Bringing biofuels on the market

Options to increase EU biofuels volumes beyond the current blending limits

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CE Delft's solutions are characterised in being politically feasible, technologically sound, economically prudent and socially equitable.

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Introduction

In 2009, the European Parliament and Council adopted the 'Renewable Energy Directive' (RED), which includes an ambitious policy target for the transport sector: a 10% overall target for the share of energy from renewable sources in 2020. Member States have since then submitted national renewable energy action plans (NREAPs) which outline how they intend to meet this target.

A significant share of these biofuels, but not all, can be brought onto the market by low level blending of biodiesel in diesel and of bioethanol in petrol. Current fuel standards allow up to 7 volume% FAME (the most common type of biodiesel, B7) and 10 vol% ethanol (E10). Other marketing options may then be used to sell the remaining volumes, using higher blends in compatible vehicles, fungible fuels such as HVO or biofuels in non-road transport modes. Large scale implementation of these options may, however, require new, targeted policy measures, in many cases complemented by new fuel and vehicle standards, adaptation of engines and fuel distribution, etc.

In this report, the issue of bringing the desired amounts of biofuels onto the market is assessed in detail. The study was commissioned by DG Energy of the European Commission and carried out by CE Delft and TNO[1].

Current policies and plans

First of all, an overview of Member States' plans and policies regarding biofuel deployment in the coming years was developed, based on information provided in the NREAPs, progress reports and a questionnaire. About 6.6% of road transport energy is expected to be biodiesel in 2020, 2.2% to be bioethanol. Other biofuels and renewable electricity have much lower shares.

To reach these targets, Member States choose to stimulate biofuel consumption by mandates, tax exemptions and subsidies – with a trend towards the first, and away from the latter. Many of the plans do not yet address the more technical issues of bringing biofuels on the market beyond the blending limits. Furthermore, many of the current biofuel policies have only been defined for the coming years, creating uncertainty in the market regarding the longer term policies until 2020 and beyond.

Technical options for biofuels marketing

An inventory was made of potential means to market biofuels in the transport sector in 2020. A range of biofuel types and blend percentages was identified, addressing the various transport modes.

In 2020, about 95% of the passenger cars and vans will be compatible with E10, and all diesel vehicles are compatible with B7. In addition, up to 30% of HVO or BTL can be added. The current fuel standards also allow ethanol to be (partly) replaced by biomethanol, bio-MTBE and bio-ETBE. Increasing the maximum blend ratios to B10/B15 for diesel and E20 for petrol is technically feasible, and fuel standards for these blends are under development.

1 Note that the current RED methodology was applied in this study. Any potential future modifications, for example as proposed in the Commission's ILUC proposal (EC, 2012) were not taken into account.

Ethanol can also be added to diesel fuel, but this is outside the diesel specification and would create substantial issues with fuel distribution.

Higher blends or pure biofuels could also contribute significantly to the 2020 RED target, if the right conditions are met. Existing options are E85, biomethane and B30 for heavy-duty vehicles. Other options which are technically feasible, but cannot significantly contribute to the RED target are ED95 (ethanol with ignition improver, for diesel engines), biomethanol (M15 or M85) and dimethyl-ether (DME).

Scenarios for biofuels marketing in 2020

Two biofuels demand scenarios were investigated, both on EU-level and for each individual Member State:

- the NREAP scenario, where biofuels demand is in line with expectations of Member States as outlined in their NREAPs;
- the 50/50 scenario, where total biofuel demand is the same as in the NREAP scenario, but biodiesel and bioethanol have equal shares.

In both scenarios, the current blending limits provide a very good basis for the marketing of significant volumes of biodiesel and bioethanol. Looking at the EU average, additional marketing of FAME will be necessary in the NREAP scenario, whereas in the 50/50 scenario, there is a very significant need for additional bioethanol marketing. Concrete biofuels marketing mixes were derived for both scenarios.

Conclusions and recommendations

The key conclusions and recommendations of this study are the following.

- It is very unlikely that the biofuels volumes that EU Member States expect for 2020 can be brought on the market within the current blending limits and policies. Other blending options need to be developed.
- To contribute towards the 2020 target, many of these options require the development of new (bio)fuel standards and associated vehicles, and quite ambitious market shares of these vehicles and fuels in 2020. It is therefore essential for both governments and industry to decide sooner rather than later which routes need to be in place in 2020.
- Each Member State may have it’s own strategy tailored to their market and policy objectives, but fragmentation throughout the EU is counterproductive. It is more efficient and effective to focus efforts of the stakeholders towards a limited number of blending options.
- Many of the options investigated will result in more fuel grades on offer at filling stations. Consumers need to understand which fuels are suitable for their vehicle and incentives are needed to buy the higher blends.
- A stable market outlook – until 2020 and beyond - is a crucial condition for stakeholders to invest in the developments needed for the various marketing options. Stable, effective and longer-term biofuel strategies and policies, both on EU and Member State level, are conditions for successful implementation.
- The EU can play a crucial facilitating role in these developments, for example by:
  - securing and accelerating the implementation of new fuel standards for higher blending limits and implementation of these fuels in the pollutant emissions legislation;
  - providing support to the development of Member States’ biofuels marketing strategies and harmonisation of consumer information such as fuel labelling.

Summary

Introduction

In 2009, the European Parliament and Council adopted the 'Renewable Energy Directive' (RED), which includes an ambitious policy target for the transport sector: a 10% overall target for the share of energy from renewable sources in 2020. Member States have since then submitted national renewable energy action plans (NREAPs) which outline how they intend to meet this target. Biodiesel and bioethanol/bio-ETBE are expected to have the largest share (more than 85%) of the renewable energy in transport in 2020, followed by other types of biofuels and renewable electricity, most of which will be due to electric railway transport. Hydrogen use from renewable sources is expected to be negligible.

A significant share of these biofuels, but not all, can be brought onto the market by low level blending of biodiesel in diesel and of bioethanol in petrol. Current fuel standards allow up to 7 volume% FAME (the most common type of biodiesel, B7) and 10 vol% ethanol (E10)[2]. Other marketing options may then be used to sell the remaining volumes: using higher blends in compatible vehicles, using fungible fuels (e.g. HVO) or using biofuels in non-road transport modes. Large scale implementation of these additional options may, however, require targeted policy measures, as well as new fuel and vehicle standards, adaptation of engines and fuel distribution and consumers need to be made aware of the new fuels.

The European Commission is considering whether this potential discrepancy between the national targets laid out in the NREAPs and the blending limits is an issue that requires action from the EU, or whether the market itself, perhaps with specific Member State support, can find a feasible and effective way to resolve this. DG Energy has therefore commissioned CE Delft and TNO to study this issue in more detail, assess the various technical options to resolve it, and derive recommendations regarding the need for potential actions on EU-level and the various policy options that can be considered[3].

Aim and scope of this study

The key objectives of this project are:

1. To analyse the Member States' implementation of the National Renewable Energy Action Plans in terms of bringing biofuels on the market up to 2020.
2. To identify and assess potential roads for a possible EU-coordinated approach to facilitate this.

In view of the uncertain developments in both biofuels demand and supply in the coming years, a scenario approach is used, where two biofuel scenarios for 2020 are assessed. Both have the same total biofuels volume as a basis, but in one scenario biofuels demand will be as predicted in the NREAPs, in the other one the total amount of biodiesel is assumed to be equal to that of bioethanol (in terms of energy content).

[2] The RED target is expressed in energy %, fuel standards use volume %. B7 equals about 6.4 energy%, E10 about 6.6 energy%.

[3] Note that this report does not specifically address the feasibility of producing these volumes of biofuels, their sustainability, etc.

Note that this study does not address the feasibility of these scenarios, but takes the resulting biofuel volumes as a given. In addition, it does not look into the potential to resolve any technical fuel/engine compatibility issues by modifying the Member States' plans regarding biofuels and/or other renewable energy use in 2020. The analysis focusses on the years up to 2020, but longer term perspectives are considered in the comparison of the different ways to further market biofuels.

Current policies and plans

Information provided in the NREAPs, Member States' progress reports and a questionnaire was used to provide an overview of Member State's plans and policies regarding biofuel deployment in the coming years. About 6.6% of road transport energy is expected to be biodiesel in 2020, 2.2% to be bioethanol. Other biofuels and renewable electricity have much lower shares.

In order to reach these targets, Member States choose to stimulate biofuel consumption by mandates or a variety of tax exemptions and subsidies – with a trend towards the first, and away from the latter. Mandates are used in most EU Member States, sometimes with subtargets for the biofuels content of petrol and diesel. Tax exemptions or reductions are mostly related to fuel excise duties and in some cases limited to double-counting biofuels. However, differentiation of vehicle registration taxes, circulation taxes or road charging tariffs, aimed at providing incentives for alternative fuel vehicles, can also be found. A wide range of subsidies is implemented throughout the EU, ranging from subsidies to realise fuelling stations that offer high blend biofuels to subsidies for biomass (energy crop) cultivation or research into new production technologies.

Many of the plans and actual policy instruments provide targets and incentives for biofuel consumptions, but do not yet address the more technical issues of bringing biofuels on the market. Some Member States have implemented concrete incentives for high blend biofuels or specifically address the need for higher blending limits or high blend fuels, but many countries do not yet seem to have specific policy measures or strategies in place.

In addition, many of the current biofuel policies have only been defined for the coming years, creating uncertainty in the market regarding the longer term policies until 2020. Part of this seems to be due to the anticipation of the ILUC proposal mentioned earlier. As this could lead to changes in the RED, Member States have been reluctant to move forward on this issue before the decision making process is completed.

Technical options for biofuels marketing

Looking at the potential options to bring the required biofuels volumes onto the market, the first step was an investigation of the possibilities and time frame to raise the current blending limits for biodiesel (FAME) in diesel fuel and for ethanol in petrol.

For long-term flexibility in biofuel blending, it would be desired to raise the blending limit for diesel from B7 to B10 or B15 and to raise the blending limit for ethanol from E10 to E20. Basically both are feasible provided the proper lead times are taken into account and protection grades remain on the market. Raising the blending limit for ethanol is relatively easy since the technology is implemented by many manufacturers in Brazil (as E25) and also in Europe in FFVs (Flexible Fuel Vehicles). If no time is lost, E20 could be implemented for new cars by 2018 (and earlier on a voluntary basis). Raising the blending limits for biodiesel is more difficult because of the more complex diesel emission control technology (for passenger cars) and the possible presence of impurities in biodiesel. For most passenger car manufacturers substantial time would be needed to adapt the regeneration strategy for diesel particulate filters to the higher biodiesel blend. As a consequence sufficient lead time needs to be taken into account and no substantial market share is to be expected by 2020. For trucks, relying on somewhat different emission control technologies, it would be quite feasible to use B10 or B15 on a large scale in 2020. Apart from biodiesel, HVO can be added up to 30%, even within the current EN590 diesel specification and without special efforts on fuel distribution.

Within the current petrol fuel standards, conditioned to fulfilling the maximum oxygen content, ethanol can (partly) be replaced by biomethanol (up to 3%), bio-MTBE and bio-ETBE (up to 22%). Ethanol can also be added to diesel fuel, but this would be outside the diesel specification and it would create substantial issues with engine technology and fuel distribution. Whether this route could have the potential to contribute significantly to the 2020 target is very uncertain.

High blends or pure alternative biofuels such as E85 in flexible fuel vehicles (FFV), biomethane for CNG or LNG vehicles and B30 for heavy-duty vehicles can also play a significant role in contributing to the 2020 RED target. These fuels are now already on the market and especially for CNG a refuelling infrastructure is well under development.

Other options which are technically feasible, but cannot significantly contribute to the 2020 RED target are ED95 (pure ethanol with ignition improver for diesel engines), biomethanol (M15 or M85) and dimethyl-ether (DME). This technology is currently only offered by a single manufacturer or no manufacturer at all. In general it is not recommended to further develop these options on a large scale, because it would impose a very large effort on development of engine technology and fuel infrastructure. There could be some attractive niche markets, for example if there are very economic production oppertunities for the biofuel.

It was furthermore concluded that the non-automotive market segments such as inland shipping, rail and mobile machinery can most probably cope quite well with the same blending limits as the automotive market. It is recommended to supply these segments with the same fuel blends as automotive, because for a considerable part they share the same fuel distribution infrastructure. Also emission control technologies will be very similar in the future. For aviation jet fuel standards are so stringent that it is necessary to only blend it with paraffinic bio-components such as based on HVO or BTL routes.

Impacts on energy efficiency

Regarding the effect of blends or pure biofuels on engine efficiency, very interesting results have been demonstrated for both petrol as well as diesel engines, if there is a possibility to recalibrate the engine or when the engine can be redesigned.

For petrol engines, the efficiency improvement is primarily linked to the higher octane number of the biofuels. With high blends (>50%) an efficiency improvement of 15% or more seems possible, but even more interesting is a possible efficiency gain of up to 10% with a 20% ethanol blend. This means that the actual fossil fuel reduction could be larger than the biofuel share.

For diesel engines, the efficiency improvement is related to improvements of the NO_x-particulates and NO_x-fuel consumption trade-offs. With relatively simple recalibrations a 4-5% efficiency improvement is possible with pure HVO or biodiesel (FAME) or a 1-2% efficiency improvement with 20% ethanol or butanol in diesel. Especially with diesel engines, it is expected that further improvements are possible with more extensive recalibration or design optimisation.

Realisation of these efficiency gains is only possible if the new fuel blends are properly implemented in the fuel standards and if the vehicle OEMs are convinced these fuels will be available for many years to come.

Scenarios for biofuels marketing in 2020

To determine if current policies are sufficient to bring the expected biofuels onto the market in 2020, and what EU-coordinated action might help to facilitate developments, two biofuels marketing scenarios were developed.
- the NREAP scenario, where biofuels demand is in line with expectations of Member States as outlined in their NREAPs;
- the 50/50 scenario, where total biofuel demand is the same as in the NREAP scenario, but biodiesel and bioethanol have equal shares.

These scenarios were investigated both on EU-level and for each individual Member State.

Table 1 Overview of the biofuels volumes in the two scenarios, in the EU in 2020

	Scenario 1: NREAPs (Mtoe)	Scenario 2: Shift to ethanol (Mtoe)
Biodiesel	22	14
Bioethanol	7	14

In both scenarios, the current blending limits provide a very good basis for the marketing of significant volumes of biodiesel and bioethanol. Results for the EU27 are shown in Table 2, for the situation where B7 and E10 are the standard fuel grades throughout the EU. However, additional marketing of FAME or other biodiesels such as HVO will be necessary in the NREAP scenario, whereas in the 50/50 scenario, there is a very significant need for additional options to bring bioethanol onto the market.

Table 2 Maximum current blending potential (Mtoe) in diesel and petrol, and gap with the NREAPs

Type of biofuel	Application	Actual biofuel potential (Mtoe)	Mtoe expected according to NREAPs	Mtoe required in 50/50 scenario
Biodiesel	FAME B7 in road	13	**22**	**14**
	FAME B7 in non-road	2		
	HVO	2		
	Total	**17**		
Ethanol	E10 in road	7	**7**	**14**
	E10 in non-road	0		
	Total	**7**		
Total		**22**	**29**	**29**

The gap between the current blending limits and the expected biofuels volumes to be marketed in 2020 differs between Member States. Where some need much more than average additional biodiesel or bioethanol blending, some will have less of a gap to overcome. The main reason for these differences are the different petrol to diesel ratios in the Member States' road transport fuel mix, as well as different targets set in the national action plans. For example, whilst some Member States could meet their biodiesel target with nation-wide implementation of B7, others will have a strong need for other biodiesel blending options as they can only meet about half of their biodiesel goal with B7. All Member States need some type of higher blend options, though, either for biodiesel or for bioethanol.

It is thus concluded that there is a clear need to implement some of the additional technical biofuels marketing options that were identified.
The potential contribution of each potential option to the 2020 target was therefore estimated, their pros and cons were identified and the most promising options were selected. As it was found that the blending gaps could not be filled with one option but required implementation of a mix of options, the next step was then to determine attractive and feasible combinations of technical options that could meet the target. Considering practical feasibliity and cost of technical developments, a number of criteria were identified that should form the basis of this selection process:

- Limit the number of non-fungible biofuels as much as possible to keep infrastructure simple.
- Limit the number of engine/fuel variations per vehicle or transport category, i.e. choose one alternative per vehicle category if needed. This helps controlling complexity of fuelling infrastructure and efforts needed by the vehicle manufacturers to develop the engines and vehicles. It also simplifies vehicle marketing and communication with consumers.
- Focus first on long-term low blends, with one blend preferred over several blends: e.g. E20 preferred over E10 plus E85, B15 preferred over B7 or B10 plus B30.
- Add high blends if needed and available, focussing on applications with the least barriers and, if possible, the highest benefits from using the biofuels, e.g. E85 for taxis and vans, B30 for heavy trucks or bio-CNG/LNG for HD city transportation and inland ships (which will have the additional benefit of improving air quality).
- Utilise fungible fuels such as HVO, BTL and co-processing of biomass in refineries if possible, as these are diesel biofuels which requires no changes to vehicles or infrastructure (within the 30% blending limit).

Based on this assessment, various coherent sets of biofuels marketing options were developed with which the two scenarios could be met. The following table illustrate these results. Note that the strong increase of ethanol sales needed to meet the 50/50 scenario in 2020 was found to require all of the potential ethanol blending options that were identified, complemented by some of the biomethane options (bio-CNG in busses and passenger cars).
The implications of these scenarios were also assessed for a number of Member States.

Table 3 **A biofuels marketing mix in 2020 for the NREAP and 50/50 scenarios (Mtoe)**

Marketing option	Biodiesel		Bioethanol	
	NREAP	50/50	NREAP	50/50
Marketing through B7 and E10 (all road fuel)	12.8	12.8	6.7	6.7
Add fungible fuels (HVO)	2.4	1.5		
Increase blending limit from B7 to B10 (assuming 15% of cars, 40% of HDV is possible)	1.5			
B7 in all non-road diesel		0.1		
20% market share of B30 for trucks, or 5-6% of B100 (captive fleets mainly)	4.9			
Blending limit from E10 to E20 (12% of petrol)			0.6	1.3
30% market share of ED5 or 15% ED10 in heavy-duty vehicles				1.1
E85 in captive fleets (5% market share)				2.3
Bio-CNG for busses (20% market share)				0.5
Bio-CNG for passenger cars (1.2% market share)				2.5
Total all options	**21.6**	**14.5**	**7.3**	**14.5**

Marketing through B7 and E10 can result in about 6.2% of the required 10% renewable energy in 2020, the other options each contribute less than 2%.

Some potential options, for example biofuels in aviation, were not included in these scenarios as they are still in the R&D phase and are not expected to be able to contribute significantly towards the 2020 RED target. However, as they could be crucial to meeting longer term decarbonisation targets, their development should also be supported.

Implementing the options

The various biofuels marketing sets that were developed all have utilisation of B7, E10 and HVO in common, but differ regarding the other options that are implemented. They therefore result in quite different actions that need to be taken by stakeholders and governments. These vary from developing the appropriate fuel specifications and type approval procedures, to developing a market for these fuels and vehicles and setting up the distribution of new fuel grades.

Actions needed to implement the various options were identified, and associated timelines were developed. As an example, the possible timeline for the implementation of E20 and B10 or B15 is shown in de Figures 1 and 2 below. Even though the contribution to the 2020 targets is limited, raising the blending limits are the preferred long-term options for technical and economic reasons.

Figure 1 **Timeline for implementation of E20 for petrol**

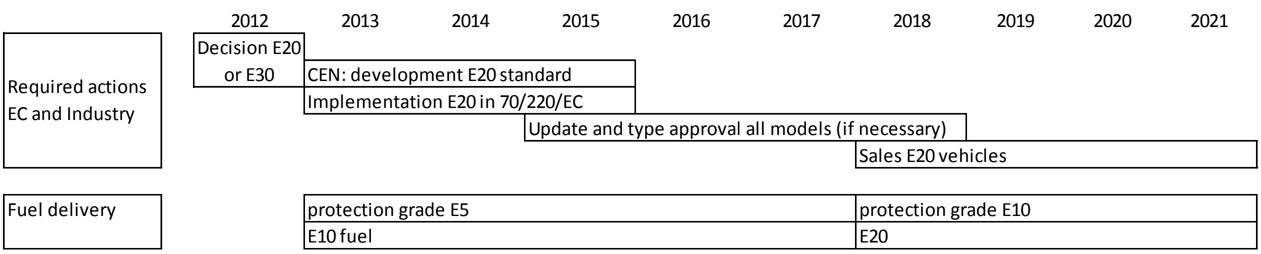
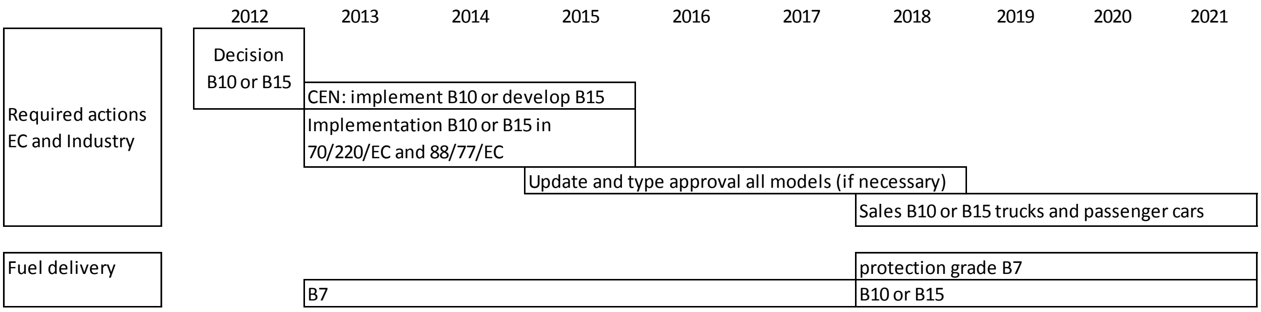


Figure 2 **Timeline for implementation of B10 or B15 for diesel**



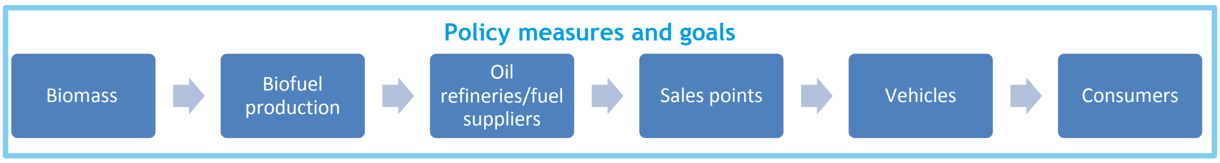
Implementation of the various options require active involvement of a range of stakeholders, as well as focussed Member State policies and EU harmonisation of developments. In view of the limited time available until 2020, some of these developments need to start sooner rather than later, as delays can significantly reduce the biofuels volumes that can technically be put onto the market in 2020.

Conclusions and recommendations

Two key conclusions emerge from this study:
1. There is not yet a clear view on how the biofuels volumes for the 2020 10% renewable energy target will be marketed throughout the EU.
2. Marketing of the necessary volumes of biofuels requires coordinated, focussed and timely actions by a whole range of stakeholders.

Some of the necessary developments and actions are already emerging, such as marketing of B7 and E10 in various EU Member States, the implementation of biofuels blending obligations for fuel suppliers, etc. However, a clear strategy seems to be lacking in most Member States, and only few longer term policy measures are in place. This leads to uncertainty about the future biofuels demand in the industry, which proves to be a barrier to investments, R&D and strategy development. Meeting the 10% renewable energy goal in all Member States in 2020 requires that these developments are accelerated, and additional measures are implemented to significantly increase market shares of high blend vehicles and biofuels sales. It is important to realise that many of the options require actions in the whole biofuels supply chain, indicated in Figure 3.

Figure 3 **Schematic overview of the various steps and actors in the biofuels supply chain**



The way forward should thus consist of the following steps:
1. Design a robust biofuels marketing strategy for the next 10-20 years.
2. Ensure timely implementation of key policies.
3. Define vehicle and fuel standards for higher blends.
4. Facilitate/support the market uptake of these vehicles.
5. Facilitate/support the market uptake of the fuels.
6. Increase biofuels R&D and production of sustainable biofuels.
7. Increase biofuels use in non-road modes, i.e. in rail, mobile machinery, inland shipping and aviation.

Note that this list does not imply that these steps need to be taken consecutively, many can and should be approached at the same time.

It is recommended to achieve the 2020 RED target with measures in the following sequence of priority:
- Utilisation of the current blending limits in all Member States: B7 and E10, in road and non-road transport modes. Fungible biodiesel (HVO) can then be added, depending on availability and cost.
- Increasing the current blending limits, to B10 or B15, and E20. The necessary fuel and pollutant emission standards can be developed within three years if sufficiently prioritised, and vehicles can enter the market on a large scale in 2018 or earlier on a voluntary basis. The fuel companies would then need to supply two blends on most filling stations (at a competitive price): a low blend as protection grade and the new blend.
- Increasing the share of high blend biofuels, preferably in captive fleets such as busses, taxis or vehicles from hauliers with their own fuel depot. Depending on the biofuels demand and the marketing strategy chosen, it is recommended to use B30 for HD vehicles, E85 and bio-CNG/LNG. The quantities per fuel can be varied per country depending on opportunities and preferences.
- If necessary (for the 50/50 scenario), development of new solutions for increased ethanol and biomethane marketing, for example via blending of 5-10% ethanol in diesel.

A stable outlook regarding the future development of biofuels demand is an important prerequisite for timely implementation of these measures.

Even though meeting the RED target is the responsibility of Member States, it is recommended that the EU plays a very active role in helping them to achieve the target, minimize fragmentation of industry efforts and secure an economical long-term fuel mix. Together with the industry, the recommended EU activities for the coming years are:
- deciding on long-term (up to 2030) blending limits for petrol and diesel, as well as on post-2020 policy targets;
- securing and accelerating the implementation of new fuel standards for higher blending limits and implementation of these fuels in the pollutant emissions legislation;
- providing support to the development of Member States’ biofuels marketing strategies and harmonisation of consumer information such as fuel labelling;
- continued support to R&D of advanced biofuels, to increase the potential range of sustainable feedstocks as well as the potential range of applications (e.g. in aviation).

1 Introduction

1.1 Introduction

In April 2009, the European Parliament and the Council adopted the 'Renewable Energy Directive', a Directive on the promotion of the use of energy from renewable sources (RED). The directive includes, among a number of other things, an ambitious policy target for the transport sector: a 10% overall target for the share of energy from renewable sources in transport in 2020. For comparison: in 2010, the renewable energy share in transport was 4.7% on average in the EU, with values ranging from 0.3 to 7.8% in the various Member States[4]. The directive also required Member States to submit National Renewable Energy Action Plans (NREAPs), setting out inter alia the contribution expected of each renewable energy technology to meet the 2020 targets in the transport sector.

According to the NREAPs, Member States collectively intend to slightly over-achieve the 10% target (ECN, 2011). Biodiesel and bioethanol/bio-ETBE are expected to have the largest share (more than 85%) of the renewable energy in transport in 2020, followed by other types of biofuels and renewable electricity, most of which will be due to electric railway transport. Hydrogen use from renewable sources is expected to be negligible.

The details of the actions plans differ between Member States, but on average, biodiesel is expected to have the largest share in the biofuels in 2020: approximately 7% of road transport fuels is expected to be biodiesel, about 2.5% will be bioethanol[5].

The RED does not specify how these biofuels (or any of the other renewable energy carriers) are to be marketed, but at present, biofuels are mostly sold through blending with petrol and diesel. The resulting blend may be marketed as petrol and diesel as long as it adheres to fuel quality regulations and standards as defined in the Fuel Quality Directive (FQD) and CEN standards. These currently limit the share of bioethanol in petrol to 10% by volume, and that of FAME (Fatty Acid Methyl Ester, the most commonly used biodiesel) in diesel to 7% by volume. As the energy content of both bioethanol and FAME is lower than that of their fossil counterpart, these maximum blending limits can result in a maximum of 6.6% bioethanol by energy, and 6.4% FAME by energy.

The current blending limits are therefore insufficient to allow implementation of the national action plans using biofuels blended into petrol and diesel only. Alternative marketing strategies are required. The main options are:
1. Both bioethanol and FAME can also be sold in higher blends, to be used in vehicles that are suited to run on these blends. These fuels can not be used by all vehicles in the fleet.
2. Other types of biofuel exist that are not subject to these blending restrictions, such as Hydrogenated Vegetable Oil (HVO) and Biomass To Liquid (BTL) in diesel.

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4 Source: Eurostat data 56/2010 - Statistics in focus.

5 All percentages in energy content.

3. The RED also allows biofuel use in non-road transport modes, such as in domestic navigation and aviation, to count towards the target. For aviation probably only the high quality HVO and BTL may be acceptable due to very stringent fuel quality standards.

Examples of practical implementation of these alternatives can be seen throughout the EU. Their current contribution to overall biofuels sales is, however, small.

The European Commission is now considering whether this potential discrepancy between the national targets laid out in the NREAPs and the blending limits is an issue that requires action from the EU, or whether the market itself, perhaps with specific Member State support, can find a feasible and effective way to resolve this. DG Energy has therefore commissioned CE Delft and TNO to study this issue in more detail, assess the various technical options to resolve it, and derive recommendations regarding the need for potential actions on EU-level and the various policy options that can be considered.

1.2 Aim and scope of this study

The key objectives of this project are

1. To analyse the Member States' implementation of the National Renewable Energy Action Plans in terms of bringing biofuels on the market up to 2020.
2. To identify and assess potential roads for a possible EU-coordinated approach to facilitate this.

In view of the uncertain developments in both biofuels demand and supply in the coming years, the assessment of the potential roads for a possible EU-coordinated approach will be based on two biofuel scenarios for 2020:

- Scenario 1: Biofuels demand will be as predicted in the NREAPs. This implies that almost ¾ of total biofuels demand will be biodiesel in 2020, the rest will be mainly bioethanol.
- Scenario 2: Biofuels demand will be much more balanced between these two types of biofuels, and the total amount of biodiesel will be equal to that of bioethanol (in terms of energy content).

The total amount of biofuel will be the same in both scenarios.

Note that this study does not address the feasibility of these scenarios, but takes the resulting biofuel volumes as a given. Especially the availability of sustainable biomass may be an issue in practice, depending on the outcome of the debate on how to include indirect land use change (ILUC) emissions in the biofuels sustainability criteria. The ILUC proposal of the Commission, published in October 2012 (COM(2012) 595 final[6]), is not addressed in this report, the scenario calculations in Chapters 5 and beyond are based on the RED as published in 2009 (EC, 2009).

In addition, the study does not look into the potential to resolve any technical fuel/engine compatibility issues by modifying the Member States' plans regarding biofuels and/or other renewable energy use in 2020. For example, biofuels volumes may be reduced by increasing the share of electricity use in transport, or of biofuels from waste and residues (i.e. biofuels that meet the criteria of Art. 21.2 of the RED), as these will count double towards the target.

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[6] http://ec.europa.eu/energy/renewables/biofuels/doc/biofuels/com_2012_0595_en.pdf

The analysis focusses on the years up to 2020, but longer term perspectives are considered in the comparison of the different ways to further market biofuels. The project scope is the EU, and includes all 27 Member States.

1.3 Relevant EU policies

A number of EU policies are directly relevant to the assessment in this study, the main ones are the following:
- the Renewable Energy Directive;
- the Fuel Quality Directive;
- European pollutant emissions legislation of vehicles;
- fuel standards;
- EU proposal for fuel tax directive.

Renewable Energy Directive (RED)

The RED (EC, 2009a) sets an overall target of renewable energy use for the EU (20% in 2020), and individual targets for the various Member States. Articles 3(4) and 17–21 are specifically relevant for the transport sector, the rest addresses various issues regarding renewable energy in the electricity and heat production.

The RED obliges Member States to ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10% of the final consumption of energy in transport in that Member State. It defines the methodology to calculate the contribution of the various renewable energy sources, and provides minimum sustainability criteria that biofuels need to meet in order to be counted towards the target.

Without going into the details of the directive[7], the following issues are worth noting in the context of this study:
- For the calculation of the denominator, i.e. the amount of fuel of which 10% should be renewable in 2020, the total amount of petrol, diesel, biofuels consumed in road and rail transport, and electricity shall be taken into account.
- For the calculation of the numerator, i.e. the amount of renewable energy in transport, all types of energy from renewable sources consumed in all forms of transport shall be taken into account.
- The contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels.
- A number of sustainability criteria for biofuels are defined that need to be met if the biofuel is counted towards the 10% target. These criteria define the methodology to calculate the GHG emissions of biofuels, set minimum GHG reduction levels, exclude biofuels from biomass that is cultivated in areas with high biodiversity or high carbon content of the soil, etc.
- The Commission was obliged to submit a report by 31 December 2011 with a review of the impact of indirect land use change (ILUC) on GHG emissions, and addressing ways to minimise that impact. The report shall, if appropriate, be accompanied by a proposal containing a concrete methodology for emissions from carbon stock changes caused by ILUC (EC, 2009a, Art. 19.6).

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[7] For details, please refer to the directive itself.

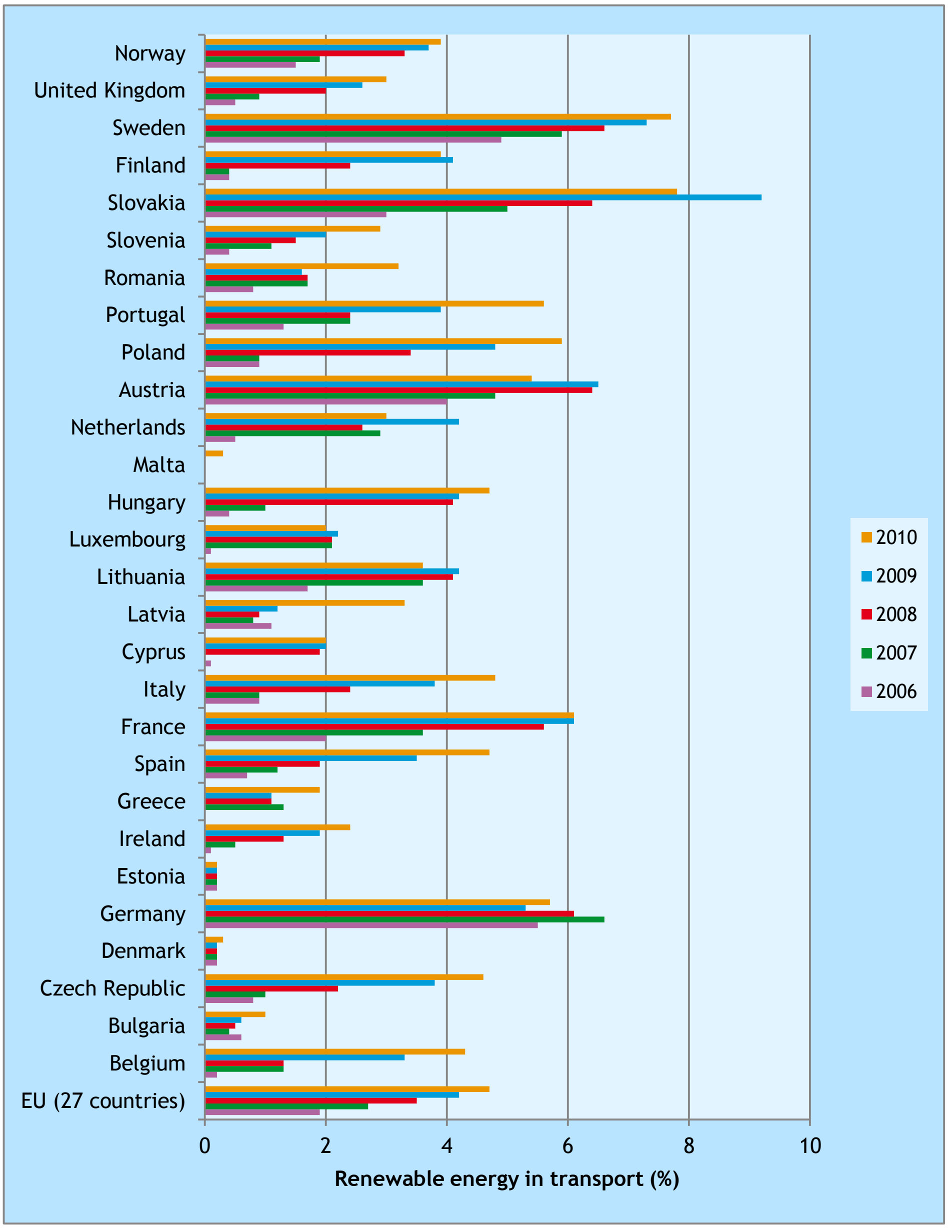
Including ILUC emission in the GHG calculations of the various biofuels may have quite a profound impact on which biofuels may contribute to the target and which may not. Modelling work carried out for the Commission concludes that a significant share of biofuels, especially the various biodiesels that are produced from plant oil, do not actually reduce GHG emissions if ILUC emissions are included in the life cycle analysis (IFPRI, 2011).

