (and benefits), though, which vary according to fuel type and energy source. In addition, security of supply can be improved by using as range of fuels sourced from a suitable portfolio of regions (risk-spreading). The third kind of external costs derive from any biodiversity impacts associated with biofeedstock cultivation as well as with fossil oil recovery. In this report we give no further consideration to the costs and benefits of security of supply and biodiversity, but these can in principle be factored in in the same way as the external costs of CO_2 emissions.

To create a level playing field on which the various technologies, with their different external costs, can compete, it is essential that the external costs be shouldered by the parties inducing those costs. The government can achieve this end by means of a charge equal to the (marginal) external costs: a so-called Pigouvian tax. The advantage of such a tax is its efficiency: the objective (in this case, carbon emissions abatement) is achieved at the lowest cost to society (Verhoef, 1999). Over and against this stands the fact that any new tax generally meets with major resistance. There is perhaps a more serious problem, though: there is no generally agreed procedure for calculating external costs. A major European research programme on the external costs of air pollution from power stations, for example, reports uncertainty margins greater than the external costs themselves (External, 1998).

There are other ways of improving the market position of biofuels relative to fossil fuels. We mention two here: standards and tradable emission allowances. These methods act in the same general direction as internalising external costs: they promote biofuel sales or reduce the price differential between fuels with low and high external costs, and may even reverse that differential. Formally speaking, though, they cannot be regarded as internalisation of external costs: standards do not work according to a price mechanism and in the case of tradable allowances the price of an allowance is governed by the cost of emissions abatement and not by the environmental damage caused.

Standards, in the form of obligatory blending of biofuels, for example, puts a cap on the maximum costs to be borne by society as a whole. Standards are not economically efficient, because they provide no scope for market mechanisms to determine which of the options for achieving the target are adopted. For this reason, the total cost to society is higher than in the case of a charge (Popp, 2001). From the angle of economic welfare, then, standards are not a good instrument. On the other hand, they constitute an unambiguous form of policy that might be less contentious than a charge. In the transport sector, where price elasticities are low, standards are more effective than charges, provided the standard is sufficiently stringent, that is.

Under a system of tradable emission allowances, oil companies or end users would have the right to emit a certain amount of CO_2 or be able to acquire allowances for that purpose at auction. At the filling station this would mean having to surrender a number of allowances equivalent to the carbon emissions embodied in the fuel. Vehicle users with surplus allowances would be allowed to sell these to users with too few. In this kind of scheme the price of an allowance is determined by the marginal costs of emission reduction. These costs are not necessarily equivalent to the external costs. The advantage of tradable allowances is that emissions reduction is achieved at the lowest possible cost. In addition, industry appears to be less opposed to tradable allowances than to Pigouvian taxes.

Summarising, there are three basic ways of improving the market position of biofuels relative to fossil fuels:

Standards
For example, by obliging all road vehicle fuel suppliers to market a specified percentage volume of biofuels.

Charge
For example, by levying a charge on vehicle fuel consumption indexed to external effects (e.g. proportional to net carbon emissions).

Emissions trading
For example, by obliging emitters to surrender carbon allowances for the CO_2 they emit, setting an emissions cap for the transport sector as a whole and tying this into an emission trading scheme.

If climate-neutral fuels are to gain a substantial market share, there must be a structural improvement of the market status of biofuels relative to fossil fuels.

Market context and innovation

Each of these three market contexts has a different effect on the direction taken by innovation. In the main, the biggest difference is between standards on the one hand and charges and tradable allowances on the other (Jaffe, 2000).

Faced with a new standard, companies will seek ways of complying with it at lowest possible cost. Standards, in other words, focus R&D on securing standards at lowest cost. After all, industry has nothing tangible to gain by reducing emissions beyond what is legally required.

A charge or trading scheme, on the other hand, rewards every further reduction in emissions because charges will then be lower or no allowances need to be bought (Popp, 2001). In principle, then, industry will focus its R&D on *continued* emissions reduction. Over and against this stands the fact that a charge or trading scheme may dampen profitability, leaving companies less funds for R&D.

Uncertainty

One important issue in investment decisions is any uncertainty surrounding government policy: is the subsidy here to stay, or will a new government decide, in times of economic downturn, say, to reintroduce fuel duty, thereby reducing the competitiveness of the alternative fuel technology?

From the economic literature emerges the picture that major uncertainties on future policy trends lead to lower investments (Farzin & Kort, 2000; Larson, 2000). If both the level of a charge and its date of introduction are unknown, for example, companies will want to see quicker returns on their investments[18]. This will mean many investments are not made. The picture changes if it is known that a charge or standard is to be implemented but the date of introduction or level are unclear. In that case, industry will tend to invest more in emission-cutting technologies and reduce those investments once there is more certainty.

A different situation arises if companies can choose between investing in the new technology and lobbying to get the standards changed. In that case they will tend to invest more in lobbying and less in the new technology (Farzin & Zhao, 2003). Conversely, the government can encourage industry to invest in technologies by giving strong signals that legislation is on its way (Emerson & Knabb, 2004).

What are the practical implications of all this in the Dutch policy context, then? First of all, it means that policy impact will be greatest if there are unambiguous standards or charges in place that are periodically tightened or raised. In that case there will not be too much uncertainty and there may even be greater investment. In the second place, the less scope industry has for wielding its influence in lobbies, the more effective a policy will be. Assuming Dutch industry brings greater influence to bear on Dutch than on European policy, the latter will be more effective than purely Dutch policy efforts, as there will then be less

[18] In their investment decisions, some companies do not use the criterion of return of investments (ROI) but internal rate of return (IRR), or net present value. In situations of uncertainty they generally want a higher ROI or IRR than in situations of certainty.

scope for choosing between lobbying and investment. European policy, or Dutch policy stemming directly from European legislation, has the added advantage of being far harder to change, as any change needs agreement among 25 countries and is not amenable to 'fast-tracking' during formation of a new cabinet, for example.

A European system can give investors greater assurance.

D.4 Innovation policy

Improving the market position of environment-friendly technologies or products means they gain a bigger slice of the market and also that greater innovative effort is expended on improving the environmental performance of existing technologies. The impact may not always be as great as desired, though. Even in the event of all external costs being internalised, industry will invest too little in technological development of eco-friendly products and processes, for two key reasons:

1 A company developing a new product or process is not always able to reap the benefits or profits. The state-of-the-art know-how underlying the products can never be perfectly protected and so other companies will be able to use it to imitate the innovation at lower cost. In other words, there is always some 'spill-over' of corporate know-how. For this reason, less investment is devoted to it than the social optimum.
2 Because of 'network effects', existing products and processes may sometimes be so advantageous to users that new products scarcely stand a chance. Certain word processing programmes may be superior to Microsoft Word, for example, as well as cheaper, but still be unable to acquire anything more than a marginal share of the market if their text files are incompatible with the standard used by the vast majority.

These two kinds of market failure may prompt a government to intervene in the market. Thus, most western countries have policies to encourage corporate R&D. In the Netherlands, for example, the wage costs of R&D employees are eligible for subsidisation under the so-called 'WBSO' scheme. This kind of policy promotes all kinds of R&D and not specifically programmes designed to improve eco-performance. There appears to be no reason for providing that kind of preferential treatment, however, for a good market context will steer innovative efforts sufficiently in the right direction.

In the case of publicly funded research, moreover, the government can already steer R&D as they see fit. In this context it is important not to opt for any one single technology (hydrogen, for example) but work with a portfolio of technologies (Jaffe, 2004). Ultimately, many of the technologies spawned will fail in the marketplace, but by spreading research (funds) across a range of alternatives the government has a good chance of know-how also being acquired on technologies that do acquire a slice of the market. A choice for one or several key technologies makes governments vulnerable to the lobbying of interested parties. This is an undesirable state of affairs, as companies and organisations with a weak market or technological position will have the greatest incentive to lobby for their own interests (Baldwin, 2002).

Network effects can motivate governments to adopt policies that promote not so much innovation itself, but its adoption or diffusion. Cases in point are the obligation to blend in biofuels with conventional vehicle fuels, or a fuel duty exemption for biofuels. An additional advantage of diffusion policy is that new technologies will be adopted on a larger scale, generally following a learning curve as they do so, causing their price to fall (Junginger, 2005). This can be explained with reference to Figure 11.