A proposal on how ILUC emissions should be incorporated in the RED (and FQD, see below) was postponed, but has been submitted on 17th of October 2012 (COM(2012) 595 final). The following key elements (relevant to this study) were included in this proposal:

- Introduction of a limit for biofuels and bioliquids from food crops to count towards the target. The contribution of those biofuels should be limited to a maximum of 5%, about equal to the estimated consumption levels at the end of 2011.
- Enhanced incentives for advanced biofuels are proposed: quadruple counting shall be considered for biofuels from feedstocks listed in Annex IX A of the proposal, like algae and glycerine, and renewable liquid and gaseous fuels of non-biological origin.
- With effect from 1st July 2014 a higher minimum greenhouse gas saving threshold is given for biofuels and bioliquids produced in new installations.
- Introduction of ILUC-factors to be used for the Member State reporting of the estimated greenhouse gas emission savings from the use of biofuels.

The average share of renewable energy in EU transport was 4.7% in 2010, but variations between Member States are significant, as shown in Figure 4. Where some countries, in particular Slovakia, Sweden, and France had a share above 6% already in 2010, in the majority of Member States the share was still well below 4 or 5%.

Figure 4 The share of renewable energy in transport in the EU Member States, 2006-2010



Source: Eurostat.

Fuel Quality Directive (FQD)

The FQD (EC, 2009b) sets technical standards for transport fuels, but also requires fuels suppliers to gradually reduce the average life cycle GHG emissions of the transport fuels that they sell in the EU. The targets were set in the directive, but the methodology to calculate the contribution of various fuels and GHG mitigation measures towards the target has only been partly defined so far.

The most relevant parts of this directive are the following[8]:

– From 1 January 2011 onwards, suppliers have to report annually on the greenhouse gas intensity of fuel and energy supplied within each Member State. As a minimum, the following information has to be supplied:
  a The total volume of each type of fuel or energy supplied, indicating where purchased and its origin.
  b Life cycle greenhouse gas emissions per unit of energy.

  'Suppliers' are, in most cases, the entities responsible for passing fuel or energy through an excise duty point.
– Member States shall require suppliers to reduce life cycle greenhouse gas emissions per unit of energy from fuel and energy supplied by up to 10% by 31 December 2020, compared with the fuel baseline.
  - 6% of this reduction is mandatory;
  - the remaining 4% can be met by, for example, carbon capture and storage and credits purchased through the Clean Development Mechanism of the Kyoto Protocol, for reductions in the fuel supply sector.
– The scope of the directive are the fuels used by road vehicles, non-road mobile machinery (including inland waterway vessels when not at sea), agricultural and forestry tractors, and recreational craft when not at sea.
– The calculation methodology to determine the life cycle GHG emissions of biofuels is the same as the one used in the RED. Hence the same comments regarding ILUC emissions apply here.

A number of methodological issues were still lacking in the 2009 directive, a proposal to fill these gaps is expected in 2013. These issues concern fossil fuels mainly, and are not directly relevant for this study.

European pollutant emissions legislation of vehicles

An overview of the Euro emission standards for passenger cars and heavy-duty vehicles are presented in Table 4 and Table 5 below. These standards are laid down within the following EC directives:

– passenger cars and light commercial vehicles: 70/220/EC + amendments;
– heavy commercial vehicles: 88/77/EC + amendments.

The most important pollutants are nitrogen oxide (NO_x) and particulates (PM). This is also the focus of the emission control systems on the engines.
The periods between the Euro steps are typically 3 to 5 years. About a decade ago each step meant a tightening of the standards of about 30%. Especially for diesel engines a fast tightening of the standards can be observed. For example for HD vehicles from Euro V to Euro VI the emission reduction is a factor of 4 for NO_x and a factor of 2 to 3 for particulates mass. Also with Euro 6 for both passenger cars and HD vehicles particle number limits are introduced. This is also applicable to cars with spark ignition engines in combination with direct injection (in-cylinder fuel injection).

[8] For details, please refer to the directive itself.

Table 4 **Overview European emission limits for passenger cars (in g/km (M1 category: GVW ≤ 2,500 kg))**

Date	Test cycle	Unit	CO	HC	HC+NO_x	NMHC	NO_x	PM[1)]	PN (#/km)
Passenger car Otto (Spark Ignition)									
Euro-4-2005	MVEG-B	g/km	1.0	0.10	-		0.08	-	
Euro-5-2008	MVEG-B	g/km	1.0	0.10		0.068	0.06	0.005	
Euro-6-2014	MVEG-B	g/km	1.0	0.10		0.068	0.06	0.005	$6x10^{11}$ [2)]
Passenger car diesel (Compression Ignition)									
Euro-4-2005	MVEG-B	g/km	0.50		0.30	-	0.25	0.025	
Euro-5-2008	MVEG-B	g/km	0.50		0.23	-	0.18	0.0045	$6x10^{11}$
Euro-6-2014	MVEG-B	g/km	0.50		0.17	-	0.07	0.0045	$6x10^{11}$

1) Slightly revised measuring procedure for Euro 5 and 6.
2) Particle number only applicable to petrol engines with direct injection.

Table 5 **Overview European emission limits for heavy-duty CI truck and bus engines (GVW > 3,500 kg)**

Date	Test cycle	Unit	CO	NMHC	NO_x	PM	PN (#/kWh)
HD diesel engines (Compression Ignition)							
Euro-IV-2005	ESC	g/kWh	1.5	0.46	3.5	0.02	
	ETC	g/kWh	4.0	0.55	3.5	0.03	
Euro-V-2008	ESC	g/kWh	1.5	0.46	2.0	0.02	
	ETC	g/kWh	4.0	0.55	2.0	0.03	
Euro-VI-2013[1)]	WHSC	mg/kWh	1500	-	400	10	$8x10^{11}$
	WHTC	mg/kWh	4000	160	460	10	$6x10^{11}$

1) Formal date is 31-12-2012 for new type approvals. 1 year later for all entries.

Apart from lower emission levels, the future emissions legislation will include more stringent requirements to secure the lowest possible emission in real world driving. These include more stringent requirements for durability, On-Board Diagnostics (OBD) and off-cycle emissions (real world driving patterns): This is especially the case for the Euro VI HD legislation.

Fuel standards

Complementary to the pollutant emission standards, the fuel specifications are important. The following standards are applicable in the EU:
- Petrol: EN228.
- Diesel: EN590.
- Biodiesel: EN14214.
- Technical Specification TS 15940 (2012). This is a specification for paraffinic diesel fuels, and therefore applies to HVO (Hydrotreated Vegetable Oil) and BTL (Biomass To Liquid), as well as fossil X-TL such as GTL (Gas to Liquid) and CTL (Coal to Liquid). The TS 15940 (2012) followed the CEN Workshop Agreement CWA 15940 (2009).
- Ethanol (as blend component): EN15376.
- Ethanol E85: EN15293.
- Biomethane: fuel quality standard is being developed (standardization work started in 2011) under the M/475 mandate in the CEN/TC 408 “Project Committee Biomethane for use in Transport and injection in natural gas pipelines”.

The following CEN activities are currently on-going:
- Expansion of E228 with an additional oxygenate specification: these are basically two tables for low oxygenate (for E5) and high oxygenate (E10).
- Finalisation of an E10+ feasibility study. To be finalised by the end of 2012.
- Specification of a B7 and B10 diesel fuel (7 and 10% FAME in fossil diesel), to be finalised in 2013.
- The options of a B30 specification are being studied.

Jet fuel specifications:
- The jet fuel standards between USA and Europe are coordinated and consequently identical:
  USA: ASTM D1655 and UK/Europe: DefStan 91-91.
- ASTM D7566: specification for drop in concept of semi synthetic jet fuel including biofuel.

Fuel standards outside Europe
Important countries with this respect are the USA and Brazil. In the USA, the EPA has issued a waiver to allow E15 under the gasoline specification (Herman 2011). This can be used for passenger cars for model year 2001 and newer.
In Brazil the overall ethanol share as a fuel for road transportation equals almost 15% (de Tarso Costa, 2005). This is almost equally split between E25 (anhydrous ethanol) and E100 (hydrous ethanol). The most relevant standards in these countries are the following.

USA:
- ASTM 4814: gasoline and its blends with oxygenates such as alcohols and ethers;
- ASTM 4806: fuel ethanol. Also valid for ethanol to be used for E15;
- ASTM D975: specification of diesel fuel oils;
- ASTM D6751: standard specification for diesel blend stock B100;
- ASTM D7467: requirements for biodiesel B6-B20.

Brazil:
- ANP Resolution #36/2005 sets the specifications for both (1) gasoline and anhydrous ethanol blends (<0.6% water), and (2) as pure ethanol, usually hydrated ethanol (6.2% < water% <7.4%);
- ANP Resolution #7/2008 sets the norms and specifications for biodiesel.

EU proposal for fuel tax directive
Directive 2003/96/EC provides the Community framework for the taxation of energy products and electricity, and sets minimum tariffs for fuels and energy carriers, including that of petrol and diesel. In many EU Member States, fuel tax levels are significantly higher than these minimum levels. In most countries, diesel taxes are considerably lower than petrol taxes.

In April 2011, the European Commission presented a proposal to overhaul these rules, aiming to restructure the way energy products are taxed. It is proposed to tax fuels and energy products based on their CO_2 emissions and energy content only. In the context of this study, this would significantly reduce the differences between petrol and diesel taxes, and it would result in lower taxes for biofuels than for their fossil counterparts.

These proposed changes can thus be expected to result in an shift from diesel towards petrol – although the extent of these effects will depend on the Member State implementation.

These effects may impact the biofuel marketing options: a larger petrol share will make bioethanol blending easier, biodiesel blending may become more difficult.

In addition, basing the fuel taxes on energy content and CO_2 emissions rather than on litres (the current practice in most countries) will be beneficial for biofuels marketing, as these typically have lower energy content (especially bioethanol) and lower CO_2 emissions.

2 Approach, assessment criteria and biofuel scenarios

2.1 Introduction

Paragraph 1.2 described the main aims of this study, which are
1. To analyse the Member States' implementation of the National Renewable Energy Action Plans in terms of bringing biofuels on the market up to 2020.
2. To identify and assess potential roads for a possible EU-coordinated approach to facilitate this.

The next chapter will thus start with an assessment of the Member States plans and their progress so far. This will show that even though all Member States have submitted concrete plans outlining the volumes and types of biofuels that they expect to be sold in 2020, only few Member States have so far developed and implemented concrete plans and policies on how these biofuels are to be marketed in their vehicle fleet.

To assess the potential role of the EU in this respect, a number of questions need to be answered. First, the issue of biofuels blending and compatibility of vehicles will be assessed from a technical perspective (Chapter 4). Then, the biofuel volumes that can be blended under the current policy framework will be calculated. Comparing these results with the Member State plans provides insight in the extent of the potential marketing problem in 2020 (Chapter 5). The various options that can resolve this issue are then identified and assessed (Chapters 6 and 7). This results in conclusions regarding the mix of marketing options that is likely to be the optimal way forward. Chapter 8 and 9 then further assess the barriers that need to be addressed and resolved to enable realisation of these options, and the actions required by the various parties involved. These are actions by a large range of stakeholders, Member States and the EU, where timing and cooperation are important issues to address.

In the following, this general approach is further elaborated in order to provide a high-level overview of the key issues of biofuels marketing in the coming years before diving into the details of the various chapters.

2.2 Are current policies sufficient?

In the past few years, all EU Member States have implemented biofuels incentives and mandates, which resulted in an increasing share of biofuels in the EU's transport fuels. In response to the RED, all Member States have issued National Action Plans that outline their plans to further increase the share of renewable energy in transport towards the 10% target that each Member State has to meet in 2020. Member States also submit progress reports to the EU on a regular basis.

However, so far only few Member States explicitly address the biofuels marketing issues that were described in the introduction of this report, in the action plans and in actual policies. The incentives and mandates have so far mainly led to an increasing share of biofuel in the conventional petrol and diesel, with no or very limited need to sell biofuels beyond the levels that all vehicles can drive on (B7 and E5). High blend vehicles and fuels are rarely incentivised on a significant scale in the national biofuels policies, only few Member States have subsidies in place for these technologies and fuel standards and vehicle type approval regulations for the high blends are not yet in place. The result is that fuel suppliers and vehicle manufacturers offer the high blend fuels and vehicles on a relatively limited scale only.

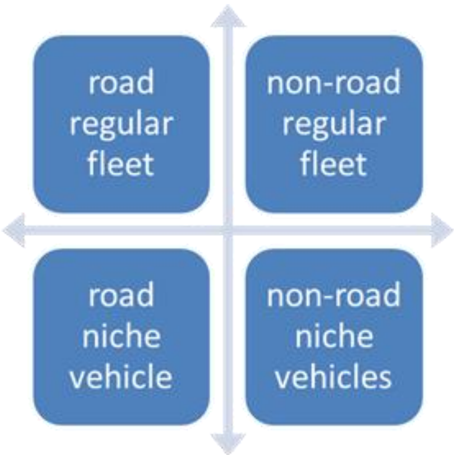
It is thus doubtful whether the current policy framework is sufficient to ensure that the biofuels volumes of the National Action Plans can indeed be marketed in 2020. This report will show that sufficient marketing options exist from a technical point of view, and that there is a need to add a number of these options to the current biofuels policy approach. Realising these requires various additional actions and decisions to be taken. These additional options are often quite complex to implement, and an analysis of the best way forward requires a careful assessment of their pros and cons.

2.3 Issues to consider in the assessment of marketing options

From a technical perspective, there are quite a number of options to market biofuels in order to increase EU biofuels volumes in addition to the option of blending within the current blending limits. These options can be categorised as follows:
- an increase of the current blending limits, either for the whole vehicle fleet or for a significant share of the fleet;
- applying high blends in road transport in niche applications, i.e. only in limited parts of the sector;
- expand the use of biofuels to non-road transport modes.

Figure 5 depicts a schematic overview of the resulting categories.

Figure 5 Schematic overview of potential ways to increase EU biofuel volumes beyond the blending limits



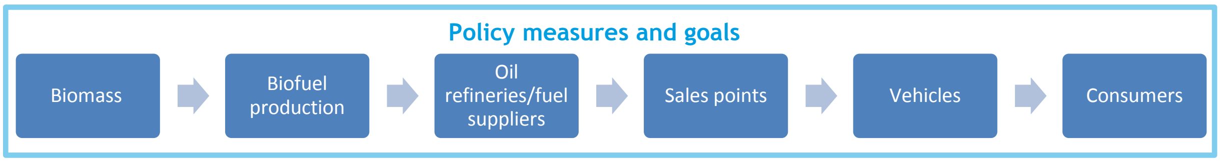
There are quite a number of options with which increased biofuel volumes could be brought on the market. Some of these options only have limited potential to contribute to the 10% target of the Renewable Energy Directive, whilst others may have high potential but other disadvantages such as high cost or limited production capacity.

To decide on the most attractive way forward towards the 2020 RED target, this study uses a three-step approach to derive the most promising routes:
– The first step is to derive an estimate of how much biofuels can already be blended, given the current fuel standards and vehicles in the fleet.
– As a second step, a comprehensive list of individual biofuels marketing options is identified. The most promising options will then be selected by identifying their pros and cons and the key barriers and opportunities for their development. Their overall attractiveness is assessed using a broad range of criteria.
– From this analysis it can be concluded that one individual option will not be sufficient to meet the 10% target of the Renewable Energy Directive, and a combination of several options will be asked for. In Section 2.4, another set of criteria will be described with which the most optimal combination of options can be developed.

It is important to realise that a biofuel route can only contribute significantly to the RED target if the whole chain from biomass production and availability to actual biofuel consumption is successfully developed. In each link of this chain, however, barriers may occur which might hinder the successful increase of biofuel consumption.

The various steps of these biofuel supply chains are depicted in Figure 6. Policy measures can impact each of these steps, for example by removing legislative barriers, by developing technical standards, by providing financial incentives or mandates, or by defining sustainability criteria.

Figure 6 **Schematic overview of the various steps and actors in the biofuels supply chain**



In the following, the most relevant issues will be described that determine the production and consumption of biofuels, for each of these steps. These issues will be used later in the report as a framework to assess the list of individual biofuels blending options.

Biomass availability and cost

Most biofuel production processes require specific types of biomass as feedstock, although many have some flexibility regarding the biomass they can use. In addition, the biofuel sustainability criteria that are defined in the RED will also limit the type or origin of biomass that can be used as feedstock. Biomass cost depend on production cost but also, as is the case with any commodity, on the balance between supply and demand. Therefore, the following factors can play a role in the assessment of options for biofuel developments:
– availability of the various types of biomass that can be used to produce biofuels that meet the sustainability criteria;
– biomass cost;
– changes in the balance between supply and demand;
– uncertainties and (perceived) risks related to price and availability in the future – these impact on investment decisions, for example of biofuel production plants.

Note that this part of the biofuel chain will not be addressed in this report, as explained in Section 1.2. This does not mean that this issue is not important, it can have a profound impact on developments in the rest of the chain. The benefit of this limitation of scope of the study is, however, that it provides the opportunity to focus on the marketing side of biofuels developments.

Biofuel production
Several biofuel pathways are still in the research and development stage and therefore not yet commercially available. The question is then to what extent these R&D efforts will result in a mature process, and in significant production capacity in 2020. Biofuels production processes that are mature may be limited in production capacity. Increasing this capacity requires both investors and time.
The following factors related to biofuel production can play a role in the available production capacity in the coming years:
- technical feasibility and maturity of the production process;
- investment costs needed to expand production capacity;
- operational costs;
- availability of suitable biomass.

Oil refineries and fuel suppliers
Fuel suppliers will need to consider the technical and operational aspects of distribution and blending of a certain biofuel and the resulting cost. They will also take into account the potential contribution of a biofuel towards the FQD GHG reduction target. The higher the contribution, the more attractive the option. Furthermore, the ratio of diesel/petrol demand may be a consideration, as this is currently not in line with the EU refining capacities: petrol is exported whereas diesel is imported. From a cost point of view, it would thus be beneficial to increase the share of biofuels in diesel rather than in petrol. And, last but not least, fuel suppliers depend on consumer demand, which is particularly relevant in case they want to sell higher blends or fuels that differ from the standard petrol and diesel.
This results in the following relevant issues:
- fuel distribution: technical issues, cost, complexity of supply chain, environmental risks (e.g. in case of spills);
- contribution to the GHG reduction target of the FQD;
- impacts on the diesel/petrol balance;
- consumer demand.

Vehicles
Some types of biofuels and blends can not be used in the existing vehicle fleet but require adapted vehicles. Depending on the biofuel blend, these vehicles may already be developed and only need to be marketed, but in some cases their development is still in its infancy and they need to go through a much more lengthy process of development, type approval and marketing.
Vehicle aspects related to biofuel consumption are:
- technical feasibility, including risk of engine shutdown and compatibility with upcoming emission standards (Euro VI);
- costs (investment costs as well as operational costs);
- fleet roll out/compatibility ready in time.

Fuel sales
In order to sell certain types of blends, a fuel supplier has to decide how to supply it to customers and consumers. If only part of the vehicle fleet can drive on these blends, this may be done via dedicated filling points at public

filling stations - which may require significant investments in some cases - or via clients with their own filling stations (captive fleets such as bus companies or large hauliers). Storage and handling at the pump might need technical adaptations. In some cases, where high blend vehicles can not drive on conventional fuels, sufficient network coverage may be needed to enable large scale market uptake of these vehicles. These investments will only be considered if future consumer demand for these blends is expected to be sufficient to justify the cost.
Summarizing, from a fuel sales point of view, the following issues may play a role when deciding on a biofuels blending route:
- technical feasibility such as potential additional safety requirements related to storage;
- investment and operational costs of filling stations;
- infrastructure network coverage;
- expected consumer demand.

The role of consumers
The consumption of biofuels depends strongly on consumer acceptance, especially in case consumers can choose between different fuels. Vehicle owners may not purchase certain high blend vehicles for various reasons (cost, driving range, perceived risk, etc.). And even if their vehicle is able to run on higher blends, vehicle owners may decide not to buy high blend fuel but rather opt for the low blend alternative in case different blends are offered, for example one high blend and one protection grade. In that case, there is also a risk that consumers fill their cars with a blend that is not fully compatible with the specific vehicle, if used regularly.
The following consumer-related factors can therefore play a role in the assessment of biofuel marketing options:
- costs, of both the vehicles and fuels;
- lack of knowledge and awareness;
- perception of biofuels (consumer acceptance);
- availability of a specific blend (i.e. fuel availability);
- risk of misfuelling.

Policy measures and goals
Several policy related aspects may also impact the choice of blending options. The main ones are:
- Availability of fuel standards and inclusion of higher blends in vehicle type approval. These are a prerequisite for any larger-scale developments of high blend options.
- Uncertainties in policy developments (and therefore future demand) may affect the attractiveness of investing in any of parts of the biofuel supply chain that are mentioned above.
- Future changes to the sustainability criteria and the potential future inclusion of ILUC effects affect the availability and cost of the various biofuels.
- Specific incentives such as double-counting in the RED and the FQD target (EU-level), subsidies and tax levels (national, regional or local level) will also play a role in steering the market towards certain options.
- Decarbonisation scenarios and roadmaps for the transport sector often conclude that in the long-term, there may be valid reasons to deploy biofuels mainly in modes with few alternative options for low-carbon transport (see for example AEA, 2010). These are typically aviation and

maritime shipping, and perhaps also long range road transport[9].
It may thus be advisable to not only focus biofuels developments on road transport, but also on the non-road transport modes with few alternatives.

Based on this overview of issues, the following list of assessment criteria has been defined. These criteria will be used as a basis for the selection of the most promising and attractive options to develop further in the coming years:
- potential contribution to the 2020 RED target, considering:
    - biomass supply;
    - biofuel production capacity;
    - potential availability of compatible vehicles in the fleet.
- potential contribution to the 2020 FQD target;
- potential marketing issues;
- need for protection grades;
- environmental risks;
- cost;
- risk that 2020 potential is not met;
- potential for future decarbonisation (post-2020).

This list will be used to compare the various biofuels marketing options, in Chapter 7.

2.4 Combining blending options

The assessment of the individual options will result in a selection of options which may be both technically and practically feasible and also attractive from cost point of view. However, not one single biofuels marketing option can meet all criteria and has the potential to bring sufficient biofuels on the market to meet the RED target. Furthermore, it may be best to have a number of options available in order to ensure sufficient diversity of biomass and biofuels. This will provide flexibility to the market and make it more robust to future developments in cost, sustainability considerations, etc.

However, not all options can be combined without significantly increasing cost or causing practical problems. To identify the optimum mix of options, the following criteria will be considered:

Cost and efforts required by the vehicle industry
Developing engines and vehicles that are compatible with higher blends or other alternative fuels requires time and effort by the industry. It will thus be both faster and less costly to introduce and optimize only one or two high blend vehicle types rather than develop solutions for a larger number of blends.

Fuel distribution
Many service stations can only offer a limited number of fuels. This will make it difficult and costly to roll out two diesel blends or three petrol blends on a large scale.

In the EU, more than 130,000 service stations are currently in operation[10], ranging from relatively small scale retailers at a supermarket to large filling stations at major European motorways.

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9 Passenger cars, vans, short distance transport and trains are then typically assumed to drive on electricity and/or hydrogen.

Some of them already have more storage tanks available of different sizes, for example to enable the sales of a larger range of fuels including premium diesel or petrol, but many are typically only equipped for one type of diesel and up to two grades of petrol.

Expanding the number of fuels on offer at a service station can incur significant cost, as underground fuel storage tanks will need to be added or existing tanks need to be modified and additional equipment (pumps and filling points, etc.) needs to be installed. It is, however, currently unknown what the potential cost is of converting these filling stations to more fuel grades. Total cost will, of course, depend on wether all fuelling stations would have to offer the various grades or whether only part of them will need to be converted.

Fuel distribution and engine development

It may be advantageous to combine options with similar characteristics, in order to increase the efficiency of investments in fuel distribution or engine development. For example, if a (low) biodiesel blend is used in diesel for road transport diesel, it can also be used in diesel for trains and inland shipping without extensive logistical implications.

Limited feedstock

Several biofuels use the same type of feedstock. If the volume of that feedstock is limited, combined biofuel volumes may also be limited.
For example, FAME and HVO can both be produced from plant oil[11].
If the supply of sustainable plant oil is limited, both FAME and HVO availability and cost may be affected. Increasing the use of FAME will then make it more difficult and costly to also increase HVO supply, and vice versa. Similar considerations hold for bioethanol from woody biomass and BTL, both (future) biofuels are expected to use the same type of feedstock.

2.5 Dealing with uncertainties: two biofuels demand scenarios

As will be discussed in more detail in Section 3.4, the biofuels market is currently quite dynamic and volatile, and there are still significant uncertainties in the future development of supply and demand. In view of these uncertainties, it is important that conclusions and recommendations of this report are robust to potential changes in the market.

This study does not address all uncertainties explicitly, except for one: the uncertainty in the future biodiesel/bioethanol ratio. Member States have written their national action plans based on certain expectations regarding price and availability of the various biofuels, but these are still quite uncertain. One of the key issues that may impact the market in the period until 2020 is the debate on indirect land use change, and the proposal of the European Commission of October 2012 on how to to address the ILUC impacts under the RED and FQD. In view of the most recent modelling result of IFPRI (IFPRI, 2011), it can be assumed that inclusion of ILUC impacts in these directives will result in a reduced uptake of FAME and HVO biodiesels, since quite a large share of these will have relatively bad GHG emission saving performance if ILUC factor is considered. This would then lead to a shift in the

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10 Source: Europia, Annual Report 2011.

11 Albeit FAME is mainly produced from rapeseed and sunflower oil (for technical reasons) whereas HVO is currently mainly produced from palm oil (because of cost).

biofuels mix, from FAME and HVO towards bioethanol, and perhaps also biomethane. The extent of this shift would depend on the methodology with which ILUC impacts will be implemented in the policies, and on how the biofuels industry then responds to the new situation. Other developments, for example implementation of the tax directive (EC, 2011) may also contribute to a future shift in the biodiesel/bioethanol balance.

In order to address this uncertainty in future biofuel demand, two scenarios will be assessed in this report:
1. The first is the 'NREAP' scenario, where the levels of the various biofuels are assumed to develop in line with the plans outlined in the NREAPs. This would result in biodiesel (FAME, HVO) sales that are about three times higher than the bioethanol sales in the EU in 2020, in terms of energy.
2. The second '50/50' scenario assumes a shift towards bioethanol in the coming years, resulting in equal shares of biodiesel and bioethanol in the EU in 2020, again in terms of energy. Compared to the first scenario, this means almost twice as much bioethanol, and only two thirds of the biodiesel.

Note that the second scenario is not the result of a detailed assessment of potential future developments, but is rather a somewhat conceptual scenario with which the sensitivity of the biofuels marketing strategy to this uncertainty can be assessed.

The key data of these two scenarios are given in Figure 4. For comparison, the biodiesel and bioethanol consumption data of 2010 are also included. As explained before, this study does not address the feasibility of producing these biofuels volumes in 2020 but rather takes them as a given, and focusses on the question how they can be marketed.

Table 6 **Overview of the biofuels volumes in the two scenarios, in the EU in 2020**

	2010 consumption (ktoe)	Scenario 1: NREAPs (ktoe)	Scenario 2: shift to ethanol (ktoe)
Biodiesel	10,748	21,639	14,474
Bioethanol	2,938	7,309	14,474

Source: 2010 data: Eurobserver, 2011. Scenario 1 data: ECN, 2011.

These biofuel volumes are actual, physical volumes. Member States expect that part of these will be produced from waste and residues, and will count double towards the RED transport target, in line with Article 21(2) of the RED. The expected shares of double-counting biofuels are given in Table 7 (based on ECN, 2011). If the actual shares of double-counting biofuels turn out to be higher than these values, the actual biofuels volume that needs to be marketed will be lower than that given in the previous table, but if they are lower, it will have the opposite effect.

Table 7 **Share of single- and double-counting biofuels according to the NREAPs**

	Single-counting	Double-counting
Bioethanol	91%	9%
Biodiesel	93%	7%

3 Biofuels implementation: plans and uncertainties

3.1 Introduction

An assessment of the potential and feasibility of different options to increase biofuel volumes by 2020 requires insight in the plans of the Member States regarding the biofuel volumes that they expect to be sold in 2020 to fulfil the target. This chapter therefore consists of an analysis of the National Renewable Action Plans, which Member States were obliged to submit to the Commission. In Section 3.3, an overview will be provided of the biofuel volumes and the type of biofuels Member States expect to consume, followed by an analysis of the envisaged policy measures to stimulate national biofuel consumption. As a first step, however, Section 3.2 will provide a short description of the various types of biofuels that might play a role in reaching the RED target.

3.2 Types of biofuels

This paragraph will describe the main types of biofuels which will be used to fulfil the RED target. The type of biofuels can be categorised according to the conventional fuel these biofuels replace in blends. For example, the physical characteristics of FAME and HVO are similar to that of diesel, these can therefore be blended with diesel, whereas bioethanol is typically blended with petrol. Blending with diesel is also being considered but not yet done on a significant scale, see the next chapter. The description provides general information on the characteristics of each biofuel. Much more detailed information on the application of biofuels in vehicles can be found in Chapter 4.

3.2.1 Diesel replacers

FAME
FAME is the abbreviation for Fatty Acid Methyl Ester, which is mostly made from vegetable oils and animal fats. The production is based on transesterification, where the biomass source reacts with methanol and a potassium hydroxide catalyst (SenterNovem, 2008).

The main crops used for the production of FAME are rapeseed and sunflower when you look at the European level. Palm oil from South-East Asia and soy (United States) are important crops on a global level. These oil crops are also used for food production, but the oil crop Jathropa cannot be used for food production. However, it turned out that Jathropa is mainly an option of local, small scale production.

To avoid the use of food crops, FAME can also be produced from residues. Due to policy incentives in the Netherlands FAME is also often produced from Used Cooking Oil (UCO). Another non-food option is to produce FAME from algae. However, this production process is still very costly and therefore the share of FAME from algae is very limited.

HVO

By direct catalytic hydrogenation plant oil or animal fats are converted into Hydro-treated Vegetable Oil (HVO). The oxygen is separated from the triglyceride of the oil by the use of hydrogen, which results in LPG as a side product. This LPG can be used for heating and other energy purposes on-side. Due to the chemical composition of HVO, it is very suitable to replace diesel. In the United States HVO is known as renewable diesel (RD). Neste Oil uses the name 'NExBTL' for their produced HVO (Aatola et al., 2008; Sunde et al., 2011; NesteOil, 2011).

The feedstocks used to produce FAME can also be used to produce HVO. Residues like waste animal fat, tall oil, used cooking oil and tallow can also be used. The use of residues might require pre-treatment of these residues, because of the higher amount of free fatty acids and water in these residues.

The main difference between FAME and HVO is the fuel quality: in contrast to FAME HVO does not compromise fuel quality.

BTL

Another group of biofuels are Biomass-to-liquids biofuels. Fischer-Tropsch diesel is an example of such fuel, where the biomass is converted to syngas and catalytic converted by Fischer-Tropsch synthesis. The hydrocarbon liquid, which is the result of those two steps can be used in the conventional refining process or can be refined in a separate process to produce 100% BTL. All types of biomass can be used for this production process (SenterNovem, 2008; UNCTAD, 2008).

3.2.2 Petrol replacers

Petrol can be replaced by bioethanol, the bio-variant of ETBE/MTBE, biomethanol and bio-DME.

Bioethanol

Ethanol can derived from sugar and starch crops, each requiring a different production process. The sucrose of the sugar crops is fermented to ethanol. Further recovering and concentrating results in the end-product. In case of starch crops conversion requires an extra production step. Hydrolysis is needed to convert the starch into glucose (IEA, 2011).

Via biochemical processing woody biomass can be converted into cellulosic ethanol. The pre-treatment splits the cellulose, hemicellulose and lignin. In the next step enzymecatalysed hydrolysis breaks down the carbohydrate molecules of the cellulose and hemicellulose. The sugar fraction, which is a result of this process can be fermented to ethanol with the use of micro-organisms. The lignin can be used as a fuel, for example for process heat.

The main biomass sources used for the production of ethanol are sugar cane, maize, sweet sorghum, wheat and sugar beet. In Europe wheat and sugar beet are mostly used. In Brazil, having the most mature bioethanol market, ethanol is mostly produced from sugar cane. In the United States maize is the most common source used.

For the production of cellulosic ethanol farmed wood, perennial grasses and wood waste from forestry have the largest potential (SenterNovem, 2008).

Bio-ETBE/MTBE

Bio-ETBE stands for bio-ethyl-tert-butyl ether and its characteristics are very similar to MTBE, methyl-ter-butyl-ether. Both can be classified as gasoline additives which are used as oxygenate to increase the octane number. Bioethanol can be transformed in bio-ETBE by adding isobutylene. Around 45% of the bio-ETBE consists of bioethanol, which is similar to 37% energy content. Adding isobutylene to methanol results in bio-MTBE. Bio-MTBE consists for 36% of biomethanol similar to 22% of the total energy content. For information on the biomass sources that can be used for the production of bioethanol see the description above.

Biomethanol

Biomethanol can for example be produced from biomethane or glycerine (BioMCN, year unknown; BioMCN, 2011).

Bio-DME

Bio-DME stands for bio-dimethyl-ether. There are different production processes for the production of bio-DME: by methanol dehydration, from synthesis gas or natural gas reforming. Bio-DME can be produced from biomethanol or syngas produced from biomass. All types of biomass can be used to produce this syngas including woody biomass and residues such as black liquor (residue of paper production).

3.2.3 Natural gas replacers

Natural gas can also be replaced by gas produced from biomass.

Biomethane (bio-CNG/bio-LNG)

Biomethane can be produced by breaking down the organic matter by anaerobic digestion. After this step, the produced biogas can be upgraded to biomethane.

Bio-CNG and bio-LNG are both produced from biomethane, but the last steps of the production processes differ. Bio-CNG is compressed biomethane. To produce LNG, the biomethane is cooled down to a temperature of -162˚C, which makes the gas liquid, thus increasing the energy density of the methane. This makes bio-LNG more suitable for longer distance transport than bio-CNG.