Figure 11 Encouraging innovation

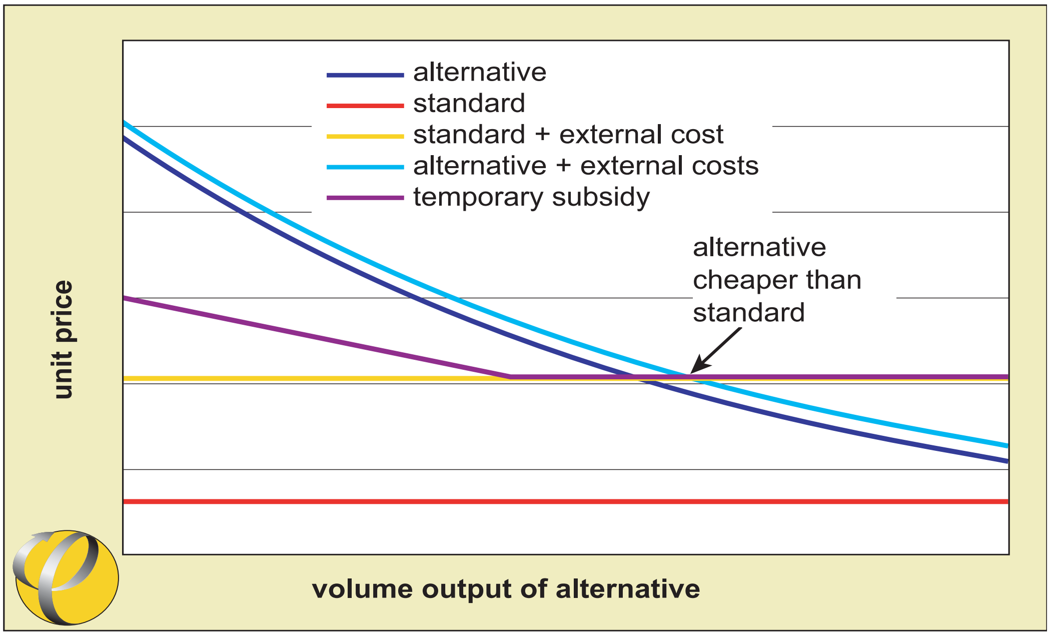
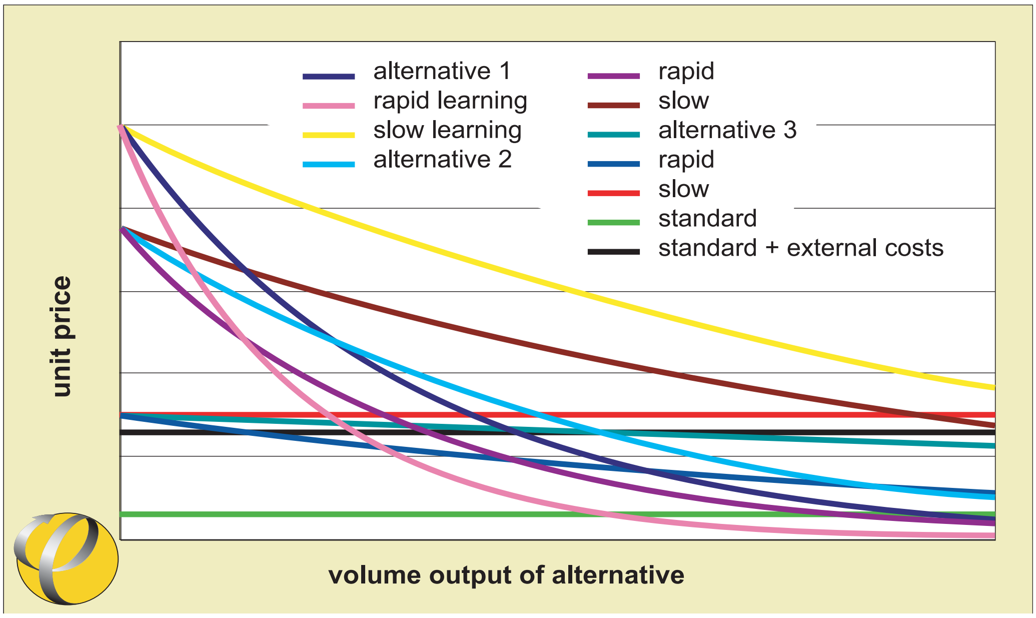


Figure 11 shows a situation with two equivalent, competing technologies. The standard technology (petrol or current diesel, say) is cheap and technologically mature - at the flat end of the learning curve. Its external costs are substantial. The alternative technology has lower external costs, but is still far more expensive. If it is widely adopted, though, it is likely to become cheaper. This situation may justify implementation of a temporary diffusion policy for the alternative technology, in our case biofuels (Jaffe, 2004) (OECD 2003). This should complement the internalisation of external costs. The policy can be elaborated in the form of educational campaigns, subsidies, voluntary agreements or standards[19].

[19] These instruments differ widely in their distributional impact. With a subsidy, diffusion policy is paid for by all tax-payers, with a standard (such as the biofuel blending obligation) only by consumers.

In reality there are hardly ever just two competing technologies, of course, and this also holds for biofuels. There are a great many technologies in part-competition with one another and they are not entirely equivalent. They all have different learning curves, moreover, and are in different phases of development. The situation is shown in Figure 12.

Figure 12 Development curves of various innovations



The government may well be familiar with the current prices of the various technologies and with estimates of future costs. However, they will generally have only limited insight into their respective learning curves. Which technology should be supported? If the learning curve eventually materialises in its ‘optimistic’ form, the most expensive technology (now) will be the one to promote, for in that case its price will end up furthest below that of the current standard, certainly if external costs are internalised. If the learning curve is rather less steep, though, the funds spent on promoting alternative 1 will have been wasted. The solution to this dilemma is for governments not to support any one technology, but a range of different, competing technologies. There is far better experience with subsidies of this kind than with subsidies geared to one specific technology (Jaffe, 2004).

Institutional barriers
Even when external costs have been internalised in prices, institutional barriers may mean that companies have no motive for minimising external costs. Such barriers include:

- Market domination by a handful of players able to keep newcomers and new technologies out of the market.
- A divide between investor and operator, with the former receiving no revenues from any additional investment which, though profitable down the entire chain, benefits him little if at all, yielding nothing but extra risk.

One particular institutional barrier in the context of climate-neutral fuels is the space that needs to be set aside at filling stations for any new fuel (of still unclear potential). The government can remove this kind of barrier by means of appropriate legislation or by shouldering the costs.

To ensure the government does not ‘favour’ certain technologies over others, even though this does not reflect their benefits to society as a whole, in the medium term it is wise to maximise the extent to which the social costs of *every* technology are duly taken into account, i.e. create an incentive (charge or reduced fuel duty) indexed to CO_2 emissions. For a brief period it is quite justified to provide higher rewards or some kind of exemption as a trigger for improve the dynamics of the market. From the market’s perspective the long-term advantage thus lies in the savings on social costs. In Figure 11 this is shown as a temporary subsidy on top of internalisation of external costs.

Temporary incentives are justified as a means of addressing institutional barriers and/or facilitating R&D. It must be clear beforehand how long they will remain in force.

D.5 Monitoring, methodology and/or certification

For a policy to be effective, from the moment the new mechanisms are introduced due thought will have to be given to monitoring and, at regular intervals, policy evaluation. Only then can it later be judged whether the policy has indeed been effective and whether it needs adjusting in any way. Careful thought should also be given to a methodology for calculating the (lifecycle) carbon savings embodied in products, in our case biofuels. This will be essential if carbon savings are to be used as a basis for policy differentiation (as in the case of differential fuel duties or charges indexed to lifecycle carbon emissions). In principle, the carbon index presently used for the so-called MEP scheme would be suitable for this purpose.

D.6 Conclusions

Summarising, successful and economically robust introduction of climate-neutral fuels requires the following steps:

- Create a market context, by making blended fuel obligatory, for example, or by internalising the external costs of *all* transport fuels. What is needed is a long-term policy package that is designed to be as generic[20] as possible. It is also important that legislation or pricing policy remains in force for a substantial period of time. A production plant is not built for the short term, but has to be utilised (profitably) for at least 10 to 15 years.
- To trigger initial change, develop a temporary system of incentives that is:
  - Technology-neutral.
  - If necessary, temporarily in excess of external costs savings.

[20] Generic policies do not favour any one particular technology (or several).

- Establish a temporary framework of incentives to trigger change;
  - Technology-independent.
  - If necessary, temporarily in excess of external cost savings.
- Establish a carbon calculation methodology, mainly to provide incentives and for monitoring policy progress.

Figure 13 Synopsis