Biomethane used for the production of bio-CNG and bio-LNG can be derived from many types of organic material, including household organic waste, manure or maize, it can also be collected from landfill sites or waste water sludge (CE Delft, 2010).

3.3 Member States' plans and goals

This section will provide an analysis of Member States' implementation plans regarding the use of biofuels in the transport sector. The main aim of the analysis is to provide an up-to-date and comprehensive overview of the Member State's plans regarding biodiesel and bioethanol volumes and marketing in 2020.

NREAPs
The analysis is mainly based on the National Renewable Action Plans (NREAPs) in which Member States have reported their plans to achieve the 10% renewable target for transport. The NREAPs include detailed information on the expected volumes of bioethanol and biodiesel by 2020, which will be discussed first. Based on these volumes the gap between current blending limits and the Member States' plans will be determined. Then, we will zoom in on the policy measures listed in the NREAPs, which will have to provide the incentive for the use of biofuels in each country. Besides volumes, Member State also included brief descriptions of national biofuel policies, which are already implemented or intended to be implemented in order to reach the volumes.

Other sources of information
In addition to the primary data obtained from the NREAPs, analyses of the NREAPs by, for example, ECN were also used (ECN, 2011). Furthermore, the progress reports that Member States submitted to the European Commission were assessed. And finally, national authorities were consulted through a questionnaire asking to complement the public available information.

3.3.1 Biofuel volumes
In line with the template for the NREAPs, Member States provide estimations of the total contributions expected from each renewable energy technology in the transport sector in their NREAPs.

Type of biofuels
Member States present expected contributions of various renewable energy carriers using the following categories:
- bioethanol/bio-ETBE;
- biodiesel;
- hydrogen from renewable sources;
- renewable electricity;
- other (biomethane, vegetable oil).

Due to the level of aggregation no information is available on for example the type of biodiesel and the biomass used for production.

In Table 8, which is based on ECN (2011), the share of the different renewable energy technologies are depicted. In 2020, biodiesel will be main contributor to the target: on average the share of biodiesel in the total biofuel volumes will be about 66%. For bioethanol/bio-ETBE the average share will be 22%. From all the Member States Slovenia, Portugal and Luxembourg will have a biodiesel share higher than 80%. Other Member States prefer to focus on bioethanol/bio-ETBE, like Greece and Hungary, which have a share of bioethanol/bio-ETBE of 65.3% and 56.8%. Consequently, the Member States focussing on bioethanol/bio-ETBE have a relatively low share of biodiesel and vice versa.

Table 8 Total renewable transport (RES-T) energy for all 27 European Union Member States (in Mtoe)

	2005	2010	2015	2020	Share of total renewable transport
	ktoe	ktoe	ktoe	ktoe	%
Bioethanol/bio-ETBE	528	2,871	4,968	7,306	22%
Biodiesel	2,379	10,956	14,541	21,649	66%
Hydrogen from renewables	0	0	0	2	0.0%
Renewable electricity	1,087	1,302	1,968	3,115	9.4%
Other biofuels	198	210	268	788	3.1%
Total renewable transport	4,192	15,339	21,747	32,860	100%

Source: ECN, 2011.

The contribution of other biofuels (typically biomethane and pure vegetable oil) is on average 2.4%, and relatively small compared to biodiesel and bioethanol. Latvia, with a share of 37.3% renewable energy from other biofuels, is the exception. Also the contribution of other biofuels to the target in Austria is relatively high: 11%.

Share of double-counting biofuels

Biofuels in line with Article 21(2) of the RED count double towards the target of 10%, because those biofuels are produced from waste and residues. In comparison to single-counting biofuels only half of the volumes are required to realise the same contribution. The EU average share of double-counting biofuels in total biofuel consumption is 8.8%. This low share subsequently results in a higher demand for biofuels in terms of volume.

The share of Article 21(2) biodiesel in the total consumption of biodiesel (7.1%) is in the same order of magnitude to the share of Article 21(2) bioethanol/bio-ETBE (9.2%). On the other hand, 40.7% of the biofuels in the category ‘other biofuels’ are produced from waste and residues.

Share of imported biofuels in total biofuels to be used

From the NREAPs it can be concluded that 36.8% of the biofuels used to fulfil the target will be imported. This implies that the other 63.2% will come from national biofuel production. There is a small difference between the average biodiesel import and bioethanol/bio-ETBE import: 44% of the bioethanol will come from import in 2020 against 36.1% of total biodiesel. Together with the earlier mentioned share of 65.9% this confirms that the European biofuel production is focussed on the production of biodiesel.

The NREAPs do not provide any information on the following aspects related to the import of biofuels:
- the share of double-counting biofuels in imported biofuels;
- the country of origin of imported biofuels (other EU Member States or non-EU countries);
- the origin of the biomass used for national biofuel production and to what extent this biomass is also imported;
- the share of imported biofuels in the category ‘other biofuels’.

The use of hydrogen from renewables
In accordance with NREAPs, hydrogen in transport will not play a significant role as renewable energy technology in 2020. Most Member States do not expect a contribution of this technology except Romania. According to Article 5.1, hydrogen from renewables is not included in the calculation of the overall target of 20% to avoid double-counting.

The use of renewable electricity
Besides biodiesel and bioethanol-bio-ETBE renewable electricity applied in road as well as in non-road transport is expected to deliver 9.5% of the renewable energy needed to achieve the 10% target. It must be noted that like hydrogen renewable electricity applied in the transport sector will not count for the overall target of 20% renewable energy to avoid double-counting.

However, renewable electricity applied in the transport sector may be used to reach the RES-T target. The RED stimulates the use of renewable electricity in road vehicles by the multiplication factor of 2.5. Despite this multiplication factor the contribution of renewable electricity will mainly be determined by the use of renewable electricity in non-road modes: 77%.

3.3.2 Biofuel policies
The higher costs associated with biofuel production and consumption ask for a national policy strategy to stimulate the use of biofuels in the EU. In '4.5 Support schemes to promote renewable energy in transport' of the NREAPs each Member State has listed the different policy measures needed to achieve the required biofuel volumes. Generally speaking the policy measures listed can be divided in the following subcategories:
- mandates;
- tax exemptions and reductions;
- subsidies;
- dedicated marketing strategies.

Within these groups of policy measures a distinction can also be made between policy measures aimed at the stimulation of low blend in conventional vehicles on the one hand and the use of high blends in niche vehicles on the other.
As said before (and as will be demonstrated in the later chapters) it is very likely that the current blending limits will not be sufficient to reach the required level of biofuel consumption on the European market, so that higher blend options need to be implemented as well.

With the term dedicated marketing strategies, policy measures are meant that are aimed at ensuring the use of specific blends that go beyond current blending limits. Examples are policies that require the introduction of E10 at filling stations, or subsidies or tax exemptions for E85 or B30. General subsidies and tax exemptions can also provide incentives to increase the levels of, for example, bioethanol or FAME, and may thus result in higher blends, but they do not ensure that certain blends will appear on the market. If mandates are high enough, fuel suppliers will be obliged to use higher blends, but they are then free to choose how they will achieve the target.

Mandates
Most of the Member States oblige fuel suppliers, which bring fuels on the national market for consumption, to put a percentage of total fuel sales as biofuels on the market. These biofuel mandates will ensure the consumption of a large part of the needed biofuel volumes in the majority of the Member States. The required volume is expressed as a percentage of the annual fuel

sales of the fuel supplier (mostly based on energy content) and therefore the actual blended volumes may vary. In Table 9 an overview is presented of the currently implemented mandates in the different Member States (status end of 2012). Overall, mandates are seen as an effective means to increase biofuel consumption, and almost all Member States have implemented them or plan to do so (according to their NREAP). Many of these mandates have already been implemented at the time of the Biofuel Directive, which obliged Member States to reach a 5.75% biofuel share by 2010. At the moment most of the mandates do not exceed the current blending limits for diesel and petrol (B7 and E5 in most countries), but they will change in the future as the mandates will increase towards the 2020 goal.

Nine Member States have explicitly stated sub mandates for the shares of biofuels in petrol and diesel. The other 17 Member States have implemented a general mandate only. Cyprus explicitly obliges the use of biogas, while Greece uses a tender system to ensure a level of biofuel consumption, although it can be questioned to what extent this systems can be seen as a mandate.

After publication of the RED, Member States that already had a mandate in place had to adopt their mandates to include the new provisions. The RED obliges Member States to count biofuels from waste and residues (i.e. biofuels that comply with Art. 21(2) of the RED) double towards the target of the mandate, and the biofuels need to comply with the sustainability criteria of the RED. These provisions are being implemented in line with the RED in an increasing number of Member States.

The mandates typically increases over time, but so far most countries have only defined the targets until 2014 or 2015. The effectiveness of the mandates depend on the penalties that are imposed on fuel suppliers that do not meet the targets. These may vary between Member States.

Table 9 Overview of type of mandates for all 27 European Union Member States

	AT	BE	BG	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT
Overall	X	X	X	X	X	X	X	X	X	X		X	X	X
Petrol	X	X			X					X		X		
Diesel	x	X			X					X		X		

	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	UK
Overall	X	X	X	X	X	X		X	X	X	X		X
Petrol					X			X	X		X		
Diesel					X			X	X		X		

A more detailed overview can be found in Annex A.1.

Tax exemptions and reductions

In addition to mandates, specific type of biofuels can be granted a tax exemption or reduction. National customs authorities are in most cases responsible for implementing tax legislation related to biofuels. The following taxes can be differentiated in such a way that these provide an incentive for biofuel consumption:
- vehicle registration tax;
- excise tax;
- CO_2 tax levied on mineral petrol and diesel.

The most common type of tax exemptions or reductions are applied to excise duties (fuel taxes are implemented in 21 Member States), but the general trend that can be derived from the NREAPs is a gradual replacement of these types of tax advantages for biofuels by mandates. In some Member States, the tax advantages are maintained for double-counting biofuels to provide an extra incentive. A more indirect way of stimulating biofuels is the use of tax exemptions and reductions on CO_2 taxes, like in Denmark, Estonia, Finland, France and Sweden. CO_2 taxes levied based on the type of vehicle can be helpful to provide incentives to more fuel efficient vehicles and vehicles running on alternative fuels, but might also result in resistance, because CO_2 taxes can also increase the costs of driving a more polluting car. The social impacts of a CO_2 tax have been heavily debated in Estonia.

Table 10 Overview of tax exemptions and reduction for all 27 European Union Member States

	AT	BE	BG	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT
Vehicle reg.	X												X	
Circulation taxes	X										X			
Fuel taxes	X	X	X		X		X	X	X	X		X	X	X
CO_2 tax						X	X	X	X					
Road charging		X												
Other									X					

	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	UK
Vehicle registration							X			X			
Circulation taxes													
Fuel taxes	X	X		X	X	X	X		X	X	X		X
CO_2 tax												X	
Road charging						X	X						
Other						X							

A more detailed overview of the identified tax exemptions and reductions can be found in Annex B.3.

Subsidies

A wide range of possibilities exist to stimulate biofuel consumption by subsidies. The following types of subsidies are mostly used by the Member States:

- subsidies related to the realisation of infrastructure (filling points, electric charging points);
- subsidies of vehicles at the moment of purchasing (like electric vehicles, niche vehicles and low emission vehicles);
- subsidies for research schemes and development and demonstrations projects;
- subsidies related to the cultivation of biomass (energy crops, etc.);
- subsidies related to biofuel production facilities and pilot plants.

There is no clear preference of the Member States for any of these types, although Member States prefer to stimulate especially second generation biofuels by subsidising research and development or biofuel production. For example, several Member States have indicated the intention to support the realisation of biogas plants in their country.

Table 11 Overview of subsidies for all 27 European Union Member States

	AT	BE	BG	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT
Vehicles				X		X							X	
Infrastructure														
R&D/pilot plants						X		X						
Biofuel prod.				X				X						
Biomass prod.			X											

	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	UK
Vehicles				X	X								X
Infrastructure													
R&D/pilot plants					X								
Biofuel production	X		X									X	
Biomass production		X											

A more detailed overview of identified subsidies can be found in Annex B.4.

Dedicated biofuels marketing strategies and policies

Most of the policy instruments described so far do not include any specific arrangements at the national level to govern the marketing of biofuels, i.e. address the discrepancy between their targets for 2020 and the current blending limits. Mandates determine the quantity of biofuels which need to be brought on the market, but do not determine in what blends those biofuels should be available for consumers. Tax exemptions and subsidies can provide incentives for high blends if they are high enough to make the high blends competitive. However, these instruments are typically not specific for certain blends (with some exceptions where tax reductions are granted on pure biofuels). but most countries do not yet specifically address biofuels marketing issues in their policies.

Although marketing strategies seem to be lacking in the action plans, there are some Member States which mention the provision of certain blends or have implemented specific policies in the past years. In France, Finland and Germany E10 has been introduced to increase the overall biofuel share in transport. This implies that this blend should be available throughout these countries. Austria had announced that E10 will be introduced as a mandatory blend in October 2012, but the decision on introduction was postponed. In the NREAP, Austria also included an expectation for the availability of B10 in 2017. And some Member States (the Netherlands, for example, have implemented support schemes for the development of high blend infrastructure (e.g. for E85 or bio-CNG).

As the information on biofuels marketing in the NREAPs is very limited and only few countries address this issue in the biofuel/renewable energy progress reports to the Commission, a questionnaire was sent to the Member States. The aims of this questionnaire were to ask for changes since the publication of the NREAPs, and to receive more detailed information on biofuel blending strategies throughout the EU. However, only four countries (Lithuania, Spain, Sweden and Ireland) have returned a completed questionnaire. The response can therefore be called very low. A number of Member States responded by providing a reference to the NREAPs and biofuel progress reports, because these include all the information currently available, or by indicating that the questions were too specific and technical to be answered by the Member States.

Annex B.5 provides an overview of the statements that specifically address the biofuels marketing strategy beyond the blending limits, per the Member State, as found in the Member States action plans and progress reports, and in the completed questionnaires. It illustrates that some of the Member States are aware of the need for standardization, authorization, incentives and/or obligations of higher blends to ensure that also higher blends will be marketed. Some Member States have implemented concrete measures such as tax incentives for high blend biofuels, but in many cases these measures are only temporary, and many countries have no specific policy measures in place yet. Noteworthy is also the large range of measures that the various Member States intend to or have implemented. Furthermore, this table leads to the conclusion that a significant share of the Member States have not yet decided on this issue.

Table 12 Specific dedicated marketing strategies for all 27 European Union Member States

	AT	BE	BG	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT
Low blends	X				X									
High blends					X		X		X			X		X
Pure biofuels			X		X					X				
Biogas														
N.a./other		X		X		X		X			X		X	

	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	UK
Low blends													
High blends	X	X			X						X	X	
Pure biofuels					X								
Biogas												X	
N.a./other			X	X		X	X	X	X	X			X

From the responses to the questionnaire we furthermore conclude that due to the uncertainties related to biofuel developments, the biofuel volumes in 2020 were already hard to predict at the moment of writing the NREAPs.
The uncertainties still exist and have perhaps even increased due to the ILUC debate. In these circumstances, quite a number of Member States have not yet developed a detailed biofuels marketing strategy for the time after 2014/2015. They were therefore not able to respond to the more detailed questions on the expectations for 2020 that were included in the questionnaire. Typically, political consensus has been reached on the information provided in the NREAPs or other already adopted policies, but not on the information asked for in the questionnaire.

3.3.3 Conclusion

The NREAPs provide an overview of the expected biofuel demand in 2020 in the various Member States, complemented to some extent with progress reports and completed questionnaires. A substantial amount of the policy measures are short-term measures, which will end in the next couple of years. The current uncertainties in future biofuel developments, in particular the on-going debate on the implementation of ILUC in the sustainability criteria, can partly explain why Member States are currently reluctant to provide estimations of biofuel consumption until 2020.

It can also be concluded that the proposed and currently implemented policy measures provide incentives for the consumption of biofuels, for example by defining mandates or granting tax exemptions or subsidies. However, they do not address the question whether the expected biofuels volumes can indeed be marketed, and what measures will be taken to ensure that sufficient marketing options will become available. As will be seen in the following chapters, a national marketing strategy which includes, for example, a clear picture of the blends that should be available in 2020, is needed to guide developments that take time. Market operators such as the fuel industry, biofuel producers, fuel station owners and vehicle manufacturers need to prepare for these developments, and therefore need to know which technology and investments are needed to reach the target of 10% in 2020.

3.4 Uncertainties in future biofuel developments

In this report, two biofuels demand scenarios that were described in Section 2.5 are assessed, in order to account for uncertainties in the EU biofuels developments of the coming years. The following is a list of key uncertainties and potential drivers for the biofuels developments in the coming years and decades.

- The decision making process concerning the potential inclusion of effects of **indirect land use change (ILUC)** in the RED and FQD is still ongoing, as discussed in Section 1.3. A proposal has been submitted by the Commission in October 2012 which contains a number of modifications to the RED that would have quite significant impact on biofuels demand and developments. It this proposal is agreed on and implemented in the coming years, the maximum contribution of biofuel from food crops would be capped at 5% of transport fuels, and biofuels from some waste and residues would count four times towards the target rather than double. The impacts of these revisions of the RED on the biofuels market will, however, only become clear once the decision making process is finalised.
- The **price of the various types of biomass** will increase or decrease over time, changing the biofuel mix with which fuel suppliers will meet the goals. This may be a result of the balance between global supply and demand, of a global increase in food demand, of climate change that impacts on agricultural yield, etc.
- The **oil price** may impact biofuels developments in various ways. Firstly, an increasing oil price will make biofuels more competitive. However, it will also cause global biofuel demand to increase, as governments throughout the world will be putting more effort into promoting alternative fuels when oil price is high. In addition, biofuel production also requires energy, increasing energy prices will thus also impact biofuel cost.
- **Investments of the biofuels industry** are necessary to ensure that supply increases in line with demand. In the current financial situation and the uncertainty regarding the future tightening of the sustainability criteria and the longer term (post-2020) outlook for biofuels, it has become more

difficult to ensure the interest of investors in new biofuels production capacity or large scale R&D.
- Until now, **consumers** did not play a very large part in biofuels developments, but this might change in the future. When moving to higher blends, consumers will typically have the choice between low or high blend fuels and vehicles. They will only consider the high blend if they have faith in the compatibility of the fuel with their car. They may also need to be incentivised to buy the higher blend fuels and vehicles. Environmentally conscious consumers, a group that includes both private car owners and businesses, will also want to be sure that the biofuels they buy are indeed sustainable.

It thus seems advisable not to take the Member States' biofuels plans as the only possible future, but rather keep in mind that a biofuels strategy will have to be flexible so that the market can respond to changes.

3.5 Long-term outlook

Looking beyond 2020, there is a clear need to further increase the share of renewable energy in the transport sector. Among other things, the EU Roadmap to 2050 and the White Paper on Transport, both published in 2011, set a goal of -60% greenhouse gas (GHG) emissions in 2050, compared to 1990 levels. These GHG emission reductions can be achieved with various types of measures:
- increase energy efficiency of vehicles;
- shift to more energy efficient transport modes;
- reduce GHG intensity of the fuels and energy carriers used;
- reduce transport demand.

In any long-term strategy, reducing the GHG intensity of energy carriers is an important pillar (see, for example AEA 2010, or www.eutransportghg2050.eu, for scenarios on how the EU transport sector can meet the -60% target).
In this study for DG CLIMA, it is also concluded that some transport modes, namely aviation and shipping, and perhaps also long distance heavy-duty road transport, have only few options to reduce the GHG intensity of their fuels.
In a future low-carbon economy, all trains, passenger cars and vans and part of the heavy-duty vehicles are expected to drive mainly on renewable electricity, and possibly on hydrogen produced from renewable energy sources. Battery electric drive trains are, however, not expected to be suitable for aviation and shipping, these sectors will thus be dependent on biofuels and energy efficiency improvements to reduce their GHG footprint.

Therefore, there will be a clear need for sustainable biofuels in the long-term. It can be noted, however, this outlook for biofuels is quite different from the current biofuel production routes and applications. It is not yet clear when and how this transition might take place, but it is useful to keep this in mind when assessing potential biofuels blending options: routes that contribute to this longer term strategy may be more robust to future developments than others.

Other long-term issues that need to be considered in any long-term biofuels strategy are related to the sustainability of the biomass used, and the potential competition for the sustainable biomass with food and other sectors. As the world's population is expected to increase further and the global diet is changing, the global food demand will increase further in the coming decades and efforts to improve agricultural management and intensity are likely to be stepped up (see, for example, the FAO/OECD Agricultural Outlook).

At the same time, other sectors such as electricity production and the chemical and materials industry will increase their demand for biomass, in their efforts to decarbonise. Longer term biofuels developments will be linked to these developments, as they will impact the availability of the various types of sustainable biomass.

Efforts will be on-going to minimise negative impacts and optimise positive effect – both from environmental, social and economical viewpoint. The future outlook of biofuels is thus expected to be based much more on biofuels production from waste and residues than in the current situation, complemented by biofuels from biomass that is produced without or with very limited (i.e. acceptable) direct and indirect negative impacts. The ILUC proposal published by the European Commission in October 2012 (EC, 2012) states in this respect: '… only advanced biofuels with low estimated indirect land use change impacts and high overall greenhouse gas savings should be supported as part of the post-2020 renewable energy policy framework'. There is still significant potential to increase biodiesel (FAME and HVO) production from used cooking oil and tallow, and also biomethane production via anaerobic digestion is a mature technology with much scope for further expansion. Suitable feedstocks for that route include manure and organic waste and residues from agriculture, food production and households. Biofuels production from lignocellulosic (woody) and starch based biomass, currently limited to R&D and relatively small scale production, is also expected to further mature in the coming years and decades. Examples of these technologies are 2nd generation bioethanol production and gasification of biomass, possibly followed by Fischer Tropsch synthesis to produce a liquid biofuel.

3.6 Conclusions

Member States will mostly use biofuels to reach the 10% target of the Renewable Energy Directive. Biofuels currently commercially available are FAME (biodiesel), bioethanol (possibly as bio-ETBE), HVO and biomethane. Other biofuels, which will be less used but are also often mentioned are BTL, bio-methanol (possibly as bio-MTBE) and bio-DME.

According to the NREAPs, the share of biodiesel in total biofuel volumes counting for the target will be around 66% and the share of bioethanol around 22% in 2020. This implies that both biodiesel and bioethanol will play a crucial role in reaching the 10% target. Of these biofuels, less than 10% is expected to consist of double-counting biofuels. Around 62% of the biofuels is expected to come from national biofuel production, the other 38% will be imported.

In order to reach the targets, Member States choose to stimulate biofuel consumption by mandates, tax exemptions and subsidies. Many of these policy instruments provide targets and incentives for biofuel consumptions, but do not address the more technical issues of bringing biofuels on the market. Important questions that are not addressed are whether the current blending limits of B7 and E10 are sufficient, or whether there is a need to stimulate a market for certain high blend biofuels. A clear biofuels marketing strategy to reach the 2020 target seems to be lacking in most Member States. This hampers developments in this field and slows down the increase of biofuel consumption over time because stakeholders such as fuel suppliers and vehicle manufacturers do not invest in the technologies needed in the near future.

4 Biofuels blending and vehicle technology

4.1 Introduction

This chapter explores the range of technical aspects of biofuels blending in vehicles.

- Section 4.2 addresses blending of biofuels in base fuels, i.e. petrol and diesel. These **low blend biofuels** include ethanol, ETBE, MTBE, FAME and paraffinic biofuels. It covers the current blending limits and raised blending limits.
- Section 4.3 evaluates **high blends and several pure alternative biofuels**, such as bio-methane, E100, methanol and DME. A large share of the current vehicle fleet may not be able to use these blends, but they can be applied in captive fleets, and efforts can be made to ensure that over time, a growing share of the vehicle fleet becomes compatible with these high blends, allowing a gradual increase of the market share of these fuels.
- Section 4.4 then describes an alternative route, where **biomass is co-processed** at existing oil refineries. This process results in high quality fuels that are compatible with the current vehicle fleet.
- Section 4.5 looks at **biofuel use in non-road transport**, namely in inland shipping, rail, mobile machinery and aviation.
- Section 4.6 finally, evaluates the influence of blends and pure biofuels on petrol and diesel **engine efficiency**.

4.2 Blending of biofuels in base fuels

The specifications of petrol and diesel are laid down in respectively the EN228 and EN590 specifications. These specification fulfil a number of purposes such as:

- characterisation of injection and combustion properties such that engine performance and pollutant emission control algorithms can be developed;
- characterisation important for the materials compatibility such as lubricity and acidity, corrosion, elastomer compatibility;
- requirements to the composition of the fuel with key influence to the environmental, safety and health aspects when combusted, stored or spilled to the environment.

The requirements from the European Commission are generally focussed on this last point, especially the environmental and health aspects. Over the last decades this was primarily focused on the reduction of the sulphur and (poly)aromatics contents for both petrol and diesel. Even earlier, it started with the reduction of lead in petrol in order to avoid the environmentally polluting lead emissions and to make the application of the three-way catalytic converter possible.

During the last 5 years the mandatory use of biocomponents has added a new dimension to this, because the available biocomponents have a quite substantial impact on the first two items, namely the combustion and injection properties and the material compatibility. The combustion properties should also be judged in relation to the more and more stringent pollutant emission requirements. Changes in combustion properties will – depending on the engine - lead to changes in pollutant levels en will require special development of control algorithms and calibrations to compensate for that.

4.2.1 Base fuels for petrol vehicles

Biocomponents within current blending limits

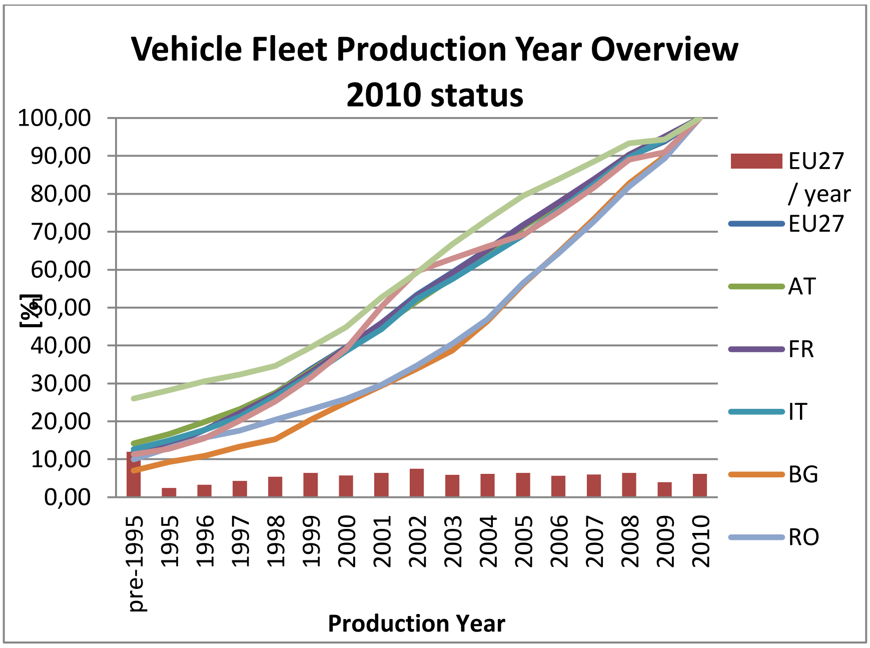
The two biocomponents available in reasonable quantities and reasonable compatible with the engine technology for petrol vehicles are ethanol and bio-ETBE.

Ethanol

In 2007 TNO/CE Delft (2008) a reference fuel was specified with 5% ethanol by volume. Since then, the maximum oxygen content of petrol was increased to 3.7% such that 10% ethanol would be possible (Fuel Quality Directive, Directive 98/70/EC as amended). The car industry has consequently produced a list with E10 compatible and E5 compatible vehicle models. This is primarily determined by the compatibility with the metals, elastomers (fuel lines and gaskets) and coatings from the fuel system including tank. For some engines the uncertainty about the durability and deposits of fuel injection nozzles is an issue.

To understand the possibilities of introducing E10 in the EU27 vehicle fleet a first analysis was performed regarding its antiquity. Therefore the TML (2010) data was processed and the cumulative results presented in Figure 7. Moreover, the same analysis was performed on six specific EU27 countries. The results show different trends between some of the countries analysed, and indicates that in 2010 and for the EU27 still some 40% of the vehicles were produced before 2000.

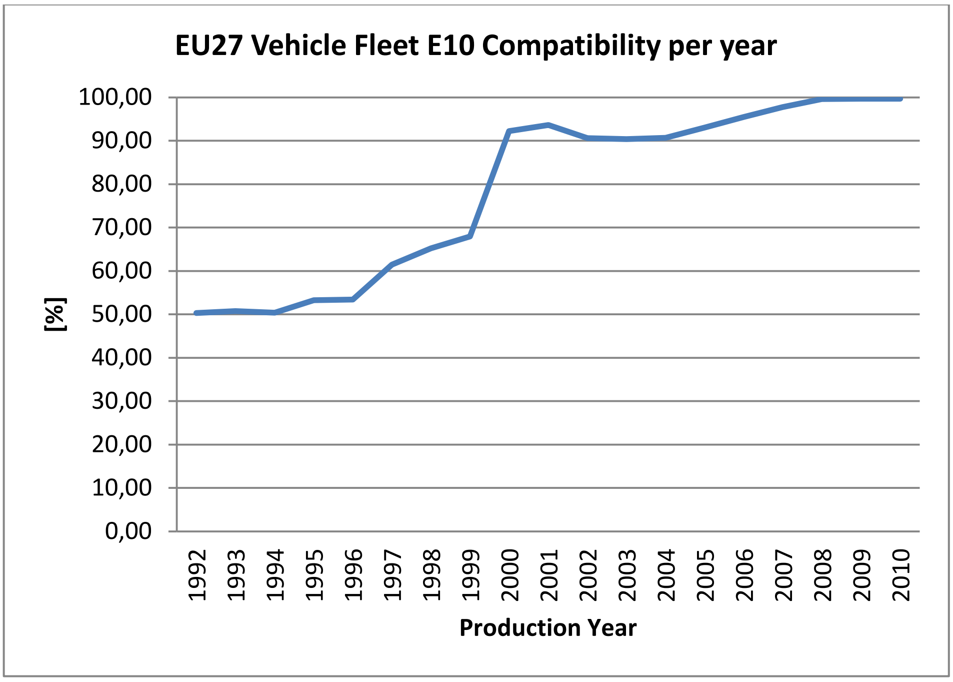
Figure 7 Production year distribution (EU27 fleet) and cumulative produced up to the year (EU27 and six countries from EU27)



The compatibility of the models sold in the European market is presented in a list published by ACEA (last updated version published on the 29.07.2011), which have as reference the technical indication of the manufacturers. Countries where E10 has been introduced have also published compatibility lists, such as in France (MEDDE, 2012), Germany (DAT, 2011) and Finland (Autotuojat, 2011). These have only minor differences with the ACEA document. Considering this, we have only used the ACEA document for the analysis.

The information contained in the E10 vehicle compatibility list of ACEA was combined with the market share (ACEA, 2012) of each of the models for different production years. With these results the graphic of Figure 8 was obtained.

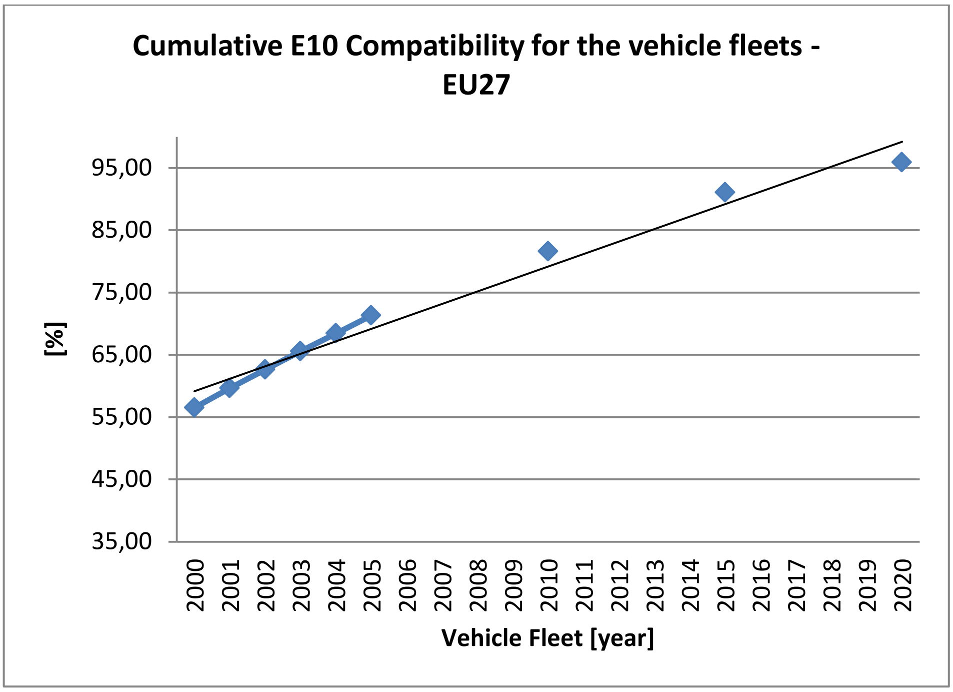
Figure 8 **E10 Vehicle Compatibility in the EU27 for the vehicle produced in the years 1992-2010**



From the analysis of Figure 8 it can be concluded that the technology applied through the years has led in 2010 to an almost full E10 compatibility in 2010 (99.7% of the vehicles produced). In this graph it is also noticeable that major technology changes introduced by the manufacturers in the period 1996–2000 resulted in an increase of the E10 compatibility. On the other way, the first generation of direct injection motors proved not to be compatible for E10 application, which slowed down the rise in E10 compatibility (even created a small dip) for the period 2001–2005.

Using the same E10 compatibility list and applying this information to the vehicle fleet age data for the period 2000–2020 the graphic of Figure 9 was obtained. The age of the vehicles in the vehicle fleet, per year, was obtained from TML (2010).

Figure 9 E10 Compatibility for the EU27 vehicle fleet in the period 2000-2020



In this version of the TREMOVE model, the vehicle fleet for the years 2010, 2015 and 2020 is a result of a baseline scenario. The available data was processed and a trend line was introduced. From the figure, one can conclude that an increase up to 95.88% in the E10 compatibility of the EU27 vehicle fleet can be achieved in 2020.

Customer behaviour

The E10 is currently offered in Finland, France and Germany. In Finland the E10 was introduced in January 2011 to become the standard petrol (labelled as '95 E10'. For the vehicles that are not suitable for the E10 application a 98 octane petrol with up to 5% continues to be available (labelled as '98 E5').
In France the E10 was introduced in April 2009 under the brand 'Super Carburant SP95-E10'. Usually the 10% ethanol fuel mixture is also available aside with classical petrol engine fuel options, such as the SP95 and SP98.
Germany has also introduced its E10 fuel in January 2011 under the labelling 'Super E10', and kept the other options available, such as Super E5 95 ('bleifrei'), and other premium fuels.

The consumers reaction was specially negative in Germany, because of fears related to potential damages to the engine. This way, the E10 consumption remained below expectations with a market share under the 20% by April 2012, but increasing (Autobild, 2012). The two major German market distributors (Shell and Aral) recently announced a further reduction in the E10 price, which in comparison to conventional fuel is already in average 2 to 3 cents lower priced (which will more or less compensate for the slightly lower energy content of E10). ADAC, the German automobile association warned for malfunctioning in vehicles that were not adapted to E10. This association also indicated the expected fuel consumption variations and other E10 use related practical advises. ADAC criticized the lack of information for users which led to an increasing uncertainty and the fact that in some cases the alternative fuel available was not Super E5 95 but the higher octane Super Plus, which is more expensive. About the latter, ADAC moved processes against five oil distributors (Tagesschau, 2011).

In France the SP95-E10 was introduced without the uncertainty of the Germany case. However, and despite having been introduced already in 2009, this biofuel accounted in 2011 for just 20% of French sales, with an increase of 40% relatively to 2010, and being distributed at 25% of the service stations (Caradisiac, 2009). Here, the price has also a reduction of 3.5 cents per litre (Bioethanol, 2012).

The introduction of E10 more successful in Finland. The consumers had some first doubts about the fuel quality but soon E10 became a success, reaching a market share of 51.1% in December 2011 (VTT, 2012). Much of this success may be attributed to education campaigns and positive consumer experiences (Petrolplaza, 2011).

Bio-ETBE and bio-MTBE

ETBE or Ethyl Tertiary Butyl Ether is a common octane improver for petrol just like MTBE (methyl tertiary butyl ether). ETBE as blend for petrol has been used for a number of years, although in recent years it is replaced by ethanol.

Bio-ETBE is produced from bioethanol (37%) and fossil isobutylene (63%), and its refinery handling has shown to be cost effective. Bio-MTBE can be produced from the same feedstock as BTL, which includes (waste) wood but also glycerin is an excellent feedstock.

The maximum blend percentage of ETBE and MTBE is 22%, because then the maximum oxygen content of 3.7% of petrol is reached.
Its specific energy content is closer to petrol than ethanol.
Other advantage described for ETBE is the energy intensity needed to obtain the octane. On an equal bioethanol content basis, ETBE delivers three times as much octane for replacing aromatics as direct ethanol blending.
Bio-ETBE can be considered as a blending component for the protection grade fuel with 0-5% ethanol. Older cars are probably compatible with a 22% ETBE blend. In that case also close to the 10% renewable content can be achieved for those cars.

Increase current blending limits for petrol

Increasing the current blending limit of 10% for ethanol is technically not very difficult, since the technology is well available in flexible fuel vehicles (FFV) Eleven European car manufacturers are currently offering some FFV models (RDW, 2012). The technologies, being materials compatibility and engine fuel injection control, are probably well available via the large suppliers and can also be implemented by others. The additional materials and software costs are expected to be low (< 25 EUR per vehicle if mass produces, refer to Section 4.3.1).

When increasing the ethanol blend, one should of course take the about 30% lower energy content of ethanol into account. In Table 13 the numbers are given for several blend options. Also three high blends are included.

Table 13 Effect of ethanol blend percentage on energy content of the fuel

	Petrol	E5	E10	E20	E30	E70	E85	E100
Energy content per litre	100%	98%	97%	93%	90%	77%	72%	67%

Also ACEA (ACEA, 2012b) supports an increase in blending of ethanol above E10 (referred to as E10+) provided the proper lead times are taken into account and preferably that this is done in one single step. Officially the lead time would be about 6 to 9 years, although in this case, taking into account the vehicle technology is readily available, it should be possible to shorten this period.

In the USA the use of E15 is supported in a number of states. The US-EPA has issued a waiver to allow E15 under the gasoline specification (Herman 2011), although 17 states maintain the cap of E10. Also other states have restrictions. According to the waiver, E15 can be used for passenger cars for model year 2001 and newer, but not all car manufacturers support the use of E15 in their vehicles.

In Brazil, 85% of the petrol vehicles use E25, the remaining 15% uses hydrous E100 (de Tarso Costa, 2005). From this it can be concluded, that it is no problem to switch to higher blends such as E25 over time. It should be noted, however, that engines, emissions control systems and type approval procedures are different between USA, Brazil and Europe. So many vehicles available in USA and Brazil cannot directly be delivered in Europe.

For Europe, higher blend ratios E20 to E30 are considered possible. Taking into account the long life time of vehicles (some 20 years), it is important to make a decision soon on a higher blend ratio. Even though the higher blends for example E20 is not generally available until 2030, it is still important to make the decision now. It may also be recommendable to separate the reference fuel for pollutant emission legislation from a compatibility requirement. So for example the (primary) reference fuel for the type approval test remains the E10 while the vehicle compatibility is set to E20 (because later in its life time the vehicle may see the E20 fuel). In that case it would also be clear for the car industry that the vehicle should be optimised for E10, because that will be the blend for the majority of the distance driven.

When the blend ratio is raised, it must be decided whether the minimum octane requirement is also raised. This would enable a somewhat higher efficiency of the engines. Refer to Section 4.6.

4.2.2 Base fuels for diesel vehicles

Biocomponents within current blending limits

The EN590 diesel fuel specification allows the blending of 5% biodiesel (FAME). The maximum blending of FAME into diesel under FQD is set at the level of 7%, while the EU Member States are allowed to place on their markets diesel with FAME greater than 7%.

The type of feedstock (plant oil) determines the properties of the FAME.
For winter grade diesel fuel care must be taken that the right mixture of FAME types is used otherwise the cold flow requirements are not fulfilled. Instead of that, also replacing a part of the FAME by Hydrotreated Vegetable Oil (HVO) is a good way to achieve the winter grade properties.

All current passenger car and truck diesel vehicles are B7 capable.

The biocomponents of a B7 fuel can be increased above the 7% by adding the fungible biocomponents HVO and BTL. BTL is currently not available in significant quantities. HVO can be added up to 30% within the fuel specification.

Increase current blending limits for diesel
Meant here is to increase the content of FAME. FAME can be made available in sufficient quantities to meet the RED target for 2020 for diesel engines.

The capability of current vehicles to accept higher blends than B7 differs a lot between light duty and heavy-duty vehicles.

Light duty vehicles
In general, currently higher blends than B7 are not accepted. Only PSA (Peugeot and Citroen) diesel cars are compatible with blends up to B30. Their market share for diesel vehicles in Europe is about 15% (EEA 2012).

The issue with higher blends than B7 is primarily related to two issues:
- The technical choice to use in-cylinder ‘post injection’ for the regeneration of the diesel particulate filter on passenger car diesel engines. The post injection with biodiesel blend leads to a quicker lubricant deterioration. PSA has a fuel additive system installed on its engines and consequently the post injection is less frequently necessary.
- Fuel quality issues which is related to impurities or undesired components within the biodiesel blend.

For the future, when there is a need to increase the FAME content there are several possible solutions to this.
- improve the post-injection strategy such that less fuel is condensed on the cylinder wall and ends up in the lubricant;
- introduce another regeneration technology for the DPF such as post injection in the exhaust manifold, mixing of fuel additives to promote regeneration or electric heating of the DPF;
- improvement of lubricant additives such that the issues related to FAME are solved (this is also important without post injection).

These options require substantial development effort and time (years), because they need to be implemented and tested in many vehicle types per manufacturer. Raising the blending limit from a B7 to a B10 or B15 does not seem to be an insurmountable problem though, taking into account that suitable technologies are available. The fuel quality issues need to be controlled by quality control within the supply chain.

Heavy-duty vehicles
The compatibility of heavy-duty vehicles with higher blends is much better than for light duty vehicles. Especially the heavy-duty vehicles with larger engines have a good capability. It is estimated that about 80% of the trucks can run safely on B30. Refer to Section 4.3.2. Maintenance interval such as oil drains are generally more frequent with higher blends.
Because of the good compatibility of current trucks with B30, it is not expected that raising the blending limit to a B10 or B15 is a very large problem.

4.3 High blends of biofuels

The purpose of high blends is to market more biofuels. The percentage of biocomponents within the base fuel stays below the blending limit. A part of the vehicle fleet can run on high blends. Unless the vehicles are part of a captured fleet, which can be refuelled at a home base (‘depot fuelled’), high blends would require additional tanks at fuel stations.

4.3.1 High blends for spark ignition engines

An overview of high blend options for petrol or 'spark ignition' engines are presented in Table 14.
These fuel options are further discussed in the following paragraphs.

Table 14 High blend options or pure alternative fuels for petrol cars

	Energy content per litre	Octane number
Petrol E10	100%	>95
Current options:		
– Ethanol E85	72%	110+
– Bio-methane (bio-CNG, bio-LNG)	25%*	≈120
Possible future options:		
– Ethanol E100	67%	110+
– Methanol M85	57%	110+
– Methanol M100	59%	110+
– Iso-butanol	92%	

Ethanol E85 or Flexible Fuel Vehicles

The vehicles that can run on high ethanol blends in Europe are all so called 'Flexible Fuel Vehicles' or FFVs. They can run on any blend ratio from 0 to 85% ethanol in petrol.
In Sweden, the FFV vehicles running on E85 represented in 2008 over 20% of the sales and the E85 was available at more than 30% of the filling stations. This high share of E85 is strictly related to governmental incentives such as fuel tax, Stockholm congestion tax exemption, legislative obligation to include E85 at pumps from a certain size, discount on auto insurance, subsidy when buying an FFV vehicle and free parking spaces in most of the largest cities (Best, 2010). In Sweden the E85 price is in average 29% lower than conventional petrol, on a per liter basis, and there was an increase in consumption between March 2010 and March 2011 of 27% (Argus, 2011) due to the lower energy content of E85.

The development of the Swedish market has led to a market offer of nearly 40 FFV models. In 2008, 79,000 FFV were sold in the EU, contributing to a total fleet of 170,000 FFV. Almost 75% of the FFV sales in the EU took place in Sweden, where also 60% of the pumping stations are located (Best, 2010).
In other European countries the number of pumps is substantially lower than in Sweden. Other countries where E85 has a high number of FFV and E85 fuel pumps are Germany, (10,000 FFV/255 E85 pumps), France (7,000 FFV/305 E85 pumps), Ireland (7,000 FFV/31 E85 pumps) and the Netherlands (6,000 FFV/ 29 E85 pumps) (Best, 2010). Despite these recent developments, the current market share in Europe is still low (<1%), mainly due to the limited infrastructure, the limited availability of FFV models in most of the markets, and the high ethanol price.

The percentage of petrol in E85 is mainly needed to improve the ignition with cold starts. In some countries the ethanol content is lowered in winter from 85 to about 70% in order to secure the start-ability. Of course this lowers the quantity of ethanol that is consumed.

In WFCC-E (2009) and TNO/CE Delft (2009) the most important risks related with the blending of ethanol are described. They are all related to water and impurities within the ethanol:

- Water in the ethanol can promote corrosion and microbial growth.
- Inorganic chloride is extremely corrosive and corrodes metals in vehicle fuel lines (even with low contamination).
- Ethanol and sulphate are corrosive as well. Metals such as copper promote oxidation of fuel and because of that cause injector deposits.
- Phosphorous and heavy metals will cause catalyst poisoning.

Effect on costs

The additional price of an FFV currently ranges from zero to about € 2,000 per vehicle (refer to Annex C) depending on the manufacturer and model. Apparently marketing strategy plays a role here. TNO estimated for the Dutch Ministry of Infrastructure and the Environment the additional production costs for a flex-fuel vehicle in mass series production, to be lower than € 25 (components and software) (Mensch, 2011). This was based on the assumption that all future produced vehicles would be FFVs. The maintenance costs for FFV vehicles are currently higher. The oil and oil filters must be changed 1.5–2 times more often when running on E85.

Effects on pollutant emissions

In TNO/CE Delft (2009) a lot of data was collected to about the effect of ethanol blends on the pollutant emissions NO_x and PM compared to petrol (E0). This was chassis dynamometer data of a large variety of Euro 4 cars and some Euro 3 cars. The graphs are shown in the factsheet ethanol Annex C. Although the scatter of this type of data is high, on average the emissions for high blends with FFVs were about the same as with petrol (E0).
When putting low blends up to E20 in normal (non-FFV) cars there was on average an increase in pollutant emission, but it should be noted that these vehicles were never developed for E20. For the future no issues for FFVs are expected, also because it is well implemented in type approval procedure. with Euro 5 phase B entering into force (2012). Then FFVs need to fulfil the same requirements on the high ethanol blend (E85) as on petrol. The emissions are then expected to be very close to those of gasoline vehicles.

Bio-methane vehicles

Bio-methane can be applied as CNG (compressed natural gas) and LNG (Liquefied Natural Gas) as a fuel for road transport. There is no difference between an LNG and CNG engine. Bio-methane can be used in both spark ignition engines and compression ignition engines. Bio methane compression ignition engines are indicated as 'dual fuel', these run on a mixture of methane and diesel fuel. Methane share of the fuel is about 75% (for OEM systems). Bio-methane vehicles have normal maintenance costs but have higher purchase costs.

The current market share of CNG for road transport in Europe is with 0.3% very small (world wide share is 1.2%) (Seidinger, 2011). This share varies throughout the EU, though, as the CNG share of passenger cars is about 2% in Italy, for example (see Section 6.7 for more detailed data no market shares).

Passenger cars and vans

(Bio)CNG passenger cars and vans are only available in spark ignition engines in combination with CNG. The CNG vehicles are possible in the following two variants:

1. dedicated: mainly use CNG as a fuel. A very small petrol tank is only used for 'limb-home' on petrol.
2. bifuel: can use both CNG and petrol.

Dedicated CNG vehicles are always OEM systems, bifuel can be either a OEM vehicles or they can be retrofitted vehicles.

The market share of CNG vehicles is very small due to the small amount of available vehicles and the limited infrastructure. Also there is an additional purchase price between € 2,000 and € 7,500 (TNO/CE Delft, 2009). Five manufacturers in Europe are offering two or three CNG models (RDW, 2012). Three of them are currently offering both bifuel and dedicated versions.

Heavy-duty vehicles

HD vehicles are generally CNG vehicles (compressed storage). Most popular application are city buses for public transportation. On a limited scale trucks are offered with LNG (liquefied) gas storage, which could become much more popular in the future. It has the advantage of a larger storage capacity. Refer to Table 15.

Table 15 Properties of alternative fuels for trucks

	Diesel	(Bio-)CNG	(Bio-)LNG
Energy density %*			
Per dm3**	100	≈ 20	≈60
Per kg***	120	105	140
Typical max operating range of the truck	1,000	250	500

* Diesel per dm3=100.
** Excluding packaging.
*** Excluding tank weight.

The natural gas HD vehicles generally have spark ignition engines, although for trucks dual fuel is becoming more popular. The advantage of dual fuel is the flexibility to switch back to 100% diesel (also for resale value) and the higher engine efficiency. Most of the European HD vehicle manufacturers are currently offering spark ignition engines. Dual-fuel engines are currently offered by two manufacturers.

Possible future high blends for spark ignition engines

Pure Ethanol E100

In Brazil, a number of car OEMs are offering E100 vehicles. These spark ignition engine run on neat hydrous ethanol (Junior, 2002). This is probably a slightly more economic fuel, because the water, naturally present in the ethanol, does not have to be removed. These vehicles generally have a very small petrol tank of a few liters, to assist with the cold start of the vehicle.

The adaptations required for E100 are referred in Taniguchi (TNO/CE Delft, 2008). This way injectors with higher fuel flow rate are introduced, in order not to increase the injection duration. Also the compression ration could be increased from 11.5:1 to 13:1 to make use of the better octane number of ethanol. With these changes the engine torque can be increased with about 10% over a large part of the engine torque range. This is due to a combination of increased engine efficiency and volumetric efficiency. These actions also showed an improvement in injector deposits formation when running on E100 (but also on E50 and E20).

Whether Europe should consider E100 is questionable, because the difference with E85 is not so large. It is probably better to stimulate the use of E85 for FFVs (so make sure infrastructure and price are competitive with E10), than to introduce another vehicle type with again an additional fuel distribution effort.

Methanol
Methanol was popular as alternative fuel for primarily SI/flex fuel engines in the eighties and nineties of last century. Currently it is used on a large scale in China. It is primarily applied in blend percentages M15 (15% methanol in petrol), but also M85 is used. It is used for both passenger cars (taxi's) as well as trucks and buses (MI, 2012).

In USA and Europe, methanol was replaced by ethanol because ethanol can be produced renewably in an easy way. Methanol also got a bad name because of risks of toxicity when consumed or when spoiled to the ground water and because of safety issues due to the invisible flame. If methanol would be considered again as an alternative fuel, these issued would need to be addressed.

Butanol: low or high percentage blends
Butanol could be an alternative to ethanol. Compared to the latter, butanol has a higher energy density, is less hygroscopic and has a lower vapor pressure (Stefan Karl, 2008).

BP and DuPont are promoting the use of (bio)butanol as an alternative to ethanol. The production process of butanol is quite similar to that of ethanol. Only different enzymes are necessary for the fermentation process of butanol from sugars. If this can be sufficiently industrialised and if factories become operational, butanol can be a good alternative to ethanol.

Butanol and ethanol both have a high octane number which can lead to somewhat higher engine efficiency. The lower vapour pressure of butanol reduces possible problems with evaporative emissions such as reported for petrol engines running on low blend ethanol.

Biopetrol
Shell and Virent have announced the joint development of biopetrol components which have higher energy content than ethanol and butanol (Shell, 2008). The biopetrol components are fully compatible with gasoline and can be used in conventional petrol engines. The biopetrol would not require a separate distribution infrastructure as would be the case for ethanol.

4.3.2 High blends for compression ignition engines

This is split up in currently used high blends and possible future blends or pure biofuels.

Current high blends or pure biofuels:
- biodiesel or FAME (Fatty Acid Methyl Ester);
- HVO or Hydrotreated Vegetable Oil;
- ethanol pure or blends with diesel:
  - ED95: ethanol with ignition improver;
  - diesel with 5 to 15% ethanol.

Possible future high blends or pure biofuels:
- BTL or Biomass To Liquid;
- pure Methanol or blend with diesel;
- pure dimethyl-ether or DME.

HVO and BTL are fungible fuels. They are very compatible to diesel fuel.

Biodiesel

FAME has different characteristics from conventional diesel fuel due to molecular differences (TNO/CE Delft, 2009; Röj, 2009; Verbeek, 2009; Bach, 2009):
- lower stability and worse cold flow properties, that increase the risk of filter plugging;
- higher boiling point, that can lead to lubricant and engine cleanliness degradation and possible polymer formation;
- an increase in engine out NO_x can be amplified by the emission control system (AdBlue injection not adjusted to the fuel properties);
- higher oxygen content, which can lead to a high exotherm of soot oxidation with active or passive regenerations, leading to failures of the DPF;
- more sensitivity to microbiological growth due to the fact that it contains oxygen.

Engine problems are generally related to impurities which originate from the fuel production process or are already present in the feedstock.
The consequences of the impurities are the following (McCornick, 2007; WFCC-D, 2009; Bach, 2009; TNO/CE Delft, 2008):
- degradation of some plastics, EGR system, and elastomers, and corrosion of metals;
- deposits formation on injector tips, clogged fuel filters and deposits at bottom of fuel tank;
- excessive injector, fuel pump, filter plugging, piston and piston ring wear;
- chemical deactivation (poisoning) of oxidation catalyst, SCR catalyst and DPF.

Light duty vehicles

See also Section 4.1.2. About 85% of diesel passenger cars are currently not compatible for biodiesel blends higher than B7. Only PSA (Peugeot and Citroen) diesel cars are compatible with B30. Their market share for diesel vehicles in Europe is about 15%.

The effort to implement the new technologies which would make high blends possible is quite large and it is not likely that this happens before 2020 or even after 2020. Before making such a decision, it should be clear that there will actually be sufficient sustainable biodiesel available in the future.

Heavy-duty vehicles
The compatibility of heavy-duty vehicles with higher blends is much better than for light duty vehicles. Especially the heavy-duty vehicles with larger engines have good capability, because of the type of fuel injection system which is applied.

The estimated market share of HD vehicles which are currently compatible with biodiesel blends and neat biodiesel is actually quite high and presented in the table below. The percentages are based on a consultation with 7 large HD vehicle manufacturers regarding biodiesel capability (Norris, 2011), the compatibility is weighted with the new registrations share of the 7 manufacturers (Hill, 2011):

Table 16 Estimated compatibility with biodiesel blends of current HD vehicles

	B7	B20	B30	B100
Estimated market share	100%	85%	80%	60%

It should be noted that there specific conditions to the use of high blends are :
- maintenance intervals are usually shorter;
- the biodiesel need to comply with EN14214;
- in some cases several components need to be added and/or replaced.

In a programme for the Dutch government regarding advice about the impact of biofuels for road transport (TNO/CE Delft, 2009) a questionnaire among vehicle manufacturers is held. The vehicle manufacturers expressed concerns with wear issues of exhaust emission related components, also an increase in NO_x emissions and some OBD problems have been mentioned. The most appropriate implementation would be B20 or B30 in captive fleets.

Acceptance of high blends for Euro VI and later are still very uncertain. Stringent emission requirements and type approval procedure make it necessary to have a separate type approval and possibly also calibrations for blends higher than B7.
For pollutant emissions security and flexibility, It makes a rather large difference whether the vehicles will be flexible fuel (one engine specification can handle low and high blends) or whether there will actually be different engine control versions. With the latter case, misfueling is possible, which may lead to an increase in pollutant emissions.

The chances that a ‘flexible blend’ EURO VI truck is possible is much higher with a B30 than with a B100 though, reason why a larger share of B30 would be more recommendable than a smaller share of B100 vehicles.

HVO & BTL
The molecular structure of HVO (Hydro-treatment Vegetable Oil) and BTL (Biomass to Liquid) consists of paraffins and is very similar to that of diesel. Because of that, it is a quite fungible (compatible) fuel for diesel engines.

Specifications of HVO in comparison to EN590 and FAME are shown in Table 17. HVO and BTL do have a lower density than EN590. When making a blend, this offers the possibility to allow a share of heavier fossile components and still meet the EN590 specification.

Table 17 **Diesel EN590, HVO and FAME specifications**

	Unit	EN 590 diesel	HVO	BTL (SunDiesel)	FAME (from rapeseed oil)
Density	Kg/m3	~ 835	775 - 785	~ 751 - 761	~ 885
Heating value	MJ/dm3	35.7	34.4	33.9	33.2
Heating value	MJ/kg	42.7	44.1	44.6	37.5
Total Aromatics	%	~30	0	0.1	0
Poly-aromatics	%	~4	0	0	0
Sulphur content	mg/kg	<10	<10	<10	<10
Ash	% m/m	~0	~0	-	<0.02
Cetane #	-	~ 53	~ 80-99	~ 83	~ 51

Sources: Nylund, 2011; Blades, 2005; Ng, 2005; EN 14214 and Mikkonen, 2012.

The production process of HVO is based on the reduction of the glycerol backbone to propane and of the fatty-acids to the corresponding alkanes. At the end a mixture is formed without oxygen. BTL is also produced without oxygenation species. From the decomposition and gasification of biomass a syn-gas is formed, a mixture of combustible gases which is catalytically converted into alkanes, following the Fischer-Tropsch process.

The following companies have developed HVO production processes (Mikkonen, 2012):
- Axens IFP: Vegan
- Honeywell UOP: Green Diesel
- Neste Oil: NExBTL
- Syntroleum
- UPM: BioVerno

A blending of up to 30% of HVO is possible while meeting the EN590 specification. Higher blends up to 100% are also possible. All EN590 specification are then still met except for the density requirements (Mikkonen, 2012). HVO fulfills the CEN technical specification for paraffinic diesel fuels: TS 15940 (2012).

HVO is known to have a positive effect on exhaust emissions, which is primarily due to the high cetane number and low aromatics. The positive effects on exhaust emissions is shown in many publications (Mikkonnen, 2012; Nylund, 2012; Nylund, 2011; Mikkonen, 2009; TNO/CE Delft, 2009). Similar positive effects are to be expected from the other paraffinic diesel fuels such as BTL and GTL.

Nylund, 2011 showed the effects of several blends and pure HVO. The average results for a range of HD engine technologies for urban bus applications are:
- 30% HVO blend: ~4% NO_x reduction and ~12% PM reduction;
- 100% HVO blend: ~10% NO_x reduction and ~30% PM reduction.

These positive effects were on average higher with advanced diesel engines such as for Euro IV, V and EEV. These advantages are likely to diminish with the new Euro VI vehicles, since the emissions are already very low and equipped with closed loop NO_x control and DPF (diesel particulate filters) (TNO/CE Delft, 2008). There are some indirect advantages though. Since paraffinic diesel fuel lead to a lower particulates emission, the particulate load of the particulates filter will be lower, which will lead to a lower frequency of active regenerations. This will save some fuel and also improves the durability of the emission control system such as catalysts and sensors. Also if an engine is optimised on HVO, it has a positive effect on engine efficiency. Refer to Paragraph 4.6.2.

Ethanol-diesel

ED95

A European standard for ED95 has been adapted and a reference ED95 specification has been made for the Euro VI legislation (2009/595/EC).
ED 95 is basically a hydrous Ethanol with about 2% ignition improver. It may contain up to about 6.5% water.

The Swedish manufacturer Scania, is at present the only supplier of ED95 vehicles. In a project at the city of Stockholm some 600 buses run on this type of biofuel. Other manufacturers are expected to present in the coming future its bioethanol driven vehicles. As the ethanol (which already contains 5% of water) has a very low cetane number, about ignition improver is added to increase the compression ratio to a standard CI engine. For the ignition improver there is one supplier, which is SEKAB that owns simultaneously the patents (Best, 2010). This manufacturer is also preparing a specific fuel for the bioethanol engines.
Considering the lower combustion value of ED95 compared to diesel, the flow rate during injection are quite different as well as the injection quantity and timing. ED95 contains 60% of the energy of diesel if compared per liter, and an ED95 bus consumes 1.7 times more than its equivalent diesel, but its lower flash point require it to be handled as a petrol fuel. Looking at the future development potential, the very restricted number of engine producers is an important restriction for its further implementation.
For ED95 the maintenance costs are higher as the check-up periods are shorter. Furthermore, the initial cost is in average 10% higher, in comparison to a normal diesel bus.

5-15% ethanol diesel blends

These medium blend ethanol diesel blends have been marketed by some fuel or fuel additive suppliers. They are marketed under the names E-diesel and O2-diesel. The ethanol and diesel are often mixed at the depot of the transportation company. The fuel is used in standard – not adapted - HD diesel vehicles. The ethanol basically brings some oxygen within the fuel which often leads to a reduction in particulates emission. 0-30% PM reductions are reported for E-diesel and O2 diesel (for conventional diesel engines whithout particulates filer).

E-diesel is referred in the Best report. It is a blend of anhydrous bioethanol and diesel, with an emulsifier or solubilizer as additive. These blends can vary from 5 to 15% and the additive content from 0.5 to 5%, depending on the type of additive used. The flash point of this fuel is very low due to the addition of bioethanol to the diesel, and so E-diesel must be handled as petrol. One of the changes it the need to introduce flame arrestors on the fuel tank to avoid fire risks. This type of fuel has only been approved for use in France. A possible larger scale use of E-diesel is dependent on the introduction of a standard, somewhat similar as the one for the 7% FAME blending in diesel (BEST, 2010).

Possible future high blends for compression ignition engines

This paragraph will discuss biofuel blends which have been used in the past for diesel engines but never captured a significant market share. They generally did not come further than a demonstration phase.

Dimethyl-ether (DME)
In Sweden activities are on-going on both the production of DME as well as the demonstration in vehicles by Volvo (Salomonsson, 2010). DME can be produced from natural gas or from renewable feedstock (same feedstock and similar process as BTL). China is producing over 7MMtpa DME, but this is blended into LPG for cooking. Dimethyl-ether (DME) as an alternative fuel for CI engines. This has the advantage of the high 'diesel cycle' engine efficiency.
DME is basically a very nice 'compression ignition' fuel, because it has a very low auto ignition temperature and it vaporizes to a gas almost instantaneous after injection. Because of these characteristics the NO_x and PM emissions are very low in a correctly optimized engine and without the need of a diesel particulate filter. DME is non toxic. High concentration can be inhaled without serious health effects. Also spill or leakage to the environment would not lead to any environmental risks.

Unfortunately DME has also some disadvantages:
- It is a liquid gas (similar to LPG) which requires a special fuel system both for the low and high pressure side.
- Even in liquid phase it is relatively compressible and characteristic are sensitive to temperature. This requires a special fuel injection system even though the fuel injection pressure is much lower than for diesel fuel.
- It is relatively aggressive to elastomers.
- It would require a new infrastructure for fuel distribution.

DME has a similar energy content as ethanol, which is about 30% lower than diesel and petrol. This means a reduced driving range and/or an increased fuel tank size (up to a factor of 2).

Various information can be found on the website of the International DME Association (IDA): http://www.aboutdme.org/.

4.4 Co-processing in refineries

An alternative to stand-alone HVO production is co-processing of vegetable oils and animal fats in the diesel hydrotreater of an existing crude oil refinery. The focus of this study concerns the processes utilizing a diesel HydroDesulphurisation Unit (HDS) installation at an existing mineral oil refinery - e.g. Petrobras's H-Bio technology[12] or Haldor Topsoe's technology.

This technology is in use in various refineries worldwide, but volumes are still limited. The potential biofuel volume that could be produced with this technology is, however, significant.

In the hydrotreater pure vegetable and animal fats and oils are hydrogenated at a temperature 300-400°C and a pressure of 40-100 bar. Under these conditions, oxygen in the fats and oils are hydrogenated into water and double bonds in the fats are saturated.

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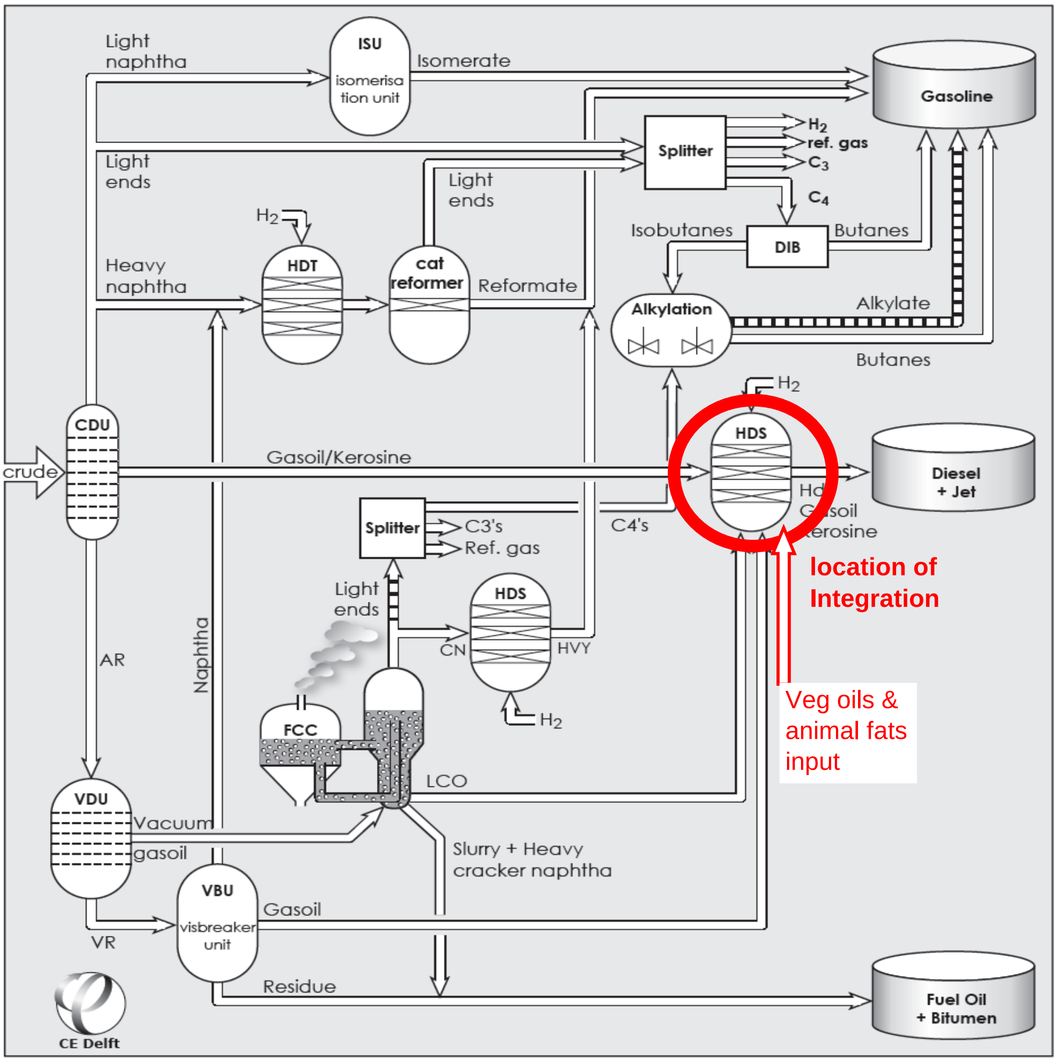
12 http://www2.petrobras.com.br/tecnologia/ing/hbio.asp.

Figure 10 Integration of vegetable oils and animal fats hydro deoxygenation in existing mineral oil refineries



Note: The figure represents a refinery with FCC configuration.

In these processes pure vegetable or animal oils and fats - free of water, dissolved metals, phosphides, proteins, particles, free fats and oils - is hydrogenated. During hydrogenation oxygen, sulphur and nitrogen are removed as water, H_2S and NH_3 and unsaturated bonds are saturated. The glycol present in the vegetable oil is hydrogenated into propane.

Hydrogen consumption and products assay depend on feed and required degree of isomerisation[13]. Every vegetable oil has a specific composition of glycol esters of different fats and oils, differing in length of chain and level of saturation. Level of saturation and percentage of oxygen in the feed (higher with shorter fatty acid chains) partly determine hydrogen consumption.

Co-processing of vegetable oils and animal fats in a refinery is practically limited because of the prohibitive increase in cloud point of diesel caused by co-processing. This effect is caused by the higher molecular weight of the hydro deoxygenated fats and oils and the associated high solidification

13 http://www.uop.com/objects/UOP_ENI_Ecofining_Process%20-%20final.pdf.

temperature. Increases will depend on vegetable oil composition, mainly on the length of the fatty acid hydrocarbon chain. Vegetable oils with high concentrations of fats and oils of lower chain length (e.g. palm oil) would be preferable and would give lower cloud point increases compared to oils with longer fats and oils (soy, rapeseed, sunflower). Information about such a relation has however not been found.

The problem of cloud point increases is countered in standalone installations (i.e. HVO production plants) by isomerizing the produced paraffins[14]. We found no information suggesting extension of a refinery with diesel isomerization processing in case of co-processing of vegetable oils is being considered or proposed. Without additional isomerization the percentage of vegetable oil and animal fats that can be co-processed will be limited, the limit being a function of ambient temperature.

The amount of vegetable oils that can be co-processed in EU refineries is not readily identifiable on the basis of available information:
- The amount of vegetable oils that can be processed is at least 1.5 to 5% - depending on the season of diesel production.
- Information from a petrochemical company with a refinery in the Netherlands indicates that probably 7-10% of the crude diesel production can be replaced. In public literature by Petrobras also higher percentages (10% and higher) are mentioned (CE Delft, 2008).
- At Preem's refinery in Gothenburg, up to 30% of vegetable oils are co-processed. This mixture is only supplied to the market in the summer, though.

Co-processing of high ratios of vegetable oils also require modifications to the hydrotreater – such as staged injection and intercooling - and construction of additional infrastructure for the storage and internal transport of vegetable oils.

The product mix that is produced with this process is a function of feedstock composition (see above) and operational conditions, and may range from:
- Propane 2-4 weight%
- Naphta 1-10 weight%
- Diesel 88-98 weight%
- Catalysts applied in the H-Bio process are a 0,33 ÷ 1 to 0,54 ÷ 1 mixture of sulphides of Group VIII (Mo, W) and Group VI-B (Co, Ni) metals.

Maturity
The technology used to refine vegetable oils is already in use for many years. Especially for palm oil, there is a global market of around 40 million tonnes per year and growing very rapidly.

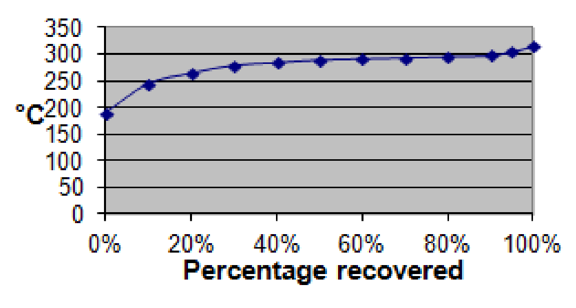
For the co-processing of the pure oil or fat the technology providers are e.g. Petrobras (H-Bio), Haldor Topsoe, Albemarle Catalysts and ConocoPhilips. Petrobras has fitted four of its refineries in Brazil to produce H-Bio diesel fuel. When all four refineries are operational, Petrobras has the capacity of processing 425 million litres of vegetable oils per year. Indications of refinery integrated processing capacity for ConocoPhillips and Haldor Topse's technology are given Chapter 6.

14 http://www.uop.com/objects/UOP_ENI_Ecofining_Process.pdf.

Product specifications and hydrogenation
The co-processing route results in a high quality diesel (as does stand-alone HVO production). The hydrogenated vegetable oil is completely paraffinic and has a very high cetane number, compared with traditional diesel.

Figure 11 Specifications of the resulting biodiesel

An indicative distillation curve is given below.



PONA composition is approximately:
- Paraffins = ± 100%
- Olefins < 0,1%
- Naphtalenes < 0,1%
- Aromatics < 0,1%
- C14+ > 80%

API Gravity at 60°F	= 50	Cloud point (°C)	≈ -25
Sulfur content	< 0,001% weight	Cetane number	≈ 80
Ash content	< 0,001% weight	Viscosity at 40°C (mm2/s)	≈ 3
Carbon residu (D-524)	< 0,5% weight	LHV	≈ 44

4.5 Biofuels in non-road transport

4.5.1 Inland shipping and rail transport

Since 2011 inland shipping and rail are supplied with EN590 low sulphur diesel fuel. Before 2011, shipping and rail had a separate specification with a higher sulphur level of about 1000 ppm or more. Even though EN590 for road transport generally is blended with up to 7% biodiesel (FAME), this is not always the case for inland shipping. In the Netherlands which has a large inland shipping fleet, B0 was mainly supplied through 2011 and 2012, so EN590 with 0% biodiesel. This was done to allow ship owners some years to update their fuel tank systems to be able the handle the biocomponent blend.
The necessary modifications include arranging accessibility to the tank for cleaning and installation of water separators and filters on fuel lines and on air vents. On old engines, replacement of rubber gaskets or seals may be necessary. It is expected, that within 1 or 2 years, the exemption of inland shipping will be ended and the sector will then be supplied with the same blend as on-road vehicles. Rail is currently already supplied with B7 en most likely in some countries, such as Germany, also inland shipping is already supplied with B5 or B7.

The options to use biofuels for inland shipping and rail can be summarised as follows:
- biodiesel up to the blending limit (for road transport);
- fungible bio fuel such as HVO and BTL;
- higher blends of biodiesel;
- use of Pure Plant Oil (PPO);
- biomethane in the form of bio-LNG (liquefied gas).

Biodiesel low and high blends
There are some issues with the use of low or high blend FAME. Especially for older ships and trains there can be issues which are given in Table 18 (Kattenwinkel, 2007a and 2007b; Ecofys, 2012).

Table 18 Potential issues with using FAME blends in inland shipping and diesel trains

Inland shipping	Locomotive
– Hygroscopic biodiesel in aqueous environment – Separation invaded water with biodiesel – Materials compatibility in older ships – Ship auxiliaries using diesel not compatible with biodiesel – Tendency to oxidation and stability storage of fuel of leisure marine (often long storage periods) – Degraded low-temperature flow properties – FAME material deposition on exposed surfaces, including filter elements	– Materials compatibility in older trains – Some heaters using diesel fuel may not be compatible with biodiesel

Besides the factors previously indicated, also the increase in consumption identified at the road transport takes place in the inland shipping.
In the case of distillate fuels (DMX, DMA, DMZ and DMB) it is recommended that 'de minimis' to be taken in order does not exceed approximately 0,1% volume when determined in accordance with EN 14078, following Ecofys (2012).

A study of IVR, the international association of the inland shipping sector, indicates that a blending of bio-components up to 5-7% can be performed by the refiner or fuel-supplier (IVR, 2010). The same organisation indicates that the technical performance variation is the same as with the automobile. Currently diesel for inland shipping may include up to 7% blending of biocomponents, but its introduction is not mandatory, following the specification BS 2869:2010 Part 1: Class A2 . Following the introduction of the European Commission directive 2009/30/EC of 23rd April 2009 the sulphur levels were reduced to 10 milligrams per kilogram of fuel in January 2011, leading to a practically undifferentiated difference between the red diesel and road transport diesel, where a 7% blending of biocomponent is applied.
This way, some of the diesel used for road transport may be introduced in the inland shipping fuel supply chain leading to a higher biocomponent average blending in the inland shipping sector.
The use of higher blends in inland shipping has been subject to pilot projects in the Rotterdam port area, using blends up to 20% of FAME. Also a B100 Scania motor of 285 kW is being tested at an inland ship, the Haaibaai, in a project promoted by Argos Oil (Schuttevaer, 2009).

The blending of a biocomponent should also consider the infrastructure and logistics requirements. Incorrect storage, transport or filtering may lead to an increase in the impact of side effects, such as microbial growth. The fuel blending can occur at the refinery, at the storage (into a pre-blend), on the bunker ship, or on board of the receiving ship.

However, using biodiesel is extremely uneconomical for inland shipping companies at the present time, because of the higher cost. As mineral-oil-based diesel for inland navigation is currently exempt from petrol tax, fuel tax incentives can not be used. A similarly unfavourable situation prevails for the use of biofuel in agriculture, where part of the tax on diesel fuel is reimbursed to farmers in the form of a diesel subsidy. While legislative regulations on the use of biodiesel and other environmentally-sound fuels for privately-used ships would not impact unfavourably on competition they would, however, only lead to a small amount of fuel being introduced on the market (TAB, 2011).

Fungible fuels
Paraffinic diesel diesel fuels such as HVO and BTL can be added in large percentages. Within the EN590 specification about 30% of paraffinic diesel fuel can be added. This can be added on top of the 7% FAME or instead of this. Either way is fine.

Pure Plant Oil (PPO)
Pure plant oil can be considered mainly because of its lower price and lower Well To Propellor GHG emission. Why lose energy in conversion of the plant oil to a FAME or a HVO when it can also directly be used in a diesel engine?

An overview of the prices of several possible marine fuels are presented in Table 19 (2011 data). It should be noted that these fuel prices can fluctuate quite rapidly.

Table 19 Comparison of marine fuel prices (2011 data)

Fuel	Costs (Euro/ton)	Costs (Euro/GJ)
MGO	725	17
PPO	900-1,000	24-27
Biodiesel	960-1,110	25-30
LNG (fossil)	330-440	6.4-8.5

The properties of PPO are quite different which makes it sometimes necessary to heat the fuel tank and fuel lines and the engine should be compatible for it.

Bio-Methane (bio-LNG)
The inland shipping branch is quite interested in using Liquefied Natural Gas (LNG) as a fuel for inland shipping. The first ships are currently operational and a number of carriers are considering/planning to build these LNG ships. The primary reasons to use LNG is the expected low (future) fuel price and the (expected) low environmental emissions (CO_2 and pollutants).

So if bio LNG (liquefied bio-methane) would be available at a similar price as fossil LNG, the interest would be large. Especially because the associated perception would be excellent (extremely low GHG emission).

Possible drawback of LNG is the high installation costs of engine + fuel tank system. This is currently about twice that of a conventional diesel engine with the main cost penalty on the (vacuum insulated) fuel tank. This price is expected to go down if the numbers increase and possible lower costs technology is developed (Verbeek, 2011). In this reference also GHG and pollutant emissions compared to diesel were evaluated. A pleasant conclusion was, that there is not a big gap between engine efficiencies of the diesel and the gas engines, such as is generally seen with road vehicles. This difference was only about 1% percentage point. Refer to Table 20. This was based on data of three gas engines from which two spark ignition.

Table 20 **Engine efficiency comparison for inland shipping**

	Diesel	(Bio-)LNG
Engine efficiency	43%	42%

Source: Based on Verbeek, 2011.

The fuel blending of biofuels is a possibility but has not been a reality in the inland shipping sector. An investigation project developed by a consortium that includes Deen, PON Power (Caterpillar), Cryonorm Projects, Shipyard Trico and CBRB used a blend of 80% bio-LNG and 20% Diesel in a project that consisted of the development of the sustainable inland ship Arganon, which uses two Pon Power Catterpillar 3,512 motors.

The advantages of the low cost fuel are best served with inland shipping applications with a large number of operating hours per year. A typical number found for long distance, international transport was 6,000 hours per year.

Taking into account these type of applications with a high yearly fuel consumption and a high engine efficiency, may very well results in the lowest costs to society to use bio-methane in transportation.

4.5.2 Mobile machinery

Mobile machinery is currently already using B5 and B7 biodiesel blends on a large scale. They are basically supplied with the same fuels as on-road vehicles. For mobile machinery, fuel properties have changed a lot during the past 15 years. The fuel specification lagged behind that of road transportation with respect to sulphur content.

The EU regulations with respect to sulphur content are the following:
- < 2,000 ppm by 1st January 2000
- < 1,000 ppm by 1st January 2008
- < 10 ppm by 1st January 2011

The last step, in 2011, basically meant the general introduction of EN590 fuel (with <10 ppm S) in non-road transport and thus a synchronisation with on-road transport. The sharp reduction of sulphur content was initiated by the pollutant emissions legislation. Especially for the Stage IIIB legislation, it is necessary to go to the Ultra Low Sulphur Diesel (<10 ppm). The Stage IIIB engines have emissions control systems such as exhaust aftertreatment (diesel particulate filters or SCR deNOx) and/or EGR systems which cannot handle higher sulphur fuel.

With the phasing in of EN590 automatically also the bio-components were phased in. Primary issues reported are related to the storage of fuel, such as plugging of filters and bacteria growth.

All engines are B5 compatible and a number of engines are also compatible with B20 or higher. With blends higher than B5 or B7, the manufacturer can recommend to reduce maintenance intervals such as oil and filter changes. Sometimes also additives are recommended to clean injectors. Fungible fuels can also be applied here.

4.5.3 Aviation

Biofuel (blends) are not yet used in significant quantities in aviation. Some airlines experiment with the blending of biofuel in fossil jet fuel. There are several initiatives to address sustainable fuels for the future, such as the formation of associations to developed strategies and to exchange knowledge. One organisation is the SAFUG, the Sustainable Aviation Fuel Users Group. The members are 26 airline companies, which cover about 15% of the commercial flights worldwide. The SAFUG and other associations share the following vision on the future iusage of biofuels:

- the fuel should be fully fungible with fossil jet fuel. The fuel is called 'drop-in' fuel;
- the production of feedstock for the biofuel should not compete with food and should not have any other significant negative effects on bio-diversity, water supplies and socio-economy.

A technical standard for the drop-in fuel is defined. This is ASTM D7566, a general specification for semi synthetic jet fuel (fossil and biofuel). In 2009 FT kerosene (up to 50% blend) was certified under this specification, followed by HVO Kerosene in 2011.

In June 2011, the European Commission (DG Energy) launched an initiative 'The European Advanced Biofuels Flight Path' was launched in June 2011 by the European Commission, in close coordination with Airbus, leading European airlines (Lufthansa, AirFrance/KLM and British Airways) and European biofuel producers (Neste Oils, Biomass Technology Group, UPM, Chemtex Italia and UOP) with the objective to to achieve an annual production of 2 million tonnes of sustainably produced biofuel for aviation by 2020. The Flightpath workshops have taken place.[15]

Initiatives for the use of sustainable advanced biofuels are also launched by IATA, the International Air Transport Association (Zschocke, 2011), ICAO, etc. For a good overview on the situation with biofuels for aviation is referred to European Biofuels Technology Platform (EBTP, 2012) and also to recent IEA-bioenergy report (Rosillo-Calle, 2012).

Some technical and quality control measures presented during the workshop are described below.
Zschocke (2011) presented risk control measures, which included:

- check new actors (new biofuel producers)
- joint distribution: keep concentration of bio jet fuel low by dilution over entire jet fuel quantity;
- organise controlled evaluations, also in an early development stage.

Novelli (2011) gave an overview of the technical routes to produce fungible bio jet fuel. These are split in:

- HRJ (Hydroprocessed Renewable Jet), also known as HEFA (hydrogenated ester and fatty acids), which are hydroprocessed oil plans including algae and jatropha Esters and Fatty Acids;
- BTL (Biomass to Liquid), where the feedstock consists of lignocellulose biomass such as switchgrass, SRC and miscanthus.

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15 http://ec.europa.eu/energy/renewables/biofuels/flight_path_en.htm

More options are evaluated by (Ausilio Bauen, 2009). These options include butanol derived fuels, alkanes from aqueous phase reforming or pyrolysis or algae derived fuels. With these fuels it is also possible to tailor the fuel to very neat paraffins and iso-paraffins and remove undesired components such as oxygen.

Several sources emphasise the special boundary condition for the aviation sector (Mike Farmery, 2006):
- no safety risks: lead time for new fuel components is long (~10 years);
- one fuel grade almost a must in order to avoid a very complex fuel infrastructure. Planes with special engines are not flexible to operate;
- high energy density is a must. Oxygenated fuel such as conventional biodiesel have a 10-20% lower energy density;
- high technical requirements of the fuel such as high thermal stability and low freezing point.

These conditions underline the importance of fungible or drop in biofuels as the best way to go.

4.6 Effect of biofuels on engine efficiency

General trends of engine manufacturers today for improving engines fuel economy includes mainly in hybridization and downsizing. While hybridization aims at energy recuperation and improved energy management, downsizing is a mean for reducing the fuel consumption in the combustion engine itself.
In fact, a smaller engine has lower absolute friction losses and lower pumping losses. This results in a reasonably good thermal efficiency across a larger part of the engine map. In order to keep the same engine power output the mean cylinder pressure needs to be increased: a way for achieving this goal is by high efficient turbocharging.

In this section, the effect of the biofuel blending percentage on the engine efficiency is analyzed for petrol and diesel engines. Within each of the two engine families, an overview is first given on engine parameters affecting efficiency in relationship with the fuel characteristics. Consequently experimental data is collected for using biofuel blends for three cases regarding engine hardware and controls:
1. Without engine modifications.
2. With engine recalibration and advanced controls.
3. With hardware optimisations.

4.6.1 Effect of ethanol blend on petrol engine efficiency

According to the technical literature, SI engine parameters affecting fuel consumption which features a close relationship with fuel properties are:
- Compression ratio. Despite the fact that theoretical engine efficiency increases with increasing compression ratio, the octane number of the fuel used limits the feasible compression ratio in order to prevent knocking phenomena.
- Spark Timing. Variations in spark timing relative to top dead centre affects the engine specific fuel consumption; determination of the optimum spark timing is performed at the engine test bed and is affected of course by the fuel properties. Generally the higher the octane number, the earlier the timing, which leads to the highest efficiency.
- EGR ratio. EGR was adopted in order to reduce engine out NO_x and to comply with legislation targets accordingly. Although catalytic aftertreatment such as the 3-way catalyst mainly took over this role.

EGR is also used to reduce the pumping losses of the engine.
No data was found in the public domain, about the possible influence of biofuel blends on EGR strategy and engine performance. Equivalence ratio. Effect of equivalence ratio on engine performance is complex and is affected by many design and operational aspects. Nevertheless, such a parameter strongly depends on fuel properties and needs to be considered in this analysis.

Regarding the fuels characteristics, ethanol, but also methanol and methane (natural gas) have a higher octane number than regular petrol fuel.
In addition, ethanol and methanol have a higher heat of evaporation value. These properties can be considered in the calibration phase and in the control strategy or, in an earlier stage, during the design phase, in order to come up with an engine with higher efficiency.

Effect of biofuel blend on engine efficiency: no engine modifications
Generally, the effect of an ethanol blend from 0% up to max 100% on engine efficiency was evaluated in a number of studies (Delphi, 2011; Ford, 2012; Stein, 2012; FEV, 2012). The effect was studied in state-of-the-art direct injection engines and an overall fuel efficiency benefit was observed.
The positive influence is attributed to two effects:

1. The high octane number of ethanol leading to a high octane number of the blend which will suppress knocking of the engine.
2. The heat of evaporations leading to a lower cylinder temperature which will also further suppress knocking of the engine.

Experimental data reported in Eydogan (2010) shows that using different blending of biofuel entails an increase in BSFC which can be explained by the lower heating value (LHV) of the biofuel; on the other hand, brake thermal efficiency increases by a couple of percentage points. This behaviour can be explained with the biofuel higher oxygen rate, which contributes to improved combustion. Furthermore, the blended fuel vaporizes also during the compression phase, limiting the temperature rise and contributing to reduce the work needed for the compression.

Effect of biofuel blend on engine efficiency: engine recalibration and advanced control
Engine parameters as spark timing and EGR ratio can be optimized in case some biofuel is blended. In Costagliola (2012) tests were carried out at stoichiometric conditions and spark ignition was optimized in closed loop with a calibration software, in order to have the same peak pressure position as with the unblended fuel. Results show an increase in global efficiency up to 4% and lower CO_2 emissions of 7% in case E85 is used; again, better performance are explained with lower compression work and thermal losses. Sayin (2012) shows that higher Octane number allows further optimization of the spark timing, preventing knocking and increasing thermal efficiency.

Effect of biofuel blend on engine efficiency: new engine design
The higher Octane number of ethanol and methanol allow to redesign the engine with a higher compression ratio avoiding the knocking phenomena. Additionally, advanced turbocharging and down-sizing lead to improved engine efficiency.

It should be noted that, for example, ethanol can be added to petrol in two ways. It can:

a Be added to a base petrol which already fulfils the EN228 octane specification.

b Be used to achieve the EN228 octane specification.

Only in the first case the engine efficiency can be increased by a higher compression ratio design. Especially with somewhat higher blends (E20 and up), it can be considered to increase this minimum octane requirement.

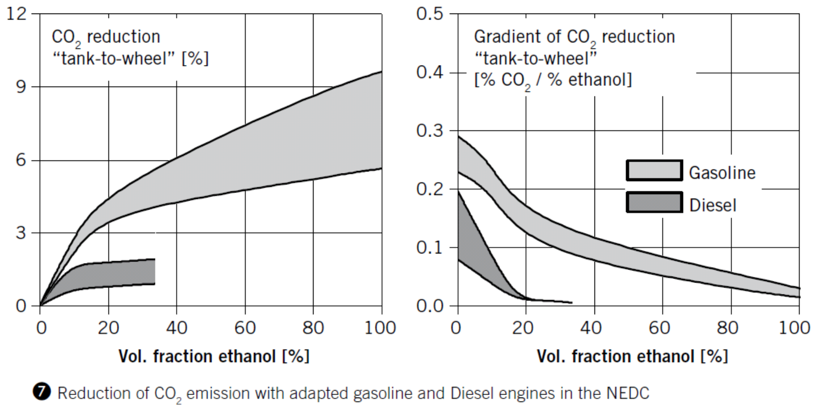
Costa (2011) investigated the effects of increased compression ratio when using E22 and B100; results show an average thermal efficiency increase from 33.5 to 36% by increasing the compression ratio form 10:1 to 12:1.

An overview of the efficiency improvements found in various studies is presented in Table 21 below. Several of the studies emphasise that the largest improvement is achieved at high load, or even high load in combination with low engine speed. Efficiency gains under those conditions are not representative for real-world driving. Nevertheless in the studies (Delphi, 2011 and FEV, 2012) also simulations of the efficiency for specific driving conditions were done (results are included in Table 21). The results of FEV (2012) are shown as a representation of CO_2 reduction in Figure 12. The figure shows also the non-linearity of efficiency with the ethanol blend %, which is also suggested by the other publications. 20% ethanol blend has a relatively larger effect on efficiency than higher blend percentages.

Table 21 Overview of the effect on engine efficiency with hardware and controls optimisation for ethanol blends with petrol

Study	Engine type	Effect on fuel consumption with optimisation of engine on ethanol blend
Delphi, 2011	Direct Injection, Variable Valve Actuation	10-20% improvement with E85 depending on driving characteristics
Stein, 2012	Research engine both DI and IDI	Max 20% improvement with E50 Max 10% improvement with E20
FEV, 2012	Direct Injection, turbo charged	E100: 7 to 20% reduction with increasing load E20: 2 to 10% reduction with increasing load

Figure 12 Simulated effect of CO_2 reduction with engines optimised for ethanol blend: gasoline and diesel, both direct injection and turbo charged



Source: FEV, 2012.

Ford (2012) recommends to specify minimum (elevated) octane numbers for ethanol blend fuels. If this is not done, the ethanol can be blended with a base fuel with a lower octane number resulting in an overall octane number of the blend which is not better than a regular E0 or E10. In that case the potential efficiency gain is (partially) lost. This makes sense since the natural economics of refineries is to make fuels which fulfil the specification, but are not significantly better than required.

Another advantage of a minimum octane requirement is that the car OEMs can really optimise the engine for the fuel blend. A higher octane number would allow the OEM to increase the compression ratio which leads to a higher efficiency. The publication unfortunately does not quantify the differences in effect from engine (knock) control (variable timing) and from design changes such as raising the compression ratio. It should also be noted that the measuring techniques for octane should also be further developed to take into account the higher octane numbers (Anderson, 2012).

A large research program involving car and fuel manufacturers is probably necessary to address the engine efficiency potential for the European situation. This would need to include a certain mix of port/indirect injection and direct injection engines, naturally aspirated and turbocharged engines and also the octane number specification.

If for example an E20 fuel would be marketed, the following question should be answered: What would be the differences in engine efficiency (or fuel consumption) and in refinery energy consumption with an E20 fuel with:

a The current octane requirement.
b An elevated octane requirement.

In Figure 13 and Table 22, some literature data indicating efficiency gain due to different biofuel blending are shown. The three cases described above , namely using the reference engine without any modification, after an optimized recalibration and with a new engine design taking into account the characteristics of the new fuel, are indicated by different collars.

Figure 13 **Effect of biofuel blend percentage (mainly ethanol) on fuel energy consumption, without and with engine modifications**

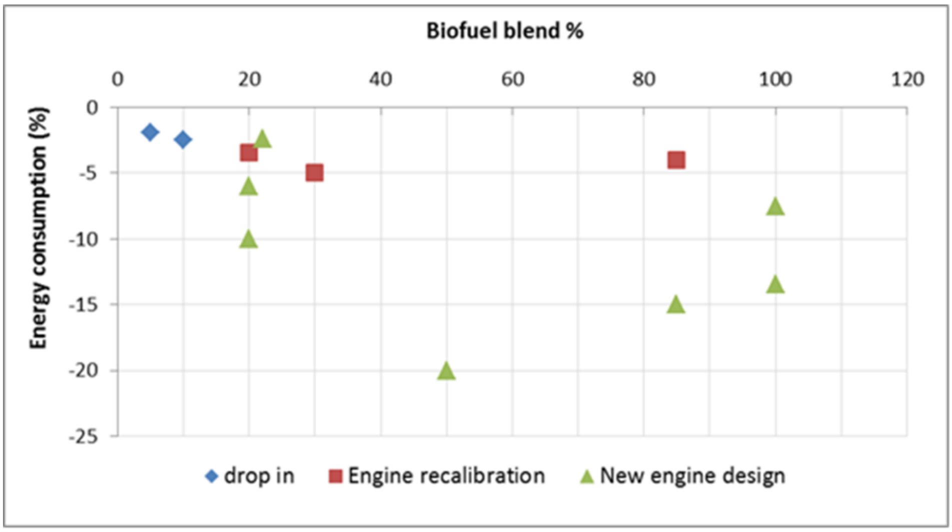


Table 22 References for effect of biofuel blend on fuel consumption

Case	Bio blend %	Energy consumption %	Biofuel type	Ref
Without engine modifications	5	-1.9	Ethanol	Eydogan, 2010
	10	-2.5		
Engine recalibration	20	-3.44		Costigliola, 2012
	30	-5		
	85	-4		
New engine design	22	-2.4		Costa, 2011
	100	-7.5	Hydrous ethanol	
	85	-15	Ethanol	Delphi, 2011
	20	-10		Stein, 2012
	50	-20		
	20	-6		FEV, 2012
	100	-13.5		
Without eng. modification	5	-1.8	Methanol	Eydogan, 2010
Engine recalibration.	10	-2.5	n-butanol	Costigliola, 2012

Conclusions on engine efficiency with blends or pure biofuels in Petrol engines

Looking at the studies that have been done, it can be concluded that the overall efficiency can improve with high octane biofuel blends such as ethanol, methanol and butanol.

Figure 13 and Table 22 show that considerable energy consumption reduction is possible with an alcohol blend in petrol, especially with redesign and re-optimisation of the engine. An energy consumption reduction or engine efficiency increase up to some 15% or possibly more seems possible. This is with ethanol with a blend percentage of 50% or more. Even more interesting is the data point where (max) 10% efficiency improvement is claimed with E20 (Stein, 2012). If this 10% could indeed be reached in practice, the actual petrol consumption would be reduced by about 23% (about 13% from the 20 ethanol + 10% efficiency gain). This is an interesting amplification of the ethanol blend. Basically, the ethanol enables a more efficient application of petrol, especially with down sized and turbocharged engines where octane number is more important for engine efficiency. More research is needed to confirm these relatively large efficiency gains.

4.6.2 Effect of biofuel blend on diesel engine efficiency

According to the technical literature, CI engine parameters affecting fuel consumption which features a close relationship with fuel properties are:

- EGR ratio. EGR is adopted in order to reduce engine out NO_x and to comply with legislation targets accordingly. EGR negatively affects engine performance and its amount is determined based on the NO_x level which the engine and aftertreatment system is allowed to emit. Due to the oxygen content of the biofuel, the EGR acceptability of the engine increases, leading to a lower engine NO_x emission and possibly to eliminate the need for deNO_x catalysts for certain diesel vehicles. Beside higher freedom for EGR-SCR calibration optimization, this might also lead to a small reduction in energy consumption and CO_2 emission due to a lower reagent/AdBlue injection (SCR catalyst) or a lower frequency of NO_x trap regenerations.

– Combustion chamber shape and fuel injection parameters, namely injection timing, rate and pressure and fuel nozzle design. These parameters affect the heat release shape and consequently the engine efficiency. Ignition delay, flame speed propagation and air-fuel spray depend strongly on the fuel properties.

Regarding the fuels characteristics, FAME has a lower energy content than diesel and contains oxygen; consequently, fuel consumption and emissions are affected. FAME also has lower oxidation stability than diesel but the higher cetane number is a positive characteristic for engine performance.

Effect of biodiesel blend on engine efficiency: no engine modifications
Several studies lead to the conclusion that some biofuel blends can have both positive and negative effects on the engine thermal efficiency, if no ECU and engine re-calibration is performed. This different behaviour depends on the biofuel percentage and on the engine speed and load. Manbae (2008) carried out testing on a light duty engine using soybean and coconut biodiesel blends, which resulted in a thermal efficiency drop of less than 1 with 20% biodiesel fuels. Tests with 100% FAME were run by Millo(2010) on a passenger car diesel engine, initially without any modifications in the ECU injection strategy, and later by adjusting engine calibration parameters so as to achieve the same air-to-fuel ratio under Diesel operation; without any ECU modification, the use of biofuel does not seem to substantially change the engine efficiency at full load condition. Dogan (2011) shows 2% efficiency increase by using B5 to B20 n-Butanol blend fuel, but the tests were run only at constant speed of 2,600 rmp. This efficiency increase is justified by the oxygen content of the fuel which improves the diffused combustion phase. Efficiency improvement was shown also by Czerwinski (2009) at high engine load and by Varde (2011), for biofuel blend below 50%. On the contrary, Sayin (2010) measured a fuel brake thermal efficiency penalty as the ethanol and methanol content increased.

Effect of biodiesel blend on engine efficiency: engine recalibration and advanced control
Tests from Millo with ECU setting adjustments showed a slight improvement on brake thermal efficiency with engine running with 100% Fame. The same conclusions were drawn by Hulwan (10), where thermal efficiency slightly increased with biodiesel blend at all speeds and injection timing.
FEV (2012) analysed the effects on engine efficiency and CO_2 emissions of ethanol blends with diesel. This was evaluated by blending (up to 40%) E85 with diesel. The positive effect which is described in the publication is the reduction in particulates emission, which would allow a lower regeneration frequency of the particulates filter. The lower hydrogen to carbon ration of ethanol will further contribute to the lower CO_2 emission presented in Figure 12.

In the Finish urban bus HVO program a large number of buses were tested on several HVO blends:10, 30, 50 and 100% HVO (Nylund 2011). As a drop in fuel, the energy consumption (in MJ/km) consistently improved slightly up to 0.5% with 50 and 100% HVO blends. With simple engine recalibration on an engine without EGR or aftertreatment (timing sweeps), the reduction in energy consumption was on average 4% at the same NO_x level with 100% HVO (included in Figure 14). With a 30% HVO blend, the energy consumption reduction was about 1% with recalibration. In addition the smoke level was much lower.

Effect of biodiesel blend on engine efficiency: new engine design
Injection system and combustion chamber design optimization seems able to exploit the characteristics of biofuel in order to improve engine efficiency. Tests carried out by Jaichandar (2012) with optimized injection timing and combustion chamber geometry fuelling the engine with 20% Pongamia Oil Methyl Ester showed 5.6% brake thermal efficiency improvement compared with baseline engine run with standard diesel. The use of biofuel seems to also enhance the potential of turbocharging. Karabektas (2009) carried out tests with standard diesel fuel and with RME, first on a naturally aspirated engine and then with a turbocharged one; biodiesel efficiency was slightly higher than standard fuel in both conditions, with higher difference in the turbocharged engine.

In Figure 14 and Table 23, some literature data indicating efficiency gain/loss due to different biofuel blending are shown. Cases above described are highlighted, namely using the reference engine without any modification, after an optimized recalibration and with a new engine design taking into account the characteristics of the new fuel.

Figure 14 **Effect of biofuel blend percentage on energy consumption, without and with engine modifications**

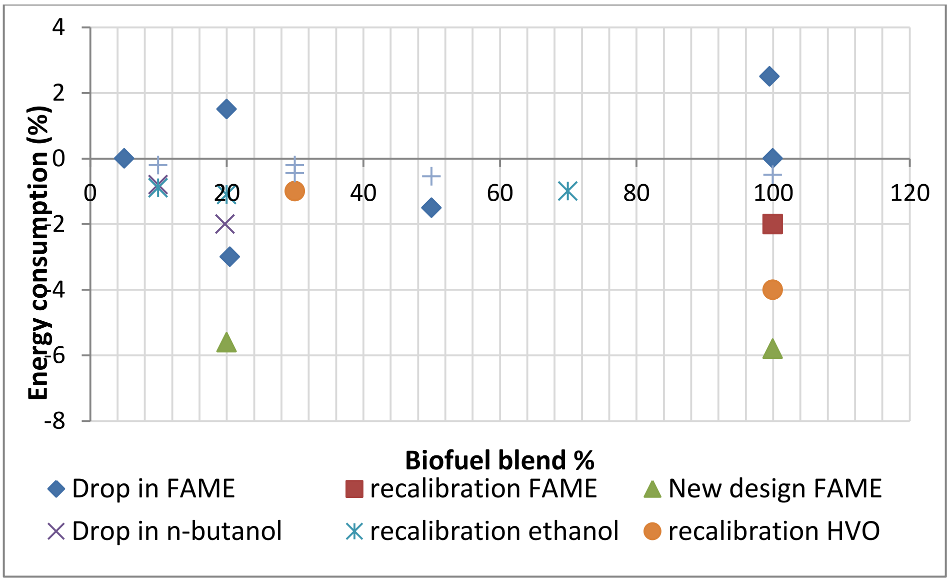


Table 23 References for effect of biofuel blend on fuel consumption of diesel engines

Case	Bio blend %	Energy consumption %	Biofuel type	Ref
Without engine modifications	5	0	Soybean biodiesel	Mambae, 2008
	20	+1.5		
	20	-3		Varde, 2011
	50	-1.5		
	100	+2.5		
	100	0	FAME	Millo, 2010
	10	-0.8	n-butanol	Dogan, 2011
	20	-2		
	10	-0.2	HVO	Nylund, 2011
	30	-0.2		
	30	-0.45		
	50	-0.55		
	100	-0.5		
Engine recalibration	10	-0.9	Ethanol	Hulwan, 2011
	20	-1.1		
	70	-1		
	100	-2	biodiesel /FAME	Millo, 2010
	30	-1	HVO	Nylund, 2011
	100	-4		
New engine design	20	-5.6	Pongamia biodiesel	Jaichandar, 2012
	100	-5.8	Rapeseed biodiesel	Karabektas, 2009

Conclusions on engine efficiency with blends or pure biofuels in diesel engines

Looking at Figure 14, it can be concluded that blending of biofuels in diesel fuels generally have a positive effect on energy consumption or no significant effect. For the three cases, the results can be summarised as follows:

Drop in biofuels (blend with diesel or pure):
- biodiesel (FAME): no consistent change: 0%;
- butanol: -1% to -2% at relatively low blend of 10-20%;
- HVO: consistent minor reduction up to 0.5%.

Engine recalibration (blend with diesel or pure):
- FAME: reduction of 2% for B100;
- Ethanol: reduction of about 1% not dependent on blend ratio;
- HVO: consistent reduction of about 4% (same NO_x level).

New engine hardware (blend with diesel or pure):
- FAME: up to 6% reduction.

Especially when there is an option to optimise the calibration or the hardware of the engine, a relevant reduction in energy consumption of 4 to 6% can be achieved with the application of pure biofuels. It should be noted that this is already achieved with very simple measures such as a timing change. It can be expected that with more comprehensive optimisation (such as injection rate shaping and EGR strategy) considerably higher energy consumption reductions can be achieved. Generally also the engine out particulate emissions are considerably reduced. This makes it possible to re-optimise the NO_x-PM trade-off.

The lower PM emission will also lead to a lower frequency of active diesel particulate filter regeneration, which can also result in a fuel consumption reduction of around 1%.

It would be interesting to further investigate more extensive recalibration with not too high blends of HVO and FAME. That could possibly amplify the CO_2 reduction of the bio-components. Butanol and ethanol already show a significant effect on energy consumption with relatively low blends up to 20 or 30%.

For the common diesel replacers such as HVO and FAME, it can be concluded that an energy reduction of at least some 5% is possible if applied as a pure fuel.

4.7 Conclusions

With respect to low blends and fungible biofuels, the following can be concluded:
- 95% of the passenger cars and vans are compatible with E10 in 2020;
- according to the petrol fuel specification EN228, (bio)methanol can be blended op to 3% or up to the maximum oxygen content of the fuel, whichever is reached first;
- (bio-)MTBE and (bio-)ETBE can be blended up to 22%;
- all diesel vehicles are compatible with B7 (7% FAME type biodiesel);
- within the fuel specification up to about 30% HVO can be added;
- ethanol can be added to diesel fuel, but this has only been done by specialized fuel suppliers.

With respect to high blends or neat alternative fuels, the following can be concluded:
- Spark ignition (petrol) engines:
  Ethanol (E85), bio-methane and methanol (M85) are suitable alternative fuels which can be made from renewable feedstock. Flexible Fuel Vehicles (FFV) suitable to run on E85 and CNG/LNG vehicles suitable to run on bio-methane are currently offered by a number of manufacturers.
- Compression ignition (diesel) vehicles:
  Bio-methane (dual-fuel with diesel), ethanol (ED95), methanol (with ignition improver) and dimethyl-ether (DME) are suitable alternative fuels which can be made from renewable feedstock. CNG dual fuel vehicles are offered by one OEM and several retrofit companies. ED95 vehicles are offered by one truck manufacturer.

Regarding the effect of blends or pure biofuels on engine efficiency, very interesting results have been demonstrated for both petrol as well as diesel engines if there is a possibility to recalibrate the engine or if the engine can be redesigned:
- For petrol engines, the efficiency improvement is primarily linked to the higher octane number of the biofuels. With high blends (>50%) an efficiency improvement of 15% or more seems possible, but even more interesting is a possible efficiency gain of 10 with a 20% ethanol blend. More research is needed to confirm these relatively large efficiency gains.

- For diesel engines, the efficiency improvement is related to improvements of the NO_x particulates and NO_x fuel consumption trade-offs. With relatively simple recalibrations the following improvements are possible:
  - about 4-5% efficiency improvement with pure HVO or biodiesel (FAME);
  - about 1-2% efficiency improvement with 20% ethanol or butanol in diesel.
- Especially for diesel engines, it is expected that further improvements are possible with more extensive recalibration or engine design optimisation.

5 Current blending potential

5.1 Introduction

This section assesses the current blending potential of biofuels in conventional vehicles of the vehicle fleet. First of all, this means that B7 is used in diesel vehicles and E10 in petrol vehicles. As discussed in the previous chapter, these are the limits allowed in current fuel regulations, and the large majority of the EU vehicle fleet in 2020 is compatible with these fuels. Applying higher blends may result in a need for vehicle adaptations or niche vehicles, which will be discussed in the next chapter, Chapter 6. In addition, HVO can also be added to diesel (up to 30% according to current fuel standards) as well as BTL. The marketing potential of these fungible fuels is not restricted by fuel standards but rather by available production capacity. An estimate of 2020 production capacities will be taken as upper limit for their maximum blending potential.

This section will calculate the current blending potential of B7, E10 and HVO in the European vehicle fleet using a purpose-built calculation model (the REST model, see Annex L). Vehicle fleet and energy use data per Member State were taken from the PRIMES-TREMOVE v.2 baseline scenario, the ratio of single and double-counting biofuels was taken from the NREAPs (see Section 2.5).

The result is the potential contribution to the RED target (in %), and the Mtoe of the various biofuels that can be marketed through these routes. The latter could then be compared to the earlier mentioned two biofuel development scenarios: the 'NREAP' scenario and the scenario assuming a shift from biodiesel towards bioethanol (50/50) (see Section 2.5 for an introduction of these scenarios). By doing this it becomes clear to what extent Member States can reach the biofuel volumes of the NREAPs by the use of E10 and B7, supplemented by fungible fuels. The rest of the 10% RED target then requires other measures, such as using biofuels in adapted or niche vehicles[16].

5.2 EU wide

As discussed in Section 3.3, the EU Member States expect to meet the 10% target in 2020 by a total of 7.3 Mtoe bioethanol/bio-ETBE, 21.6 Mtoe biodiesel and 3.9 Mtoe other renewable energy carriers. About 8% of these biofuels is expected to be produced from waste and residues and comply with Article 21(2) of the RED, and therefore count double towards the target. This was taken to be the starting point for the 'NREAP scenario' in this report. As a sensitivity analysis, this study also looks at a 50/50 scenario, where the total biofuels volume is assumed to be the same as in the NREAP but the amounts of ethanol and biodiesel are taken to be equal. The resulting ethanol and biodiesel demand per scenario is given in Table 24.

[16] Other options are to increase the use of alternative renewable energy sources in transport, such as an increase of renewable electricity, or increase the share of double-counting biofuels. However, these options are not further explored in this study.

Table 24 **Overview of the biofuels volumes in the two scenarios, in the EU in 2020**

	Scenario 1: NREAPs (Mtoe)	Scenario 2: Shift to ethanol (Mtoe)
Biodiesel	21.6	14.5
Bioethanol	7.3	14.5

In the next subsections it will be assessed to what extent these biofuel quantities can be marketed by the blending limits B7 and E10, plus HVO. This assessment will first focus on road transport after which the additional potential of using B7 and E10 in non-road modes will be estimated[17].

5.2.1 Road transport

B7

When looking at the expected developments in the EU27 vehicle fleet and energy demand, it is estimated that up to **12.8 Mtoe** of FAME can be brought on the market in 2020 by using B7 in road transport. This assumes that all diesel in road transport contains 7 vol% FAME at that time, throughout the EU. Assuming that part of this FAME is double-counting (using the ratio of single- and double-counting biofuels as derived from the NREAPs), this amounts to a contribution to the RED target of **4.5%.**

Comparing this blending potential to the biodiesel demand of the two scenarios, it can be concluded that even when the full potential of B7 in road transport is exploited, this is insufficient to market the 21.6 Mtoe of biodiesel that were included in the NREAPs, or the 14.5 Mtoe of biodiesel in the 50/50 scenario. Clearly, the gap with the biodiesel demand in the 50/50 scenario is much lower than in the case of the NREAP scenario.

Fungible fuels

Technically, this gaps could be filled by adding sufficient volumes of the fungible biodiesels, i.e. HVO and BTL. However, production capacity of these fuels is still limited. HVO production capacity currently amounts to about 1.3 Mtoe in the EU and an additional 0.8 Mtoe/yr outside the EU (Neste Oil operates an HVO plant in Singapore). BTL production capacity is currently negligible on EU scale, and we are not aware of any concrete plans to increase BTL production to significant scale (on EU-level) in the coming years.

Assuming that in the coming years, HVO production increases further, and a significant part of the non-EU HVO production will be imported into the EU in 2020, we estimate the maximum HVO potential on the EU market to be around **2.4 Mtoe** in 2020. This estimate is, however, very uncertain: it depends on further investments in HVO production capacity and assumes both full utilisation of the production capacity and that the EU uses a very significant share of global HVO production. Assuming a 9% share of double-counting HVO (in line with overall biodiesel expectations), this amount of HVO would contribute about **0.8%** towards the RED target.
A more extensive overview of production capacities and outlook towards 2020 of HVO and BTL is provided in Section 6.6.

[17] HVO could also be used in non-road modes. We assume here that all HVO is used in road transport but from a technical perspective it could equally be used in non-road modes.

E10

E10 applied in road transport results in the consumption of **6.7 Mtoe** of bioethanol in the EU, which corresponds to a **2.4%** contribution to the RED target. This assumes that all petrol sold in the EU for road transport contains 10 vol% ethanol[18].

The NREAPs expect the actual use of bioethanol to be 7.3 Mtoe which leaves a gap of 0.6 Mtoe. In addition, some EU Member States plan to have much higher ethanol shares than average, which also leaves a marketing gap.

When comparing this blending potential with the 14.5 Mtoe of ethanol that needs to be marketed in the 50/50 scenario, a very significant gap arises: 7.7 Mtoe of ethanol needs to be brought on the market by some other means.

Table 25 Biofuels marketing in road transport within current blending limits (EU27)

Type of blend	Blending potential (Mtoe)	Contribution to the RED target
B7	12,8	4.5%
E10	6,7	2.4%
HVO	2,4	0.8%
Total		**7.8%**

5.2.2 Non-road transport

Another option to market biofuels within the current fuel standards is the application of these blend in the non-road transport modes rail and inland shipping, and off-road mobile machinery (used in construction, agriculture and forestry).

B7

By extending the use of B7 to these non-road transport modes the consumption of biodiesel can be increased with about 1,800 ktoe, which is equal to a maximum contribution of about 0.6% to the RED target.

E10

Due to the fact that most non-road modes run on diesel fuels, the use of petrol is not significant. Only 10 ktoe of ethanol can be blended in non-road modes, which results in a negligible contribution to the RED.

Table 26 Contribution to the RED target by the application of B7 and E10 in non-road transport (EU27)

Type of blend	Blending potential (ktoe)	Contribution to the RED target
B7	1,800	0.6%
E10	10	0.0%

18 The previous chapter concluded that in 2020, about 5% of the petrol vehicle fleet is incompatible with E10 and needs to use E5. For sake of simplicity it is assumed here that this E5 also contains the equivalent of 10 vol% ethanol due to the addition of bio-ETBE.

5.2.3 Total blending potential - EU wide

The combined road- and non-road blending potential is given in Table 27, together with the expected biofuels demand in the two scenarios. If the full potential of B7, E10 and fungible biofuels in road and non-road transport is used, a total of up tot 22.5 Mtoe biofuels can be marketed throughout the EU, whereas it is expected that 2.9 Mtoe will be needed to meet the RED transport target.

Assuming that the NREAP biofuels volumes will need to be marketed in 2020, these results show that other marketing options are needed to bring another 5.9 Mtoe of biodiesel and 0.6 Mtoe of ethanol on the market – and the full potential of B7, E10 and HVO is utilised.

The 50/50 scenario does not need any other biodiesel marketing measures (it has a surplus of biodiesel blending potential) but requires an additional 7.7 Mtoe of ethanol to be sold – again assuming full utilisation of B7, E10 and most of the global HVO production capacity. This is more than the volume of ethanol that can be blended via E10.

Table 27 Amount of Mtoe as result of B7 and E10 and gap with the NREAPs

Type of biofuel	Application	Actual biofuel potential (Mtoe)	Mtoe expected according to NREAPs	Mtoe required in 50/50 scenario	Gap with NREAPs	Gap with 50/50 scenario
Biodiesel	FAME B7 in road	13	22	14	5	-
	FAME B7 in non-road	2				
	HVO	2				
	Total	**17**				
Ethanol	E10 in road	7	7	14	0.6	8
	E10 in non-road	0.01				
	Total	**7**				
Total		**22**	**29**	**29**	**6**	**8**

5.3 Differences between Member States

Section 5.2 identifies the gap between the estimated biofuels demand in the NREAPs and the amounts which can be marketed within the current fuel standards on an EU-level. However, on a national level, the size and composition of the vehicle fleet and energy mix might be quite different, as well as the national strategy to meet the RED target in 2020. These differences may lead to quite different conclusions on a national, Member State level, compared to those for the EU as a whole.

This section will analyse to what extent the biofuels demand presented in the individual NREAPs can be met within the current blending limits. This assessment will be limited to B7 and E10, as it is not yet clear how the HVO will be distributed over the various Member States. This will probably depend mainly on the overall biofuels policy and incentives in the various countries, as well as on differences in cost of HVO distribution and logistics.

From a technical point of view, HVO could be used in all Member States to at least partly fill the gap between the B7 (FAME) blending potential and the expected biodiesel demand in 2020.

5.3.1 Road transport

B7

At the national level the contributions of the use of B7 in road transport to the RED target vary from 3.2% (Sweden) to 7.2% (Malta) – the EU average is 4.4%. These differences reflect the ranges in the petrol/diesel ratio in the total transport fuels sold in the various countries.

Table 28 presents the potential to blend FAME into diesel within the B7 boundary condition for the different Member States (in ktoe), as well as information on the gap between this blending potential and the biodiesel demand in the NREAP and 50/50 scenarios. As can been seen, the differences between the Member States are significant. In some Member States (Cyprus, Hungary, Latvia, Malta and Slovakia) the application of B7 in road transport results in meeting the biodiesel demand depicted in the NREAPs. However, there are also some Member States where the gap is around 50% or more of the expected biodiesel demand. Examples are Germany, Ireland, United Kingdom and Poland.

Because less biodiesel is required in the 50/50 scenario, more Member States are able to meet the ktoe required under the 50/50 scenario. Those gaps that remain are much smaller compared to the gaps with the NREAP scenario.

Table 28 Overview of potential B7 in road transport for the 27 Member States including the gaps with the scenarios (ktoe)

Member States	B7: FAME blending potential (ktoe)	Biodiesel demand in NREAPs (ktoe)	Biodiesel demand in 50/50 scenario (ktoe)	Gap with NREAPs (ktoe)	Gap with 50/50 scenario (ktoe)
AT	313	411	246	98	-67
BE	385	697	394	313	10
BG	117	220	141	103	24
CY	24	24	19	-2	-5
CZ	291	494	310	203	19
DE	1,997	4,443	2,651	2,446	654
DK	141	167	131	26	-10
EE	29	50	45	21	14
EL	150	203	308	53	158
ES	1,894	3,100	1,751	1,206	-143
FI	136	430	279	294	143
FR	1,911	2,849	1,751	939	-162
HU	208	203	253	-7	45
IE	172	342	241	170	67
IT	1,381	1,880	1,240	499	-141
LT	62	131	84	69	21
LU	131	193	107	62	-24
LV	50	29	24	-21	-26
MT	10	7	7	-2	-5
NL	418	552	418	134	0
PL	721	1,452	951	728	229

Member States	B7: FAME blending potential (ktoe)	Biodiesel demand in NREAPs (ktoe)	Biodiesel demand in 50/50 scenario (ktoe)	Gap with NREAPs (ktoe)	Gap with 50/50 scenario (ktoe)
PT	299	449	239	153	-60
RO	244	325	244	84	2
SE	246	251	358	7	112
SI	100	174	96	74	-5
SK	112	110	93	-2	-19
UK	1,297	2,463	2,102	1,166	805

E10

The application of E10 in road transport can result in a contribution to the RED target varying from 1.3% (Belgium) to 6.3% (Cyprus). Again, this reflects the differences in petrol/diesel ratio of road transport fuels in the various countries.
Similar to the findings regarding B7, the use of E10 in road transport is sufficient to meet the required ethanol demand in some Member States in the NREAP scenario. For example, Austria, Belgium, Germany and Italy can reach more ktoe than needed. However, most Member States still need to deploy other marketing measures. When looking at the 50/50 scenario, only Cyprus and Latvia can meet the required ktoe of bioethanol by the application of E10 in road transport.

Table 29 Overview of potential E10 in road transport for the 27 Member States including the gaps with the scenarios (ktoe)

Member States	E10: Bioethanol blending potential (ktoe)	Bioethanol demand in NREAPs (ktoe)	Bioethanol demand in 50/50 scenario (ktoe)	Gap with NREAPs (ktoe)	Gap with 50/50 scenario (ktoe)
AT	0.13	0.08	0.25	-0.05	0.12
BE	0.10	0.09	0.39	-0.01	0.29
BG	0.04	0.06	0.14	0.02	0.10
CY	0.02	0.01	0.02	-0.01	0.00
CZ	0.16	0.13	0.31	-0.03	0.15
DE	1.16	0.86	2.65	-0.31	1.49
DK	0.11	0.09	0.13	-0.01	0.03
EE	0.02	0.04	0.05	0.02	0.03
EL	0.25	0.41	0.31	0.16	0.05
ES	0.49	0.40	1.75	-0.09	1.26
FI	0.11	0.13	0.28	0.02	0.17
FR	0.64	0.65	1.75	0.01	1.11
HU	0.12	0.30	0.25	0.18	0.13
IE	0.12	0.14	0.24	0.02	0.12
IT	0.97	0.60	1.24	-0.37	0.27
LT	0.03	0.04	0.08	0.00	0.05
LU	0.03	0.02	0.11	0.00	0.08
LV	0.02	0.02	0.02	-0.01	0.00
MT	0.00	0.00	0.01	0.00	0.00
NL	0.20	0.28	0.42	0.08	0.21
PL	0.36	0.45	0.95	0.10	0.59

Member States	E10: Bioethanol blending potential (ktoe)	Bioethanol demand in NREAPs (ktoe)	Bioethanol demand in 50/50 scenario (ktoe)	Gap with NREAPs (ktoe)	Gap with 50/50 scenario (ktoe)
PT	0.11	0.03	0.24	-0.08	0.13
RO	0.13	0.16	0.24	0.03	0.12
SE	0.23	0.47	0.36	0.23	0.13
SI	0.05	0.02	0.10	-0.03	0.05
SK	0.05	0.07	0.09	0.03	0.04
UK	1.04	1.74	2.10	0.70	1.06

Conclusion
The conclusions on the application of B7 and E10 in road transport at the national level are more or less comparable to the conclusion on the EU-level. However, differences between the Member States are significant. This implies that additional marketing of biodiesel and bioethanol is generally needed, but not necessary in each individual country and to the same extent.

5.3.2 Non-road transport
The potential of B7 and E10 in non-road transport is very limited and in some Member States negligible.

B7
In Table 30, the amount of FAME which can be marketed by the use of B7 in inland shipping and railways is given (in ktoe). B7 in these modes can result in significant contributions in some of the countries, in particular in Greece, followed by Denmark, Spain, Sweden and the United Kingdom. However, in most of the Member States the potential is very low, and this blending option can only contribute a few per cent of the total ktoe required in the two scenarios. In the 50/50 scenarios these percentages are higher, because the total required ktoe of biodiesel is lower in this scenario.

Table 30 Potential of B7 in non-road transport in % of the required ktoe of the NREAP and 50/50 scenario

Member States	B7: FAME blending potential (ktoe)	Biodiesel demand in NREAPs (ktoe)	Biodiesel demand in 50/50 scenario (ktoe)	Gap with NREAPs (ktoe)	Gap with 50/50 scenario (ktoe)
AT	2	411	246	408	244
BE	17	697	394	681	377
BG	2	220	141	217	139
CY	0	24	19	24	19
CZ	7	494	310	487	303
DE	38	4,443	2,651	4,404	2,613
DK	12	167	131	155	119
EE	2	50	45	48	43
EL	48	203	308	155	260
ES	141	3,100	1,751	2,959	1,610
FI	14	430	279	416	265
FR	24	2,849	1,751	2,826	1,727
HU	2	203	253	201	251

Member States	B7: FAME blending potential (ktoe)	Biodiesel demand in NREAPs (ktoe)	Biodiesel demand in 50/50 scenario (ktoe)	Gap with NREAPs (ktoe)	Gap with 50/50 scenario (ktoe)
IE	2	342	241	339	239
IT	21	1,880	1,240	1,858	1,218
LT	5	131	84	127	79
LU	0	193	107	193	107
LV	2	29	24	26	21
MT	0	7	7	7	7
NL	14	552	418	537	404
PL	7	1,452	951	1,445	943
PT	2	449	239	447	236
RO	7	325	244	318	236
SE	10	251	358	241	349
SI	0	174	96	174	96
SK	0	110	93	110	93
UK	122	2,463	2,102	2,341	1,980

E10
Looking at the national level, ethanol blending via E10 in non-road transport does not result in a substantial contribution to the target, as was also concluded on the EU-level.

5.4 Conclusions

A summary of the maximum potential of blending within the current petrol and diesel fuel standards is presented in Table 31 for the EU as a whole. Comparing these results to the biofuels demand in the two scenarios leads to the conclusion that additional biofuels marketing options are necessary in both scenarios. In case of the NREAP scenario, there is a significant need for additional biodiesel marketing, the 50/50 scenario requires very significant additional ethanol marketing options.

These calculations of the current blending potential assume that all diesel sold in the EU will contain 7 vol% FAME in 2020, and 10 vol% ethanol. They also include significant volumes of HVO, which amount to almost 90% of current global production capacity.

Table 31 **Maximum current blending potential (Mtoe) in diesel and petrol, and gap with the NREAPs**

Type of biofuel	Application	Actual biofuel potential (Mtoe)	Mtoe expected according to NREAPs	Mtoe required in 50/50 scenario	Gap with NREAPs	Gap with 50/50 scenario
Biodiesel	FAME B7 in road	13	**22**	**14**	**5**	**-**
	FAME B7 in non-road	2				
	HVO	2				
	Total	**17**				
Ethanol	E10 in road	7	**7**	**14**	**1**	**8**
	E10 in non-road	0				
	Total	**7**				
Total		**22**	**29**	**29**	**8**	**6**

Note: Non-road includes mobile machinery.

It should be realised that the blending potential figures given here are likely to represent the upper limits. A number of factors can be identified that can affect this potential and thus the biofuels marketing gap:

- Utilisation of B7 and E10. B7 does not require any specific action by Member States or fuel suppliers, but E10 needs to be introduced alongside the protection grade E5 which requires specific attention.
- HVO production capacity and fuel cost. HVO volumes assumed here are equal to the current EU production capacity plus the full capacity of the HVO plant of Neste Oil in Singapore.
- The use of double-counting biodiesel and bioethanol. These calculations take the shares given in the NREAPs as a starting point, but these are still quite uncertain. The biofuel marketing gap can reduce if the share of double-counting biofuels is higher than expected (around 8%), and increase if it is lower.

Overall, it can be concluded that the use of B7 and E10 in road and non-road transport modes result in a contribution of up to 7.9% to the RED target. This is largely due to blending in road transport, as fuel demand in non-road transport is much smaller. According to the NREAPS, other renewable energy sources are expected to contribute by about 0.9%. This results in a total contribution of up to 8.8%. The gap which needs to be overcome by other applications of biofuels (or alternative renewable energy sources) is therefore around 1.2%.

The gap between the current blending limits and the expected biofuels volumes to be marketed in 2020 differs quite strongly between Member States. Where some need much more than average additional biodiesel or bioethanol blending, some will have less of a gap to overcome. The main reason for these differences are the different petrol to diesel ratios in the Member States' road transport fuel mix, as well as different targets set in the national action plans.

6 Options to market biofuels beyond current limits

6.1 Introduction

When looking at the results of the previous chapter, it is clear the current approach to biofuels blending is likely to be insufficient to meet the RED target for the transport sector. If the production of FAME and bioethanol is simply increased and then blended into the petrol and diesel in the EU up to the maximum blending limits currently allowed, they can contribute to about 7% of the transport target. 1.8% is expected to be met by renewable electricity used in rail and road transport and other biofuels such as bio-methane (ECN NREAP report, 2011), leaving 1.2% of the target to be met through other routes.

This may be achieved by a number of options:
1. Increase the share of biofuels that meet Art. 21(2) of the RED, and thus count double towards the target.
2. Increase the share of electric transport in the sector.
3. Increase the blending limits of petrol and/or diesel, either for the whole vehicle fleet or for a significant share of the fleet.
4. Apply high blends in road transport in niche applications or captive fleets, i.e. only in limited parts of the sector.
5. Expand the use of biofuels to non-road transport modes.

In this report, we focus on options 3, 4 and 5 of this list. Option 1, increasing the share of double-counting biofuels, will not be considered in detail, but it will be taken into account that some biofuels are likely to be produced from waste and residues (e.g. biomethane is currently often produced via digestion of organic waste or manure).

In the following section, a comprehensive list of options is provided that contains a large variety of ways to implement options 3, 4 and 5 of the above list. This mainly builds on the findings of Chapter 4, where the issues of vehicle compatibility with biofuels is discussed, but other constraints such as biofuel production capacity are also taken into account.

Vehicle-related aspects of the FAME and ethanol related options will be discussed further in Sections 6.3 and 6.4, potential issues with biomass availability and biofuels production capacity will be addressed in Section 6.5. The potential contribution of fungible biofuels (including co-processing in refineries) is discussed in Section 6.6, followed by a section on biomethane and an assessment of biofuels marketing options in non-road transport.

An assessment and comparison of the options is then the topic of Chapter 7.

6.2 List of options to market larger volumes of biofuels

The list of options is compiled according to the categorisation listed above, distinguishing between options that affect a large part of the fleet, options aimed at niche applications, and options in non-road modes. The uptake assumed in these options are rough estimates of what might be feasible in 2020. A more detailed assessment of realistic potential will be done for the options that are selected for the short list.

Type 1: Increase blending limits of petrol and/or diesel, either for the whole vehicle fleet or for a significant share of the fleet

1 0,8% HVO in all diesel fuel for road transport
2 Blending limit for diesel from B7 to B10 (15% cars, HDV 40%)
2A Blending limit for diesel from B7 to B10 (15% cars)
2B Blending limit for diesel from B7 to B10 (HDV 40%)
3 Blending limit for petrol from E10 to E20 (25% market share of petrol)
4 Blending limit for petrol from E10 to E30 (6% market share of petrol)
5 15% market share of ED10 for diesel trucks and buses
6 Co-refining: 0.5% of bio-feedstock in diesel
7 30% market share of ED5 in diesel trucks and busses

Type 2: Applying high blends in road transport in niche applications, i.e. only in limited parts of the sector

8 25% market share of B30 for trucks
9 10% market share of B100 for trucks
10 1% market share of bio-ED95 for buses
11 5% market share of E85 for passenger cars
12 20% market share of bio-CNG for buses
13 2% market share of bio-CNG for passenger cars

Type 3: Expand the use of biofuels to non-road transport modes

14 Mix 1% of HVO with kerosene for airplanes
15 10% market share of B20 in inland shipping
16 10% market share of B20 in trains

An overview of some of the key parameters of these options is shown in Table 32. In all options, the share of double-counting biofuels is taken to be in line with the average EU share as given in the NREAPs, about 8%. In all cases, it is assumed that this blending options is additional to the B7 and E10 that is likely to be the standard blending level in 2020[19].

[19] For example, Option 2 assumes that an additional 3 vol% FAME is added to diesel, Option 11 assumes that for 5% of all passenger cars, the ethanol blend is increased from E10 to E85.

Table 32 Overview of the potential biofuels blending options

		ktoe	RED contribution	FQD contribution
	Increase blending limits for large share of vehicles			
1	0,8% HVO in all diesel fuel for road transport	1,505	0.5%	0.3%
2	Blending limit for diesel from B7 to B10 (15% cars, HDV 40%)	1,481	0.5%	0.3%
2A	Blending limit for diesel from B7 to B10 (15% cars)	263	0.1%	0.1%
2B	Blending limit for diesel from B7 to B10 (HDV 40%)	1,218	0.4%	0.2%
3	Blending limit for petrol from E10 to E20 (25% market share of petrol)	1,338	0.5%	0.3%
4	Blending limit for petrol from E10 to E30 (6% market share of petrol)	645	0.2%	0.1%
5	15% market share of ED10 for diesel trucks and buses	1,170	0.4%	0.2%
6	Co-refining: 0.5% of bio-feedstock in diesel	979	0.3%	0.2%
7	30% market share of ED5 in diesel trucks and busses	1,146	0.4%	0.2%
	High blends in niches (captive fleets)			
8	25% market share of B30 for trucks	7,070	2.5%	1.4%
9	10% market share of B100 for trucks	10,844	3.8%	2.2%
10	1% market share of bio-ED95 for buses	48	0.02%	0.01%
11	5% market share of E85 for passenger cars	3,009	1.1%	0.6%
12	20% market share of bio-CNG for buses	502	0.3%	0.1%
13	2% market share of bio-CNG for passenger cars	2,962	1.9%	0.2%
	Increase biofuels use in non-road modes			
14	Mix 1% of HVO with kerosene for airplanes	597	0.2%	0
15	Increased use of B20 in inland shipping (10%)	119	0.02%	0.02%
16	Increased use of B20 in trains (10%)	48	0.01%	0.01%

Note: ED10 refers to a blend of 10% ethanol in diesel. ED95 refers to pure ethanol with ignition improver to make it suitable for (special type) diesel engines.

6.3 Increase blending limits for diesel and/or petrol

The following provides an overview of the vehicle compatibility issues of increasing the blending limits from B7 to B10 and from E10 to E20/E30 and to allow 5 or 10% ethanol to be blended in diesel.

6.3.1 B10

The commitment of the vehicle industry to ensure compatibility with fuels that meet certain specifications is basically formed within the Motor Vehicle Emissions Group (MVEG) working groups of DG Enterprise, when the pollutant emissions legislation is decided. The reference fuels are currently a B5 for Euro 6 passenger cars and a B7 for Euro VI HD vehicles. On the other hand, both car and HD vehicle manufacturers have accepted B7 as the maximum blends the vehicles are formally compatible with. The discussion to make B7 the reference fuel for passenger car is on-going and implementation is projected for Euro 6 stage 1 (2014/2015) (ACEA, 2012b).

The majority of the vehicle industry is reluctant to go higher than a B7, although for more than 50% of the current heavy-duty vehicles high blends up to B100 are accepted under certain conditions (refer to Paragraph 4.3.2). From this, it can be concluded that going from B7 to B10, also for existing trucks, should not be a problem. The largest concern seems to be the quality of the bio-components. For passenger car engines, the technical issues are larger and compatibility with higher blends is only supported for around 15% of the fleet. It is possible that better lubricants and post injection strategies for DPF (diesel particle filter) regeneration solve these issues and would make a B10 acceptable. But this would take considerable development time and can only be implemented for new vehicles. Raising the blending limit from a B7 to a B10 or B15 does not seem to be an insurmountable problem though, taking into account that suitable technologies are available.

It is therefore proposed to further evaluate the scenario where B10 becomes the base fuel with B7 as protection grade. B10 can then become the standard fuel for HD vehicles quite soon while the transition for passenger cars is to a large extend after 2020. This option makes fuel distribution more complex than in the current situation, especially in countries where currently only one diesel fuel quality is offered.

For the scenario calculations (Table 32) it is assumed that in 2020 85% of the trucks and 15% of the passenger cars can run on B10.

6.3.2 E20 or E30

The technology to increase the blending limit to a E20 or E30 is not very complex and already implemented in flexible fuel vehicles. Also many car manufacturers have experience with E25 for the Brazilian market. There may be a clear distinction between E20 and E30 though. The E20 can probably be accommodated for by a slight upgrade of conventional fuel injection control strategies currently implemented in most vehicles, while for the E30, flexible fuel control strategies are necessary.

If E20 is chosen, it may be possible to include that as a voluntary step for Euro 6 Stage 1 (2014/2015) and then mandatory for Stage 2 (2017/2018). For the scenario calculations, this is assumed. It is further assumed that from 2015 onwards, 50% of the new vehicles are E20 compatible and that from 2018 100% of the new cars are E20 compatible. That results in a market share of about 30% in 2020.

For the E30 option, it is expected that Euro 6 Stage 2 (2017/2018) is the earliest possible implementation date, mandatory for all cars. For the scenario calculations, it is assumed that this results in a market share of 15% in 2020.

6.4 High blends of non-fungible biofuels (FAME, ethanol)

Increasing the market share of high blends of FAME and bioethanol requires action from a range of stakeholders: biofuels producers and fuels suppliers, engine and vehicles manufacturers and consumers. Fuel suppliers need to offer these blends to their customers, high blend vehicles need to be put on the market, and customers then need to fuel their vehicles with these blends. The following focuses on the vehicle compatibility issues and opportunities.

6.4.1 Vehicle availability

In Table 33 and Table 34, projections are made about the market share of vehicles which are compatible with higher blending limits or with high blend fuels. This projection is based on the assumption that the fuel options are decided within one year and that after that implementation starts and goes full speed ahead. This includes implementation in pollutant emission legislation and type approval testing. It is also based on the assumption that conditions and incentives are there such that the people will buy these vehicles in sufficient quantity.

Passenger cars and vans

In Table 33, the projection about the compatibility with higher blending limits or with high blend fuels is made for the passenger cars and vans.
The replacement rate of passenger cars is assumed to be about 6% per year.

Some notes on this per fuel blend are:

- E20 or E30:
  In consultation with ACEA and DG Environment, it should be decided when this can be implemented and what the reference fuels are (It may include two blends to secure real world pollutant emissions compliance).
- E85 flexible fuel vehicle:
  Additional purchase price should be limited and this should be compensated by a lower fuel price.
- (Bio) CNG:
  The additional purchase price will probably remain fairly high. So the fuel price will need to be low. Best chances are depot fuelled vehicles such as vans and taxis, which also drive substantial distance per year.
- M20 or M85 flexible fuel vehicle.
  Methanol is substantial more aggressive and corrosive than ethanol, so will take more time to develop. Development of fuel standards and vehicles, and clearance for environmental risks and toxicity will take at least a number of years. The same is the case for the development of the fuel infrastructure. So it is not realistic to have a contribution from methanol by 2020.

Apart from the technical possibility, from an economic point of view, it is not desirable to add new fuel options to the fuel mix. It will probably take too much effort on the development of the fuel infrastructure and vehicles.

Table 33 Possible market share cars capable for increased blending limit or high blend, provided proper legislation and incentives are timely implemented

	Introduction year	2012 % Vehicles	2020 % Vehicles	2020 % Fuel
'Petrol'				
E20 Euro 6 stage 1 voluntary	2015	0%	15%	20%
E20 or E30 Euro 6 stage 2	2018	0%	15%	20%
E85	Current	< 1%	10%	15%
(Bio) CNG	Current	< 1%	2%	
M20	> 2020			
M85	> 2020	0%	0%	
'Diesel'				
B10	Current	15%	20%?	
(Bio) DME	2025	0%	0%	

– B10:
  Uncertain if the market share of B10 compatible cars will really rise. Car manufacturers and lubricant developers are not stimulated at all with the sustainability discussion on biodiesel on-going.
– Bio-DME:
  Technically quite complex engine development. Fuel injection system suppliers would need to develop the technology. No incentive to start with that as long as production with high capital investment, remains uncertain.

Trucks

In Table 34, the projection about the compatibility with higher blending limits or with high blend fuels is made for trucks. The replacement rate of trucks is assumed to be about 10% per year.

Remarks per fuel blend are:
– (Bio-)CNG and LNG:
  A substantial market share is difficult to achieve, because of the high vehicle price and also the fuel station is costly. Only possible for depot fuelled vehicles, although for LNG certain long distance corridors could be considered.
– M85:
  Technically not a very complex engine, although for HD engines it would be entirely new. It can probably be based on spark ignition natural gas engines. Development of complete new engines, as well as fuel standards and fuel infrastructure will take many years. For that reason a contribution to the 2020 target is not possible.
– B10–B100:
  Estimates for 2020 are uncertain. For Euro VI vehicles it will be more difficult to blend biodiesel (FAME) because of the more stringent pollutant emission levels and OBD requirements. Also separate type approvals necessary for different blends.
– ED5–B7 and ED30:
  Complexity for engine and infrastructure are not yet sufficiently known. ED30 probably much more complex than ED5. Development of standards and compatible engines, as well as fuel infrastructure will take a number of years. For that reason a contribution to the 2020 target is uncertain.

Also here should be noted, that apart from the technical feasibility, there are high cost involved in the development of completely new engines and infrastructure for methanol or diesel ethanol mixtures.

Table 34 **Possible market share trucks capable of increased blending limit or high blend, provided proper legislation and incentives are timely implemented**

	Introduction year	2012 % Vehicles	2020 % Vehicles	2020 % Fuel
'Spark ignition'				
(Bio-)CNG	Current	< 1%	2%	
(Bio-)LNG	Current	Demo	1%	
M85	> 2020	0%	0%	
'Diesel'				
B10	Present	85%	85%	
B30	Present	80%	50%	
B100	Present	60%	30%	
ED95	Present	< 1%	< 1%	
ED5 B7	2015 2018	0%	30% 15%	
ED10	2018	0%	15%	
ED30	2018 2021	0%	15% 0%	
(Bio-)DME	2025	0%	0%	

– Bio-DME:
  Technically quite complex engine development. Fuel injection system suppliers would need to develop the technology. No incentive to start with that as long as production with high capital investment, remains uncertain.

6.4.2 The important role of consumers

Consumers play an important role in the marketing of high blends, as they will first have to buy the vehicles that are compatible with these biofuels, and then fill up these vehicles with the high blends during their use. As high blend biofuels do not have better driving performance - instead, some have lower energy content and thus driving range – the main reasons why consumers may choose high blend vehicles and fuels are either cost benefits or environmental considerations.

With respect to the latter, differences in pollutant emissions between engine/fuel types quickly disappear. Especially the Euro VI HD standards are so tight, that no significant differences are expected between the different fuels. For passenger cars, there are still differences between spark and compression ignition, but they are also likely to diminish before 2020. Any greenhouse gas reductions will remain, though, assuming that implementation of the sustainability criteria is effective and emissions of ILUC are included.

High blend vehicles and fuels are typically more expensive than conventional vehicles and fuels. Making their cost comparable to low blend alternatives then requires either government support or cost discounts by vehicle manufacturers and/or fuel suppliers, perhaps as part of a broader marketing strategy. This type of government support can be found in various EU countries and can take various forms. For example, in Sweden, flex fuel (E85) vehicle buyers receive a subsidy, and E85 (in fact, all biofuels that meet certain standards) benefit from a tax exemption; in the Netherlands, there is a subsidy program that supports service stations that offer high blends of biodiesel or bioethanol, natural gas or biomethane. Various fuel suppliers and vehicle manufacturers offer high blend fuels or vehicles without extra cost, as a marketing tool.

When looking at marketing options for high blends, a number of different consumer types can be distinguished:
- 'general' consumers, individuals who buy vehicles and fuels;
- 'professional' vehicle owners, such as LDV fleet owners (e.g. managers of company car fleets, taxi drivers) and HDV fleet owners (e.g. hauliers, bus companies);

The second group will be easier to target from a marketing and communication point of view.

An interesting sub-group of the professional vehicle owners are those with captive fleets, with their own fuelling station. Switching these to high blends does not require large scale availability of high blends at public service stations, which has significant cost advantages. Unfortunately, there are only very limited data on the fuel consumption of centrally-fuelled captive fleets in the EU and the various Member States. The literature on this topic is limited, estimates appear to be quite rough and show significant ranges. For example, for the situation in Ireland, EPA (2008) estimates that the share of transport fuels used in centrally-fuelled captive fleets was found to be about 5-6%, half of which was found to be in the public passenger transport services (busses, taxis, etc.). Estimates for the UK are much higher, AEA (2011) estimates that about 38% of the aggregated fuels were supplied to depot fuelled fleet vehicles.

6.5 FAME and bioethanol availability

Biofuel availability depends on two key factors: production capacity and biomass availability.

6.5.1 Biofuel production capacity

The current EU production capacity of FAME and bioethanol are shown in Table 35. For comparison, the expected demand for biodiesel and bioethanol in 2020 is shown as well for the two scenarios that are assessed in this report: biofuels demand according to the NREAPs and a 50/50 split between these two biofuels. Note that the share of FAME in the biodiesel demand has not been specified in the scenarios, biodiesel may also be HVO or BTL.

Table 35 Current FAME and bioethanol production capacity in the EU versus expected demand in 2020

	Current production (Mtoe)	Current production capacity (Mtoe)	2020 Demand Scenario 1: NREAPs (Mtoe)	2020 Demand Scenario 2: shift to ethanol (Mtoe)
Biodiesel	8.4 (Data for 2010)	19.4 (FAME, data for 2011)	21.6	14.5
Bioethanol	1.9 (Data for 2009)	3.8 (Data for 2010)	7.3	14.5

Data source: Current production biodiesel: Eurobserver, 2011; Biodiesel production capacity: European Biodiesel Board, www.eeb-eu.org; Bioethanol production and capacity: ePURE, www.epure.org.

Based on these data, it can be concluded that from a fuel production capacity point of view, increasing the supply of FAME to the expected biodiesel levels in 2020 is quite feasible. The current production volumes are only about 55% of the existing capacity, increasing production to the maximum capacity level will almost result in 2020 demand of the NREAP scenario. In case of a shift to ethanol (Scenario 2), FAME production levels can be expected to increase by 70% compared to 2010 levels, but some overcapacity will remain, if we take the currently installed production capacity as a starting point.

Current EU ethanol production capacity is also higher than currently needed (about half of the capacity is in use), but expected production levels of 2020 can not yet be met. According to ePURE (www.epure.org), another 0.5 Mtoe/year capacity is currently under construction, but that would still leave a production capacity gap of about 3.5 Mtoe in Scenario 1, and about 10.7 Mtoe in Scenario 2.

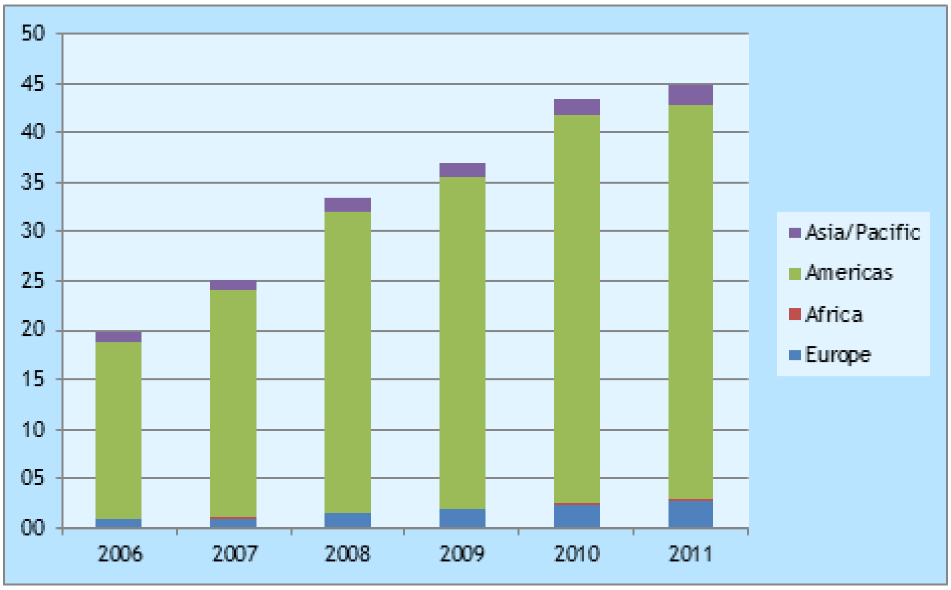
This gap could be filled by increasing ethanol imports and/or by further expanding EU capacity. The latter would be quite a challenge, although Scenario 1 might be feasible, as EU ethanol production increased from 0.3 Mtoe/year to 3.8 Mtoe/year between 2004 and 2010. The FAO/OECD also predicted a further growth of ethanol production between 2010 and 2020 in the EU, to a total of 8.4 Mtoe/yr – more than required in the NREAP scenario. This scale of investments would, however, only be considered if the industry has a relatively high certainty about future demand, feedstock cost and ethanol price.

Scenario 2 would mean that current EU capacity would have to almost quadruple in the coming 7 years, not a very likely scenario. In that case, the EU would have to rely quite strongly on increasing both bioethanol imports as well as own production capacity. Bioethanol imports have been declining in recent years, though. The main reasons for this decline are the increasing bioethanol demand in other parts of the world, namely in Brazil and the US (Eurobserver, 2011), but in addition a decline in production due to poor weather conditions in Brazil, and higher sugar prices in 2009 was observed[20] .

Even when looking at a global scale, however, increasing ethanol production by 10.7 Mtoe/yr (the gap between 2010 EU production capacity and 2020 EU demand in Scenario 2) is quite challenging. Global ethanol production is currently about 44.9 Mtoe, as shown Figure 15. Between 2006 and 2008, production rates increased very rapidly, with 25-35% annually, but in recent years, this growth rate has declined, to 3% in 2011. Increasing production by almost 10.7 Mtoe represents an increase of global production by almost 25% over the next 7 or 8 years, which could be achieved by an annual growth of global production of about 3%. Looking at projections of the FAO/OECD (Agri.Outlook, 2011-2020), global ethanol production is expected to increase by more than 31 Mtoe between 2010 and 2020, which would mean that the EU would ‘claim’ about 1/3rd of the global production increase. Considering that ethanol demand also continues to increase in other parts of the world, namely in the US and Brazil but also e.g. in Japan, this increased demand would increase pressure on the market, and thus cause the price to increase. This may be prevented by increasing global production faster than the 4% annual growth predicted in the FAO/OECD Outlook, which also requires confidence in the future demand growth and attractive return on investments.

20 http://www.epure.org/theindustry/eumarket, consulted on 24 April 2012.

Figure 15 **Global ethanol production in Mtoe**



Source: Data bij F.O.Licht and GRFA (http://www.marketwire.com/press-release/global-ethanol-production-to-reach-887-billion-litres-in-2011-1395312.htm).

6.5.2 Biomass availability

Increasing FAME and bioethanol production will also require increasing feedstock volumes. As discussed earlier, both biofuel production processes require different types of biomass as a feedstock: FAME uses plant oils such as rapeseed oil, soy oil, palm oil, etc., where the ethanol processes are currently based on wheat, grains, maize, sugar beet and sugarcane. So-called 2nd generation bioethanol production is in the R&D stage, if these developments are successful in the coming years the feedstock range can be expanded significantly, to ligno-cellulosic biomass such as straw, grasses, etc.

The sustainability criteria defined in the RED and FQD effectively limit biomass availability. The stricter these criteria, the less biomass will be suitable to use as feedstock for EU biofuels. This may increase biomass and thus biofuel price, as it affects the balance of supply and demand, it may also mean that more costly biomass cultivation or conversion methods will be used.
If biofuels demand is only a limited part of overall demand for a commodity, this effect will be relatively limited, as the sustainability criteria can then be met by shifting the feedstock that meet the criteria towards EU biofuels production, whereas feedstock that does not meet the criteria will be used for other, unregulated applications. If biofuels demand is a significant share of the overall market, however, the impact may be significant as the biomass will become scarce. This effect will result in higher prices for the biofuels and a shift towards other biomass-to-biofuel routes – depending on the cost of the alternative options.

6.6 Fungible biofuels: HVO, BTL and co-processing in refineries

As discussed before, there are currently two types of biofuels that are fungible with petrol and diesel, i.e. which have no or less blending restrictions than FAME and bioethanol: HVO and BTL. These biofuels do not require modifications to the vehicle fleet, but their future growth may be limited due to biomass availability, production capacity and biofuel cost, compared to alternatives. Co-processing of biomass in refineries can be considered to be an alternative to the HVO route, which also results in a fungible diesel.

HVO is already in large scale production in a number of countries in the EU, and the processes are also used in various production plants in the USA. Typical feedstocks are vegetable oils (mainly palm oil but others can also be used), and waste oils and animal fats. HVO can be blended into diesel, the current fleet can accept up to 30% while staying within the formal fuel specification. The HVO process can also produce kerosene, although kerosene yield is only a relatively small share of the overall output.

BTL is still in the R&D phase, although progress has been made in the past years, especially in the USA. This type of biofuel uses gasification to convert biomass into a hydrocarbon, a process that can, in principle, be applied to a large variety of biomass feedstocks, including woody waste and residues from forestry and agriculture. BTL is a so-called 'designer fuel' and can be converted into any type of fuel, although it is typically intended to be used as diesel.

Note that the same feedstock can also be used to produce methanol and DME, probably at higher efficiency. However, these fuels no not have the technical compatibility advantages of BTL.

HVO production capacity

Based on publicly available literature, the following plants in operation and targeted initiatives for industrial production of HVO could be identified in the EU.

For vegetable oil based HVO production, current EU production capacity is about 1.2 Mtoe, as following plants are currently operational:

- two 190 kilotons/year plants in Porvoo in Finland, operated by Neste Oil;
- one 800 kilotons/year plant in Rotterdam in the Netherlands, operated by Neste Oil.

Neste Oil has another 800 kilotons/year plan in operation in Singapore.
It's output can also be imported to the EU, depending on demand from elsewhere.

Two HVO plants based on UOP's and ENI's Ecofining technology have been under consideration for several years now. Recently, a decision was made to apply this technology in ENI's Venice refinery[21]. The plan is to produce more than 300 kiloton synthetic diesel per year, beginning in 2014. There are plans for another 330 kilotons/year plant to be operated by Portugal based Galp Energia, but no decision has been made so far.

[21] http://www.uop.com/italys-largest-refiner-honeywells-uopeni-ecofining-process-technology-venice-refinery/

Two tall oil based HVO initiatives could be identified:

- Swedish oil refinery company PREEM has been revamped for co-processing of up to 30% vegetable oil in its diesel hydrotreater. The initiative has been operational since April 2011[22]. A 15/85% HVO/diesel blend is marketed as 'Evolution Diesel'. Total aimed annual production is 100 ktons/year of renewable diesel from tall oil, consuming approximately 1/3 of the tall oil annually produced in Scandinavia[23] and covering up to 10% of Sweden's annual diesel consumption. The tall oil is supplied by Perstorp TallOil – a tall oil supplier which will also participate in the project. Perstorp TallOil previously mainly sold tall oil as a fuel to other companies[24].
- UPM-Kymmene Corporation has announced plans for realization of a 100 ktons/year of biodiesel plant, processing crude tall oil[25] into HVO. It is unclear what the original use was of the tall oil, for example whether the crude tall oil was previously refined by Forchem/Arizona Chemicals.

Summarizing, the total HVO production capacity in the EU is currently about 1.3 Mtoe /year. Most of this capacity is located in the Netherlands (Rotterdam), followed by Sweden and Finland.

Co-processing of biomass in refineries

Practical co-processing of vegetable oils from oilseeds at petroleum refineries (a process very similar to HVO) seems to be limited to the Conoco-Phillips refinery in Cork, Ireland producing 40 ktons/yr of renewable diesel. Repsol has publicly announced aiming at co-processing of vegetable oils from oil seeds in their refineries and is currently investigating options and technology[26].

Industrial scale technology has been developed by Haldor Topsoe[27] and Albemarle[28] has been implemented at PREEM's Gothenburg refinery (see above).

BTL, Fischer Tropsch Synthesis

No industrial scale biobased BTL plants currently exist, are under construction or have been announced. All initiatives are at best at demonstration scale with regard to technological development:

- CHOREN Industries was in the commissioning phase of a 13,000 t/a demonstration plant in Germany before it filed for bankruptcy in 2010. The technology was bought by Linde in 2011.

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22 See: http://www.biofuelsdigest.com/bdigest/2011/05/04/preem-launches-wood-residue-based-evolution-diesel-in-sweden/.

23 See: http://www.topsoe.com/business_areas/refining/~/media/PDF%20files/Refining/paper_industrial_scale_prod_of_renewable_diesel.ashx.

24 See http://www.perstorp.com/News/PressReleases/Pressrelease_Archive_2007/2007-10-29%20TallOil.aspx?pagelang=en.

25 See http://www.upm.com/EN/INVESTORS/Investor-News/Pages/UPM-to-build-the-world%E2%80%99s-first-biorefinery-producing-wood-based-biodiesel-001-Wed-01-Feb-2012-10-10.aspx, see http://www.youtube.com/watch?v=WNKlFwTiUrQ for process steps.

26 See: http://www.repsol.com/es_en/corporacion/conocer-repsol/canal-tecnologia/proyectos-casos-estudio/otros-proyectos/proyectos-aceites-vegetales/default.aspx and http://rrbconference.org/bestanden/downloads/323.pdf.

27 See: http://www.topsoe.com/business_areas/refining/~/media/PDF%20files/Refining/novel_hydrotreating_technology_for_production_of_green_diesel.ashx.

28 See: http://www.albemarle.com/_filelib/FileCabinet/Literature_Library/Catalysts_Literature/Catalysts/Courier/Catalysts_Courier_73.pdf.

- StoraEnso and Neste Oil have formed a consortium to realize BTL plants on basis of biomass gasification and FT in Europe. Neste Oil and Stora Enso have operated their 12 MW demonstration (8 kton/yr of BTL) plant since 2009 in Varkaus, Finland.
- UPM and Carbona UHDE together with a number of French companies announced the realisation of a small pilot scale FT plant using biomass and/or torrefied material under the BioTfuel project led by CEA in Bure-Saudron. The project will be based on UHDE's commercially available Prenflo entrained gasification technology.[29]
- In the UK, Solena is developing a waste to biojet fuel facility using patented plasma gasification technology combined with Fischer Tropsch processing. The planned capacity is 50,000 t/a biojet fuel, with full production by 2014 and the process has potential to be replicated in other European sites. Partners in development of this technology roadmap are SA, British Airways and a number of US based Airliners.

As this list illustrates, research is on-going in various EU Member States. Due to the large range of biomass that this technology is able to convert to a biofuel and the high quality fuel it can produce, a breakthrough of this technology might significantly increase the supply of fungible fuels for all modes (including aviation) in the longer term. Various EU initiatives are therefore supported by EU programmes such as FP7 and NER300[30]. Examples of currently on-going FP7 research projects related to BTL are OPTFUEL, BioTfueL and BRISK, where the first, for example, aims to convert fast growing woody biomass such as willow and poplar to transport fuel. Apart from the technological challenges related to BTL production, the continued availability and cost of feedstock is a key consideration for the commercial viability of this type of production routes.

Developments outside the EU

Solena[31] also aspires realisation of installation in other parts of the World:

- The Air Transport Association of America, Inc. ('ATA'), issued a June 20 news release announcing that seven of its members had signed letters of intent with Solena Fuels, LLC ('Solena') for future supply of jet fuel derived exclusively from biomass. The ATA news release stated in relevant part: Solena's 'GreenSky California' biomass-to-liquids (BTL) facility in Northern California (Santa Clara County) will utilize post-recycled urban and agricultural wastes to produce up to 16 million gallons of neat jet fuels (as well 14 million gallon equivalents of other energy products) per year by 2015 to support airline operations at Oakland (Oak), San Francisco (SFO) and/or San Jose (SJC). The project will divert approximately 550,000 metric tons of waste that otherwise would go to a landfill while producing jet fuel with lower emissions of greenhouse gases and local pollutants than petroleum-based fuels.
- There are also plans for a Solena installation in Australia.

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29 See: http://www1.icheme.org/gasification2010/pdfs/uhdeactivitiesinthe developmentofabtlprocesschain.pdf.

30 An overview of on-going activities can be found at the website of the European Biofuels Technology Platform, www.biofuelstp.eu/btl.html, or www.ieatask33.org

31 http://www.solenafuels.com/sites/default/files/The%20Guardian%20March%2016%202012.pdf and http://www.mitchellwilliamslaw.com/energy-seven-airlines-sign-letter-of-intent-to-negotiate-purchase-of-biomass-derived-jet-fuel and http://www2.icao.int/en/SAAFA/Lists/Summary%20of%20Sustainable%20Alternative%20Aviation%20Fue1/ReadOnly.aspx.

A demonstration-scale Fischer-Tropsch (BTL) plant is owned and operated by Rentech Inc in partnership with ClearFuels, a company specializing in biomass gasification. Located in Commerce City, Colorado, the facility produces about 10 barrels per day (1.6 m^3/d) of fuels from natural gas. Commercial-scale facilities are planned for Rialto, California, Natchez, Mississippi, Port St. Joe, Florida, and White River, Ontario[32].

Solena Group Inc of Washington D.C. has signed a letter of intent with Rentech Inc of Los Angeles, CA, to use Rentech's Fischer-Tropsch synthetic fuel technology in Solena's BioJetFuel project[33].

Syntroleum/Tyson FoodsTyson and Syntroleum make diesel and jet fuel from chicken fat, beef tallow and a range of greases and oils at a plant built in Geismar, La., south of Baton Rouge. The raw materials are leftovers from Tyson's meat-processing plants and other food-processing factories and restaurants. The refinery has the capacity to produce 75 million gallons of fat-based fuel annually.

Flambeau River Biofuels LLC is developing of a 50 ktons/yr Fischer Tropsch BtL plant in Park Falls, Wisconsin USA[34]. The plant will be located next to Flambeau River Papers paper mill and will utilize non commercial wood and waste wood. The $ 250 million project, funded in part with a grant from the US Department of Energy, is expected to be fully operational by 2013.

Amyris has developed a technology in which fermentable sugars are converted into a 15-carbon hydrocarbon called beta-farnesene, using genetically modified microorganisms in fermentation. Farnesene can be converted to render a number of products, including fuels (primarily diesel). Recently, Volkswagen signed an agreement with Amyris and Solazyme to promote automotive use of renewable fuels. http://www.amyris.com/en/science

Potential growth towards 2020

In view of the maturity of the conversion process, HVO is the fungible fuel with the highest potential in 2020. In principle, quite significant additional production capacity could be built between now and 2020 – there were about 3.5 years between commissioning of the Rotterdam plant and start of its operations. For example, if another 2 plants of the size of the Neste Oil facility in Rotterdam would be built between now and 2020, the current EU-based HVO production of 1.3 Mtoe/yr could be expanded to about 2.9 Mtoe/yr. In addition, global HVO production capacity might continue to grow, allowing HVO imports to increase.

However, a major barrier to this growth seems to be the current uncertainty regarding the outlook for oil-based biofuels, in the context of the ILUC debate. Investors will be hesitant as long as there is no clarity on future growth of HVO demand, and a significant overcapacity in the EU biodiesel industry. It is to be expected that if the sustainability criteria of the RED and FQD are tightened in the coming years by including ILUC impacts in the greenhouse gas calculations, the feedstock base that can be used for HVO production could be limited quite

32 See: http://www.rentechinc.com/.

33 See: http://www.renewableenergyfocususa.com/view/13876/rentech-aids-solena-s-bio-jet-fuel/.

34 See: http://www.mainepulpaper.org/openhouse/2011presentations/ByrnePresentation.pdf and http://www.bioenergy2020.eu/files/publications/pdf/2010-bericht-demoplants.pdf.

significantly, and costs of the feedstocks that can be used can be expected to increase.

Co-processing of biomass in refineries is also an interesting route with technical potential for further growth. Research so far has shown that technically, refineries could use up to 5-10% of bio-feedstock, which would then result in very significant biofuel volumes to be produced. To provide an indication of its potential: current diesel output of EU refineries is almost 250 million tons/year. If 1% of the feedstock would be bio-oil, this would result in 2,500 kton/year bio-diesel.

So far, however, industry has shown only limited interest in developing this route into commercial application. The main barrier to further deployment seem to be technological concerns, and potential impacts on refinery operations and cost. Despite various successful pilot projects (incl. large scale application in Sweden), it seems justified to conclude that this technology is still in R&D phase, and would need time to develop further. Furthermore, this route uses the same feedstock as the HVO process described above (i.e. oils), and is therefore faced with the same uncertainties regarding development of the sustainability criteria.

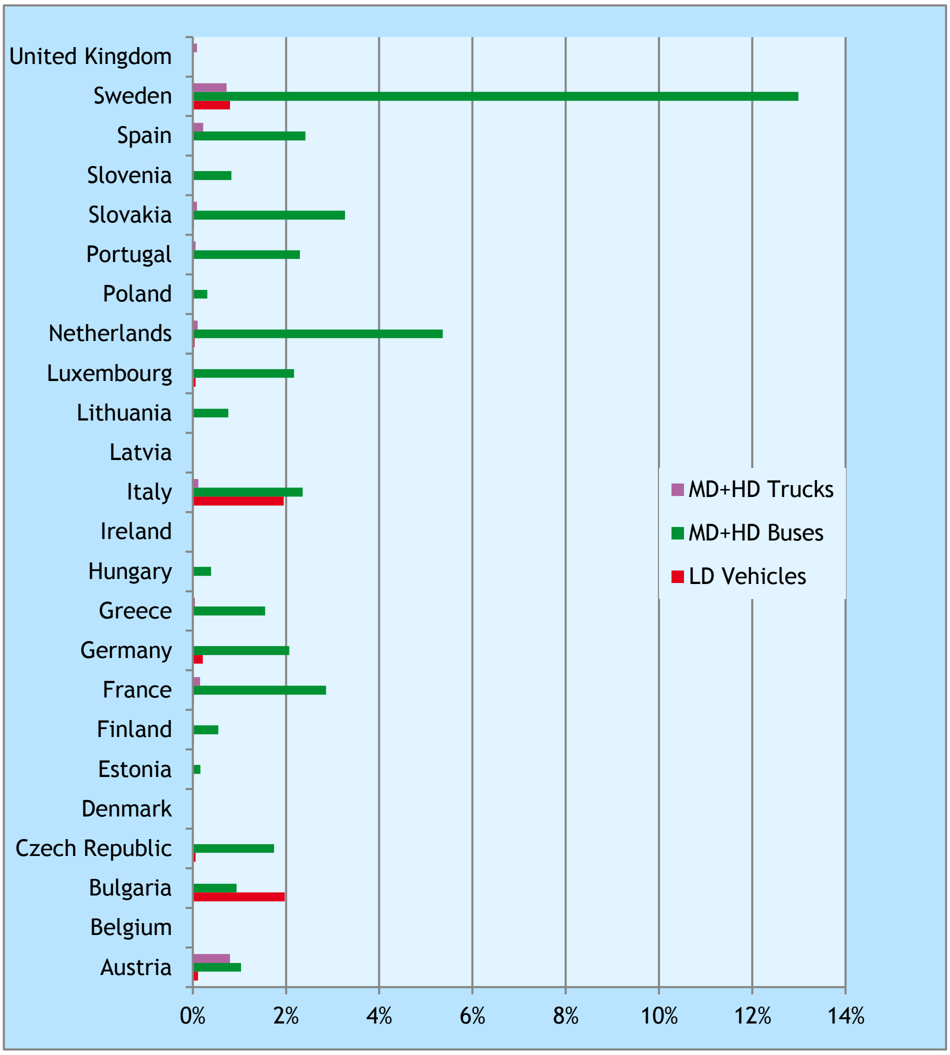
The maximum potential of this type of biofuel production is not yet known (see Section 4.4), but probably in the range of 5-10%, depending on the refinery and the technological development. In this study, we assume that in 2020, the maximum potential would be about 0.5% of the EU diesel market. This is a very rough estimate, which would require significant efforts by the oil industry.

BTL is still in R&D stage, and progress has been slow in the past few years. Large scale production requires first upscaling of the technology to larger scale, commercial operation, after which it will take time before actual production capacity can be expanded to significant size. Assuming that efforts are put into the further development of this option, construction of a large scale production plant is not to be expected before 2015/2018. It thus seems realistic to conclude that even in the best case, production capacity in 2020 can not be much more than 1 larger scale plant in the EU, with a capacity of max. 500–1,000 kilotons/year. However, it is still very uncertain whether this will indeed be realized under current policies and financial conditions.

6.7 Biomethane

Vehicles that can run on CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas) can also run on bio-methane in the form of bio-CNG or bio-LNG. The number of car models, bus or truck engines offered by the vehicle manufacturers is still relatively low on EU scale but it is growing, and there are various industry and government initiatives ongoing that aim to further increase the market share of CNG in busses and passenger cars, and LNG in shipping and heavy-duty transport. Italy is a front runner regarding gas powered vehicles, with already about 650,000 vehicles on the road (driving on natural gas), whereas Sweden has successfully implemented support policies for use of biomethane in transport, in particular in bus transport.
The Netherlands has a support scheme in place of filling stations for CNG (and other alternative fuels), which has resulted in a network of about 100 filling stations by the end of 2012. An overview of the market shares of gas powered vehicles at the end of 2011 is provided in Figure 16.

Figure 16 Overview of the market share of gas powered vehicles throughout the EU



Source: NGVA statistics, data for the end of 2011.

Increasing the use of biomethane in transport requires developing the whole supply chain:

- Biomethane production needs to be increased, or biomethane has to be redirected from current use in, for example, electricity generation or CHP towards transport. Note that in the latter case, the net renewable energy production would not increase, which means that additional efforts will be needed to meet the overall renewable energy target of Member States.
- A distribution network has to be developed, i.e. a network of bio-CNG and/or bio-LNG filling stations needs to be developed. If a CNG or LNG network is already in place, only the biomethane supply itself has to be arranged.
- Gas-powered vehicles and/or ships need to be marketed on a larger scale, and consumers need to be interested to consider buying these.

Especially the last two are linked: in order to realize a substantial growth in market share of gas-powered vehicles from the current 0.4% in Europe, the number of models would need to expand and availability of the (bio)methane, i.e. the number of filling stations, would need to increase. Also the price levels of the vehicles and gas would need to be attractive to consumer. As the purchase price of the CNG and LNG vehicles is usually higher than that of comparable diesel vehicles, this means that the price of methane would need to be lower than that of diesel, at the filling stations.

Despite the currently limited contribution of biomethane in transport, the future potential is very significant, as it can be produced from waste and residue streams such as from manure, agricultural and organic household wastes, etc. The production technology, anaerobic digestion, is mature, the engine and vehicle technology is available as is the distribution technology.

However, reaching even only part of this potential requires that the various steps of the supply chain are all developed further, and both industry and government support seem to be necessary preconditions to achieve this.

Within the EU, Sweden is an example of a Member State with successful development of the whole supply chain, where both supply and demand of biomethane in transport was developed within a relatively short time frame. The Netherlands has organized the supply chain somewhat differently, as the biomethane is not directly used in transport, but rather injected into the (extensive) natural gas grid. If vehicles are filled up with CNG from this grid the supplier can apply for 'biotickets' that contribute towards its biofuels mandate, thus ensuring that administratively, the injected biomethane is treated as if it was used directly in transport.

LNG use in transport is currently in its infancy on EU scale, and bio-LNG is still hardly used. However, their market is growing in some countries (especially Norway and Sweden) and developments in other Member States have just started with the introduction of (one or two) filling points (the Netherlands). In Sweden, bio-LNG plant has just started operations, with the bio-LNG being used in cars, trucks and busses, in the UK, bio-LNG from landfill is used to to power commercial delivery vans[35]. Activities have clearly increased in recent years, however, as and the number of LNG terminals is increasing. A number of recent studies have looked into the possibility to develop an LNG infrastructure for shipping[36].

Some examples of support measures for biomethane use in transport that are already in place in Member States in the EU, and that could be used to increase the market for biomethane:
- ensuring that the biomethane routes are included in the biofuels support policies (mandates, tax reductions, subsidies);
- provide financial support for bio-CNG and bio-LNG filling stations, trucks or ships;
- lower taxes on the fuel, and/or the vehicles (compared to diesel and natural gas);
- demand or reward biomethane use in city busses during tender procedures for public transport;
- increase the share of biomethane in the government's vehicle fleet (in the context of green public procurement).

35 See http://www.biofuelstp.eu/biogas.html for an overview.

36 See, for example, http://www.dma.dk/themes/LNGinfrastructureproject/Sider/OverallLNGproject.aspx for an in-depth study of developing an LNG infrastructure of filling stations and deployment in ships, in Northern Europe.

Note that in the longer term, the potential feedstocks that can be used for biomethane production could be greatly enlarged if the R&D efforts regarding gasification are successful, and result in large scale gasification plants. The resulting product is often called syngas, or bio-SNG, and can also be used in CNG or LNG vehicles.

For the scenario calculations for 2020 it is assumed that the market share for CNG cars could grow to 2% and that the market share for CNG buses for public transportation could grow to 20%.

6.8 Non-road transport: potential to increase biofuels blending

6.8.1 Domestic and inland shipping and railway transport

The inland shipping sector is currently not very interested in biodiesel, as cost are higher and there are some technical concerns and limitations (see Section 4.5.1). Therefore, a legal basis and governments policies are probably needed to increase the biofuel blending.

The compatibility with biofuels is probably somewhat better than for road transport due to the more conventional engine technology. On the other hand, however, on-board auxiliaries which are not biocomponents compatible and the hygroscopic properties of biocomponents in combination with a 'wet' environment make careful handling and maintenance necessary. Nevertheless, the general introduction of a biodiesel blend of the same level as road transport seems possible, as in a number of market segments this is already happening and stakeholders are not concerned about it.
In the past, experiments were done with several blends from which B20 was probably the most popular one.

For the scenario calculations, two options to increase the biofuel blending in this sector are used. A general application of B7 and the application of B20 for 10% of the fleet.

Some other options which are recommended to consider seriously are bio-LNG and PPO (Pure Plant Oil). The interest for LNG for economic and environmental reasons is currently high. This would also help to reduce the future shortage of distillate diesel and the transition to bio-LNG would be easy once LNG ships are in service. Bio-LNG is 100% compatible with fossil LNG.

For rail transport with diesel locomotive, the same strategy can be used as for inland shipping. The objections against biofuels are somewhat less expressed compared to marine.

6.8.2 Aviation

The desire to use biofuels in the aviation sector is high, although there is reluctance to accept the associated additional costs.

The safety and technical requirements for jet fuel are extremely high.
As a consequence, only synthetic fuels such as HVO and BTL kerosene are acceptable. In order to develop substantial biofuel shares, probably some kind of mandate is necessary. This could for example be based on the objective of the European Commission of two million tons bio-kerosene/year by 2020 (Tostmann 2011) and the long-term objectives of ATA, the International Air Transport Association.

7 Assessing the options: marketing scenarios for 2020

7.1 Introduction

In this chapter, the various options that were derived and elaborated in the previous chapter are assessed and compared. The result is a number of biofuels marketing strategies that depend on the scenario (the NREAP or the 50/50 scenario).

The option assessment and strategy development first focusses on the EU-averages. A harmonised approach is likely to be much more efficient than one in which each Member State develops its own strategy. However, as shown in Section 5.2.3, the differences between Member States can be quite significant, mainly due to differences in the ratio between petrol and diesel demand. This suggests that different approaches might be needed for different countries. This will be explored in Section 7.6.

7.2 Assessment of the individual options

As already discussed in Chapter 2, there are quite a number of issues to consider in the assessment of the biofuels marketing options. They relate to all the different steps and stakeholders in the biomass-to-user chain, ranging from biomass availability and cost to consumer acceptance and preferences. This long list of issues was condensed to a short list of assessment criteria with which the various options can be scored:

- potential contribution to the 2020 RED target, considering;
  - biomass supply;
  - biofuel production capacity;
  - potential availability of compatible vehicles in the fleet.
- potential contribution to the 2020 FQD target;
- potential marketing issues (consumers);
- potential environmental risks;
- cost (vehicles and fuels);
- potential for future decarbonisation (post-2020);
- risk that 2020 potential is not met;
- need for protection grades;
- EU policy efforts needed.

An overview of the results of this assessment is shown in Table 36 and Table 37. These results are for the EU27 level, the actual values may differ between Member States. Note that in the assessment of the fuel cost, the various biofuels are compared with each other, where FAME biodiesel is taken to be the biofuel with lowest cost. These estimates are, however, quite uncertain as market forces (global supply and demand), changes to the sustainability criteria etc. can affect cost quite significantly.

Table 36 Overview of the assessment of biofuels blending options, taking expected physical limitations into account. All data for 2020, EU-average

		Max. vehicle availability (share of fleet)	Cost (vehicles)	Cost (fuels)	Need for protection grade?	2020 Max. Mtoe	2020 Max. RED contribution	2020 Max. FQD contribution
	Increase blending limits for large share of vehicles							
1	0,8% HVO in all diesel fuel for road transport	100%	None	Low/medium	No	1.5	0.5%	0.3%
2	Blending limit for diesel from B7 to B10	Cars: 20% HDV: 85%	Cars: low/medium trucks: low	Low	Yes	1.5	0.5%	0.3%
2A	Blending limit for diesel from B7 to B10 (15% cars in 2012)	Cars: 20%	Low/medium	Low	Yes	0.3	0.1%	0.1%
2B	Blending limit for diesel from B7 to B10 (HDV 85% in 2012)	HDV: 85%	Low	Low	Maybe not	1.2	0.4%	0.2%
3	Blending limit for petrol from E10 to E20 (25% market share of petrol)	Cars: 30%	low	Low/Medium	Yes: E5 and E10 in the short/medium term; E10 in the longer term	1.3	0.5%	0.3%
4	Blending limit for petrol from E10 to E30 (6% market share of petrol)	Cars: 10%	Medium	Low/Medium	Yes	0.6	0.2%	0.1%
5	15% market share of ED10 for diesel trucks and buses	Trucks and busses: 15%	Low/medium	Low/Medium	Yes	1.2	0.4%	0.2%
6	Co-refining: 0.5% of bio-feedstock in diesel	100%	None	Low	No	1.0	0.3%	0.2%
7	30% market share of ED5 in diesel trucks and busses	Trucks and busses: 30%	Low	Low/Medium	Yes	1.1	0.4%	0.2%
	High blends in niches (captive fleets)							
8	25% market share of B30 for trucks	Trucks and busses: 25%	Low	Low	N.a.	7.1	2.5%	1.4%
9	10% market share of B100 for trucks	Trucks and busses: 10%	Medium	Low	N.a.	10.8	3.8%	2.2%
10	1% market share of bio-ED95 for buses	Busses: 1%	High	Low/Medium	N.a.	0.0	0.02%	0.01%
11	5% market share of E85 for passenger cars.	Cars: 5%	Low	Low/Medium	N.a.	3.0	1.1%	0.6%
12	20% market share of bio-CNG for buses	Busses: 20%	High	Low/Medium	N.a.	0.5	0.3%	0.1%

		Max. vehicle availability (share of fleet)	Cost (vehicles)	Cost (fuels)	Need for protection grade?	2020 Max. Mtoe	2020 Max. RED contribution	2020 Max. FQD contribution
13	2% market share of bio-CNG for passenger cars	Cars: 2%	High	Low/Medium	N.a.	3.0	1.9%	0.2%
	Increase biofuels use in non-road modes							
14	Mix 1% of HVO with kerosene for airplanes	100%	None	High	No	0.6	0.18%	0
15	Increased use of B20 in inland shipping (10%)	50%	Low	Low	Yes	0.1	0.02%	0.02%
16	Increased use of B20 in trains (10%)	100%	Low	Low	Yes	0.0	0.01%	0.01%

Table 37 Overview, continued

		Marketing issues (consumers)	Potential for further decarbonisation (post-2020)	Main constraints	EU policy efforts needed
	Increase blending limits for large share of vehicles				
1	0,8% HVO in all diesel fuel for road transport	No	Technical: ++ Sustainable feedstock: -	HVO production capacity, availability of sustainable feedstock, biofuel cost	Decide on ILUC
2	Blending limit for diesel from B7 to B10 (15% cars, HDV 40%)	Consumers may prefer B7 Price advantage B10 recommended	+	Acceptance of car OEMs, consumer demand, availability of sustainable feedstock	Negotiate Implementation B10 as reference fuel for pollutant emission legislation (HD probably earlier than cars)
2A	Blending limit for diesel from B7 to B10 (15% cars)	Consumers may prefer B7 Price advantage B10 recommended	Technical: o	Acceptance of car OEMs, consumer demand, availability of sustainable feedstock	Negotiate Implementation B10 as reference fuel for pollutant emission legislation
2B	Blending limit for diesel from B7 to B10 (HDV 40%)	Consumers may prefer B7 Price advantage B10 recommended	Technical: +	Acceptance of car OEMs, consumer demand, availability of sustainable feedstock	Negotiate Implementation B10 as reference fuel for pollutant emission legislation
3	Blending limit for petrol from E10 to E20 (25% market share of petrol)	Consumers may prefer E10. Price advantage E20 recommended	Technical: ++	Consumer demand for vehicles and fuels, ethanol production capacity, availability of sustainable feedstock, sufficient supply of E20 vehicles.	Negotiate Implementation E20 as reference fuel for pollutant emission legislation. Possibly voluntary in 2015 and standard in 2018. Coordinate agreement with vehicle and oil industry about vehicle availability and fuel price compared to other fuels

		Marketing issues (consumers)	Potential for further decarbonisation (post-2020)	Main constraints	EU policy efforts needed
4	Blending limit for petrol from E10 to E30 (6% market share of petrol)	Consumers may prefer E10. Price advantage E30 recommended	Technical: ++	Consumer demand for vehicles and fuels, ethanol production capacity, availability of sustainable feedstock, sufficient supply of E30 vehicles.	Clarify issues with oil companies and vehicle manufacturers If positive: Negotiate Implementation as reference fuel for pollutant emission legislation. Possibly 2015 or 2018
5	15% market share of ED10 for diesel trucks and buses	Users may prefer standard diesel. Price advantage ED10 recommended	Technical: o		Clarify issues with oil companies and vehicle manufacturers If positive: Negotiate Implementation as reference fuel for pollutant emission legislation, possibly 2015.
6	Co-refining: 0.5% of bio-feedstock in diesel			Oil refinery interest and perceived operational risk, R&D, availability of sustainable feedstock	Develop methodology to include this route in RED and FQD, decide on ILUC
7	30% market share of ED5 in diesel trucks and busses	Users may prefer standard diesel. Price advantage ED10 recommended	Technical: +		Clarify issues with oil companies and vehicle manufacturers If positive: Negotiate Implementation as reference fuel for pollutant emission legislation, possibly 2015
	High blends in niches (captive fleets)				
8	25% market share of B30 for trucks	Users may prefer standard diesel B7 or B10. Price advantage B30 recommended (on energy basis).	Technical: +	Availability of sustainable feedstock, consumer demand (incl. cost and environmental perception), sufficient number of type approval Euro VI and Euro VII B30 trucks	Coordinate agreement with vehicle and oil industry about vehicle availability and fuel price compared to other fuels, decide on ILUC
9	10% market share of B100 for trucks	Price of B100 should be lower of comparable to standard diesel. Uncertainty about fuel flexibility (B100 & B10 compatible)	Technical: o	Availability of sustainable feedstock, consumer demand (incl. cost and environmental perception), sufficient number of type approval Euro VI and Euro VII B100 trucks	Coordinate agreement with vehicle and oil industry about vehicle and fuel availability and fuel price compared to other fuels, decide on ILUC
10	1% market share of bio-ED95 for buses	Only one fuel and vehicle supplier at the moment. Price has to be attractive. Driving range more limited.	Technical: - (large development effort for engines)	Lack of ED95 engine and fuel suppliers (currently only one) Consumer demand for vehicles and fuels (i.e. cost), ethanol production capacity, availability of sustainable feedstock	Implement excise tax proportional with energy content and CO_2 emission Coordinate agreement with vehicle and oil industry about vehicle availability and fuel price compared to other fuels

		Marketing issues (consumers)	Potential for further decarbonisation (post-2020)	Main constraints	EU policy efforts needed
11	5% market share of E85 for passenger cars.	Users may prefer standard vehicles and petrol. E85 price has to be attractive. Driving range more limited.	Technical ++ (fuel distribution more expensive)	Consumer demand for vehicles and fuels (i.e. cost), Ethanol production capacity, availability of sustainable feedstock	Clarify issues with fleet owners (is the objective realistic?) Implement excise tax proportional with energy content and CO_2 emission Stimulate E85 flex fuel vehicles Coordinate agreement with vehicle and oil industry about vehicle availability and fuel price compared to other fuels
12	20% market share of bio-CNG for buses	Vehicles are more expensive: fuel costs must be lower, Driving range more limited	Technical: + (vehicles are more expensive)	Biomethane production capacity and distribution infrastructure, demand for vehicles and fuels (cost and driving range)	Implement excise tax proportional with energy content and CO_2 emission High vehicle price may need to be compensated
13	2% market share of bio-CNG for passenger cars	Vehicles are more expensive: fuel costs must be lower. Driving range more limited	Technical: + (vehicles are more expensive)	Biomethane production capacity and distribution infrastructure, demand for vehicles and fuels (cost and driving range)	Implement excise tax proportional with energy content and CO_2 emission High vehicle price may need to be compensated, support expansion of fuelling network
	Increase biofuels use in non-road modes				
14	Mix 1% of HVO with kerosene for airplanes	No, provided fuel quality can be guaranteed	Technical: +	HVO kerosine production capacity, availability of sustainable feedstock, safety, fuel cost	Decide on ILUC Investigate whether aviation can secure more production capacity.
15	Increased use of B20 in inland shipping (10%)	Hesitation with biocomponents and associated operational risks. Fuel price must be competitive on MJ basis.	Technical: +	Availability of sustainable feedstock, consumer demand (i.e. cost and environmental perception), technical issues with storage and auxiliary systems	Decide on ILUC Organise competitive price for B20
16	Increased use of B20 in trains (10%)	Not very positive image. Fuel price must be competitive on MJ basis.	Technical: +	Availability of sustainable feedstock, consumer demand (i.e. cost and environmental perception), technical issues with storage and auxiliary systems	Decide on ILUC Organise competitive price for B20

7.3 Combining and selecting options

From the previous paragraph, it is clear that there is an almost unlimited number of options. Each one of the options have specific advantages with respect to vehicle costs, fuel costs or infrastructure costs. Developing all the options at the same time would place an unacceptable burden on vehicle development & production and infrastructure development & operation.

From the interviews with the stakeholders, the following selection strategy was derived:

- Limit the number of non-fungible biofuels as much as possible to keep infrastructure simple.
- Limit the number of engine/fuel variations per vehicle or transport category, i.e. choose one alternative per vehicle category if needed. This helps controlling complexity of fuelling infrastructure and efforts needed by the vehicle manufacturers to develop the engines and vehicles. It also simplifies vehicle marketing and communication with consumers.
- Focus first on long-term low blends (one blend preferred over several blends: e.g. E20 preferred over E10 plus E85, B15 preferred over B7 or B10 plus B30.
  No need to go higher than long-term sustainable production capacity.
- Add high blends if needed and available, focussing on applications with the least barriers and, if possible, the highest benefits from using the biofuels, e.g.:
  - E85 for taxis and vans;
  - B30 for heavy trucks;
  - Bio-CNG/LNG for HD city transportation and inland ships (which will have the additional benefit of improving air quality).
- Utilise fungible fuels such as HVO, BTL and co-processing of biomass in refineries if possible, as these are diesel biofuels which requires no changes to vehicles or infrastructure (within the 30% blending limit).

For simplicity of vehicle development, drivetrain efficiency and infrastructure, it can be concluded that raising blending limits (whilst maintaining protection grades) is preferred over the implementation of high blends or neat alternative fuels. Nevertheless these high blend fuels can serve an important role in temporarily filling the gap between the current blending limit and the renewable energy target. Also the availability of some alternatives might be better.

In Table 38 an overview and assessment on several criteria is given of the high blends and neat alternative fuels for **passenger cars and vans**.

The following is concluded from vehicle technical and infrastructure point of view:

- HVO can directly be used by both existing as well as new vehicles
  Bio-methane and E85 are seen as the good options. Bio-methane or natural gas vehicles are popular in many countries. The infrastructure is expensive, but already present and supported by government initiatives in various countries. The number of cars per fuel station is relatively low in many countries, so growth is possible without the need to immediately expand the number of fuel stations.

– The difference in overall complexity between E85 flexible fuel vehicles and B30 vehicles is actually small. But it is probably more logical to concentrate ethanol use for passenger cars and B30 use for trucks. If pricing of ethanol E85 is right, customer acceptance of E85 is fine which is demonstrated in Sweden. The additional costs per vehicle are very low.

– Methanol or M85 and DME are both good fuels but vehicles and infrastructure are currently not available. Moreover there may be environmental issues with methanol and DME engine would require a large development effort.

It is therefore recommended to focus on the options bio-methane and E85 and omit the other options. Otherwise the development cost of vehicles and infrastructure would be unnecessarily high.

Table 38 Overview high blend and neat alternative fuels for passenger cars and vans

	Engine type	Current vehicle availability	Vehicle development cost	Vehicle costs	Infrastructure costs
Ethanol, E85	Otto	≈ 34 models[1)]	☺	☺	😐
Bio-methane	Otto	≈ 11 models + retrofit[1)]	😐	😐 ☹	😐[2)]
Methanol, M85	Otto	×[3)]	😐	☺	☹
B30	Diesel	Limited[1)]	😐	☺	😐
B100	Diesel	×[4)]	😐	☺?	😐
HVO 30% or 100%	Diesel	✓	☺	☺	☺
DME	Diesel	×	☹[5)]	😐*	☹

1) Vehicles are available but expansion to more brands and models require investments.
2) Infrastructure is expensive but already present in a number of countries.
3) Vehicles are currently not available, but technology is very similar to E85 flex fuel vehicles
4) Vehicles are currently not available, but technology is very similar to normal diesel vehicles
5) Complete new systems for fuel injection, combustion and emission control are necessary. Even though fuel is similar to LPG in handling, it has completely different combustion characteristics.

In Table 38 an overview and assessment on several criteria is given for high blends or neat alternative fuels for **heavy-duty vehicles**.

The following is concluded from vehicle technical and infrastructure point of view:
– HVO can directly be used by both existing as well as new vehicles. It can be used both in road and non-road transport.
– Bio-methane and B30 are seen as good options. B30 would in fact be easier to expand to all vehicle brands and models and easier from fuel supply point of view, on the other hand availability of compatible vehicles will be uncertain with Euro VI. Also fleet owners more often favour methane vehicles because of fuel costs and image.
– B100 is not appreciated very much from a distribution point of view and also Euro VI type approval will likely be more difficult than B30.
– ED95 and DME vehicles are currently only supported by one manufacturer. There is also no information that this will change in the future. E95 engines (buses and trucks) are commercially available but DME engines are still in a development stage. DME is a very nice diesel fuel with

superior combustion properties. It would be good to pursue bio-DME as a fuel if bio-DME production is substantially more efficient and economic than BTL.
– Methanol heavy-duty engines are currently not available and also not in development. If spark ignition is chosen, then also engine efficiency will be lower. There are also issues with respect to toxicity and environmental risks when methanol is spilled to the environment.

It is recommended to focus on bio-methane and B30 as the options for HD vehicles to help to realise the RED and FQD targets for 2020.

Table 39 **Overview high blend and neat alternative fuels for trucks and buses**

Fuel	Engine	Current vehicle availability	Vehicle development cost	Vehicle costs	Infrastructure costs
Bio-methane	Otto/diesel	✓ 1)	😐	☹	☹
B30	Diesel	✓ 2)	☺	☺	😐
B100	Diesel	✓ 2)	☺	☺	😐
HVO 30% or 100%	Diesel	✓	☺	☺	☺
ED95	Diesel	1 manufact. 1)	😐	😐	😐
DME	Diesel	Prototype of 1 manufact. 1)	☹	😐	☹
Methanol	Otto/diesel	×	☹	😐	☹

1) Vehicles are available but expansion to more brands and models require investments.
2) Vehicles are currently reasonably available (Euro V), but continued availability with Euro VI is uncertain.
3) Recommendation is to raise the blending limit and phase out high blends after 2020.

7.4 Biofuels marketing in the NREAP scenario: most promising options

The best ways to market the 2020 biofuels volumes can now be determined. This depends on the biofuel scenario, i.e. on the volumes of biodiesel and bioethanol that need to be blended. In Scenario 1, it was assumed that the biofuels developments will be in line with the expectations of the Member States as presented in the NREAPs. This scenario consists of a relatively large share of biodiesel, and much less bioethanol.

First of all, the current blending limits of biofuels (B7 and E10) should be fully utilized. This is a relatively cost effective and low-risk way to market biofuels. Fungible fuels, currently limited to HVO, can be added to this. Furthermore, B7 can also be used in diesel used in inland shipping and railway transport without risk of technical problems.

From a technical point of view, expanding the use of fungible fuels (HVO, BTL, co-processing in refineries) would be the best option to further increase biofuels shares. However, production capacity of these fuels is not expected to increase fast enough in the coming years. A very large share of the remaining gap will then have to be filled by FAME.
Considering all the options, it is expected that selling this additional volume of FAME can best be achieved by offering B10 or B20 at selected service stations that supply the HDV market.

The critical issues in this option is the production and uptake of B10 or B20 compatible vehicles, and the way in which their owners will be persuaded to fill their vehicles with these fuels and not with regular diesel.

An alternative option that may also be attractive is by selling high blends, B30 or B100, to part of the HDV market. This market can be developed through captive fleets first, where fuel suppliers and fuel consumers would reach individual agreements. The main issue with this option is that it is still uncertain if all OEMs will be able to offer B30 or B100 vehicles that can meet Euro VI type approval standards.

In addition, a number of other options exist that are currently still in R&D stage, but might have the potential to develop further in the coming years. The most promising options with significant potential to increase the bio-content in diesel is co-refining of bio-oils in refineries (a means to increase HVO production without the need to add additional HVO production capacity) and BTL. It is currently difficult to predict their contribution in 2020.

Depending on the biofuels policy in place, Member State governments may need to play a role in facilitating these options of further biodiesel market uptake, especially in case of the high blend FAME options. Targeted incentives could be especially relevant if biofuels policy is based on fuel tax reductions, without specific incentives for high blends. Both fuel suppliers and vehicle manufacturers will need to change their product range, whilst consumers will need to be persuaded to buy these high blend vehicles and fuels – which have higher cost than conventional, low blend alternatives for all stakeholders involved.

In case of increasing biofuels mandates, it is expected that the fuel suppliers will look for opportunities to market the high blends, and take the initiative to approach their captive fleet customers and/or decide to offer the high blends at their service stations. In that case, however, they are dependent on whether or not engine and vehicle manufacturers put effort into the development and marketing of the higher blend FAME vehicles (B10, B20, B30 and/or B100). Member States could support this development by providing incentives to buy these type of vehicles.

An overview of the various biofuels marketing routes that could contribute to this scenario is shown in Table 40.

Table 40 Overview of the various biofuels marketing routes for Scenario 1

2020	Main	Captive fleet/depot
Passenger cars	Petrol: E20, E85, PG E10	Taxis, vans E85 or bio CNG
Vans	Diesel: B10 to B15, PG B7	
Light trucks < 12 ton	B10 to B15, PG B7	
City bus		Bio-CNG or Bio-LNG
Medium heavy trucks < 20 ton or tractor		
Heavy trucks		B30 (if needed)
Coach bus		
Inland shipping IC rail	B10 to B15, PG B7	bio-LNG (or PPO if helpful)
Aviation	Jet B0, jet HVO blend (if available)	

A more qualitative outlook is given in Table 41 and Table 42, where the contribution of the various blending options is added to meet the biofuels demand of Scenario 1. As there is some flexibility how the market may meet the biofuels demand, two different marketing routes are derived.

Table 41 A biofuels marketing mix for the NREAP scenario (Mtoe)

	Biodiesel	Bioethanol	Contribution to RED target
Total demand NREAPs	**21.6**	**7.3**	
Marketing through B7 and E10 in road	12.8	6.7	6.2%
Fungible fuels: HVO (Option 1)	2.4		0.8%
Blending limit from B7 to B10 (Option 2)	1.5		0.5%
20% market share of B30 for trucks in captive fleets (Option 8)	4.9		1.6%
Blending limit from E10 to E20, 12% market share of E20 (Option 3, about half of the max. potential)		0.6	0.2%
Total all options	**21.6**	**7.3**	**9.2%**

Table 42 Alternative biofuels marketing mix for the NREAP scenario (Mtoe)

	Biodiesel	Bioethanol	Contribution to RED target
Total demand	**21.6**	**7.3**	
Marketing through B7 and E10 in road	12.8	6.7	6.2%
Fungible fuels: HVO (Option 1)	1.5		0.5%
Co-refining (Option 6)	1.0		0.3%
B7 in non-road (100% utilization)	0.5		0.2%
5-6% market share of B100 for trucks in captive fleets (Option 9, about half of the max. potential)	5.8		1.9%
1% market share of E85 in captive fleets (Option 11, about 20% of the max. potential)		0.6	0.2%
Total all options	**21.6**	**7.3**	**9.2%**

The relative contribution of biofuels marketing in the regular fleet versus that in niche applications is shown in the following figure, for the first marketing mix. The relative contributions of the various options to the biodiesel and bioethanol goals are shown in Figure 18 for the first marketing mix, and in Figure 19 for the alternative mix.

These graphs clearly indicate the importance of B7 and E10, as well as the need to make significant use of higher blends in niches: either in the form of B30 or as B100. Ethanol marketing is much less of an issue in this scenario, although a share of high blend ethanol is also needed. E20 seems to be the most attractive route, as part of a longer term strategy to move from E10 to E20 as base fuel, but a 1% market share of E85 vehicles would also be adequate.

Figure 17 NREAP scenario, overview of the various types of measures (road/non-road, regular fleet or niche)

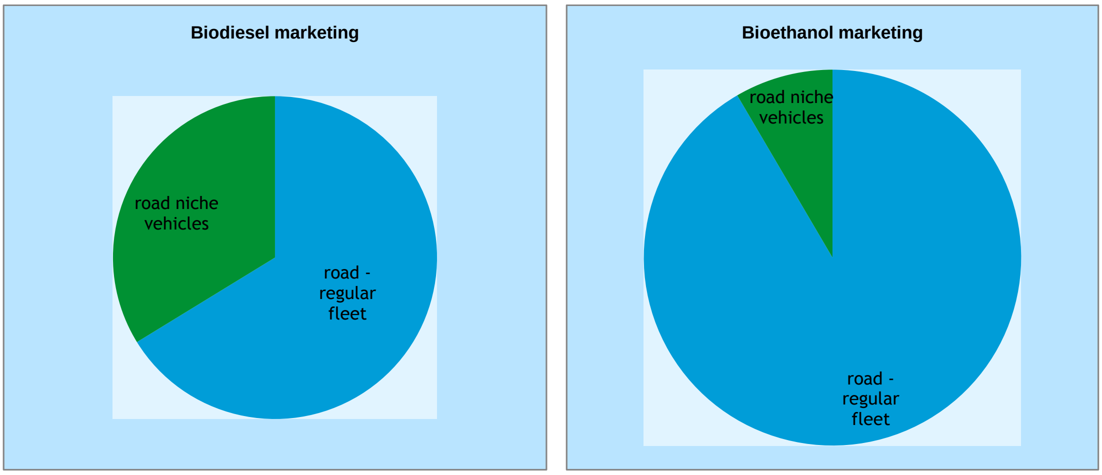


Figure 18 NREAP scenario, contribution of the various measures to total biofuels sales in 2020

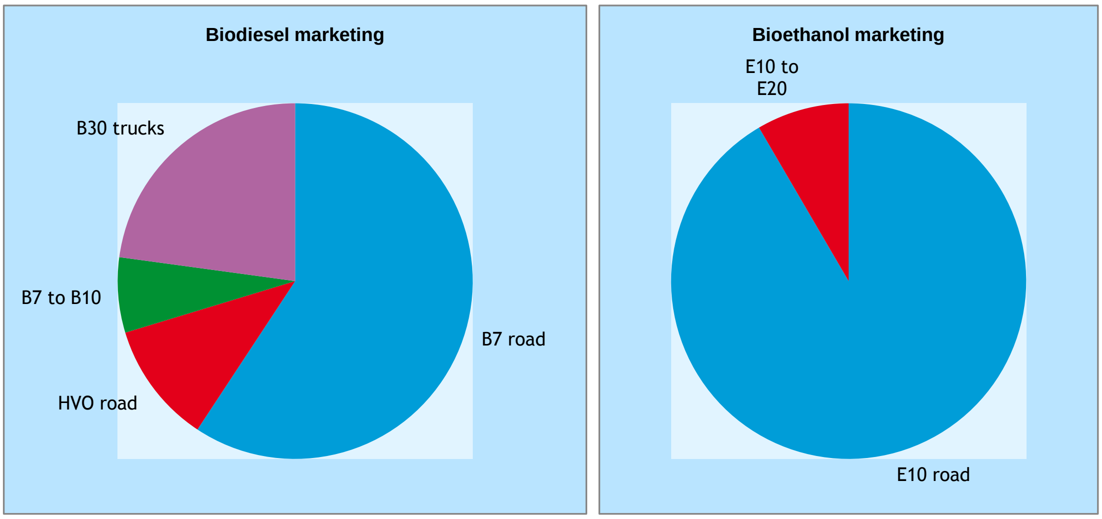
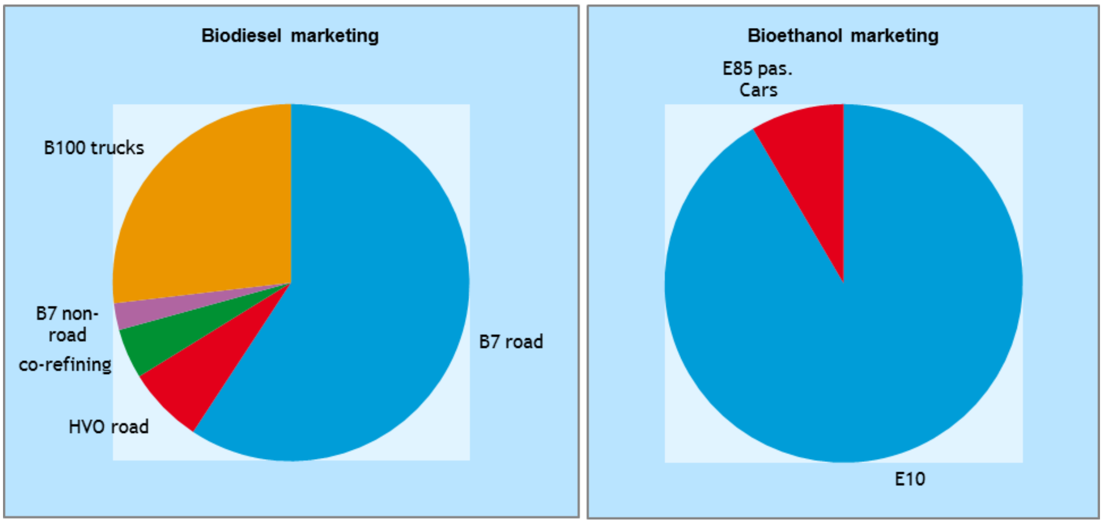


Figure 19 NREAP scenario alternative marketing mix, contribution of the various measures to total biofuels sales in 2020



An important note to make is that many of the above developments are currently hampered by the uncertainty in the market regarding the sustainability criteria, and especially regarding ILUC implementation. Decisions on ILUC could mean that a significant part of the current feedstock for especially biodiesel can not be used anymore for EU biofuels, which could significantly impact on biodiesel cost and thus availability. Many stakeholders, including investors but also fuel consumers and Member State governments, indicate that they are waiting on the outcome of the EU debate on this issue before deciding to further increase their efforts to increase biodiesel production and use.

7.5 Biofuels marketing in the 50/50 scenario: focus on ethanol and biomethane

In this scenario, there is a need to significantly increase the supply and demand of ethanol above the E10 blending limit.

As in the first scenario, the current blending limits of biofuels (B7 and E10) should be fully utilized first. This is a relatively cost effective and low-risk way to market biofuels. Fungible fuels, currently limited to HVO, can be added to this, as well as B7 in inland shipping and railway transport. All these options together are sufficient to meet biodiesel demand, but still a significant gap remains in ethanol marketing.

There are quite a number of routes to increase ethanol volumes beyond E10 levels: the passenger car fleet can gradually convert to E20 or E30, the share of E85 vehicles and fuel can be increased, ethanol can be blended into diesel for the heavy-duty fleet by shifting to a blend of 5% or 10% ethanol in diesel in diesel in addition to FAME (ED5 or ED10). So far, marketing efforts have mainly focussed on E85 (in some Member States), whilst the other options were mainly limited to R&D projects. The scale of these efforts was relatively limited, mainly because there was no large scale market demand for the other options. It can be expected, however, that if development efforts increase in the future, these options may well become more cost effective than they are now.

Table 43 Overview of the various biofuels marketing routes for Scenario 2

2020	Main	Captive fleet / depot
Passenger cars	Petrol: E20, E85, PG E10 Diesel: ED5-B7 or ED10-B7, PG B7	Taxis, vans E85 or bio CNG
Vans		
Light trucks < 12 ton	Add 5% or 10% ethanol to B7 (ED5-B7 or ED10-B7) PG B7	E85 or bio CNG
City bus		Bio-CNG or Bio-LNG
Medium heavy trucks < 20 ton or tractor		
Heavy trucks		
Coach bus		
Inland shipping IC rail	B10 to B15, PG B7	Bio-LNG (or PPO if helpful)
Aviation	Jet B0, jet HVO blend (if available)	

As the gap between the current blending limits and ethanol demand in 2020 is quite large, it seems advisable to focus on the options that have the potential to significantly contribute to the target: increased use of E85 in passenger cars and/or develop ethanol blending in diesel. Both options require significant efforts by various stakeholders and need time to develop.

Looking at cost, E85 seems to be the preferred option. There are a number of reasons to also develop the ethanol-in-diesel routes, though:

– If biodiesel potential is limited due to sustainability constraints, there are very few alternative options to decarbonize diesel, and thus a large part of the transport sector.
– Replacing petrol with bioethanol will further increase the unbalance in EU diesel production versus demand. This will increase cost to the refinery sector, and increase diesel imports. It may also be attractive and a practical route to replace traditional diesel segments such as taxis, vans and small trucks by E85 or E20 (petrol) vehicles.

Even though E85 has the largest potential in the short to medium term, gradually converting the passenger car market to E20 or E30 would be the preferred marketing route for the longer term. However, this would take time, both from a vehicle development and fuel supply point of view, and 2020 shares are expected to remain limited.

In any case, it can be concluded that it will be very difficult and perhaps even impossible to fill the whole gap with ethanol blending options. It is assumed here that the bio-CNG or bio-LNG options then need to be deployed to market the remaining (non-diesel) biofuel volume.

Adding the contributions of the various options results in a biofuels marketing mix as shown in Table 44. In this scenario, it is necessary to deploy all ethanol marketing options to their full potential, but even then, a gap remains with the 2020 target. Here, this gap is filled with bio-CNG in both busses and passenger cars.

Table 44 A potential biofuels marketing mix for the 50/50 scenario (Mtoe)

	Biodiesel	Bioethanol/ biomethane	Contribution to RED target
Total demand	**14.5**	**14.5**	
Marketing through B7 and E10 in road	12.8	6.7	6.2%
Fungible fuels: HVO (Option 1)	1.5		0.5%
B7 in non-road (100% utilization)	0.1		0.0%
Blending limit from E10 to E20 (Option 3)		1.3	0.4%
ED5 in HDV (Option 7) - or ED10 in HDV (Option 5)		1.1	0.4%
E85 in captive fleets (Option 11)		2.3	0.7%
Bio-CNG for busses (Option 12)		0.5	0.2%
1.2% market share bio-CNG for passenger cars (Option 13, 60% of the max. potential)		2.5	0.8%
Total all options	**14.5**	**14.5**	**9.2%**

There is quite some flexibility regarding how the biodiesel volumes are brought on the market (e.g. the volumes of fungible fuels, or the use of B7 in non-road modes may increase), but only few alternatives exist for the bioethanol and biomethane options included in this scenario. Potential alternative solutions could be to increase the use of bio-LNG (e.g. in trucks and/or inland shipping), to reduce the bioethanol volume by increasing the share of double-counting bioethanol (or biomethane), or to increase the share of petrol vehicles in the fleet. The latter option would increase the potential of both E10 and E20 blending.

This marketing mix is also shown graphically in the following graphs. Figure 20 clearly shows that in this scenario, there is no need to develop high blend FAME vehicles, as all biodiesel can be blended in the existing vehicle fleet. The situation is very different for bioethanol, though. More than half the ethanol has to be marketed through means other than E10 in the regular fleet. The detailed measures are shown in Figure 21.

Figure 20 NREAP scenario, overview of the various types of measures (road/non-road, regular fleet or niche)

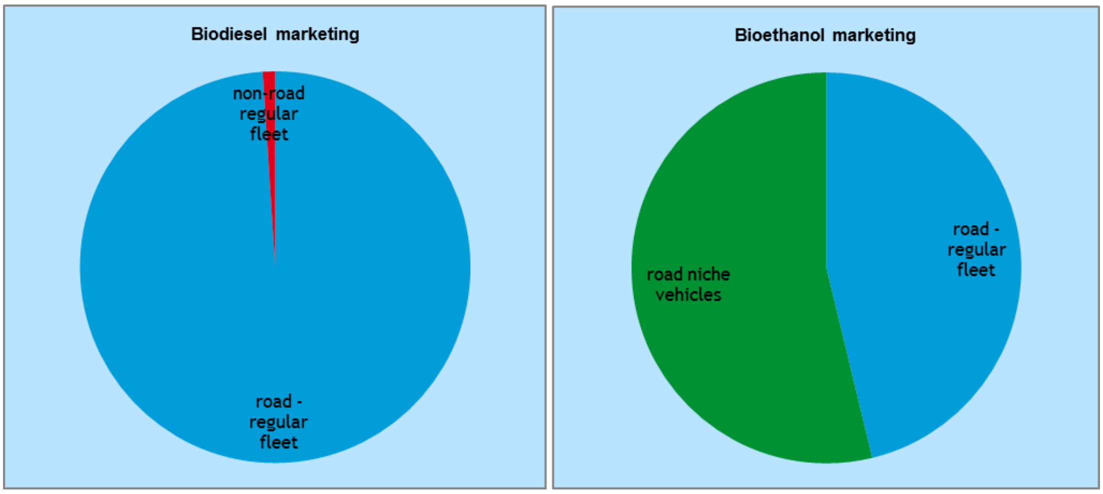
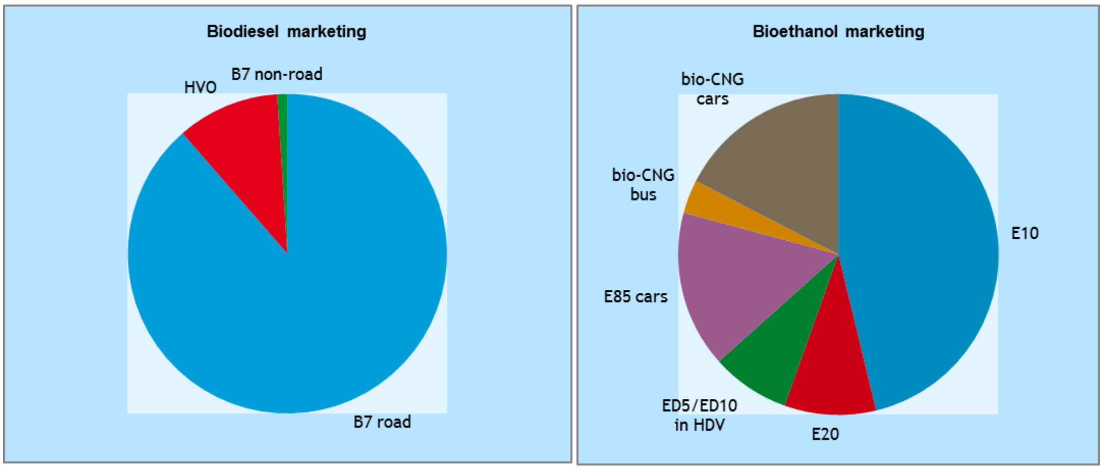


Figure 21 50/50 scenario marketing mix, contribution of the various measures to total biofuels sales in 2020



7.6 Differences between Member States with examples: Germany and Sweden

The results in the previous paragraphs are all for the EU27 level, whereas the RED target of 10% renewable energy in transport has to be met by all Member States individually. As shown in Section 5.2.3, some Member States have a relatively large gap between their desired biodiesel demand and the blending potential of B7, whereas others may have a more than average gap between ethanol demand and the potential of E10.

How these differences impact on the biofuels marketing strategy will be illustrated in the following, for two countries:
1. Germany, a Member State with a relatively high share of biodiesel in their action plan.
2. Sweden, a country with a strong focus on bioethanol.

Note that in both cases, the 2020 forecasts of national transport energy demand were taken from PRIMES-TREMOVE v2.0. These data may therefore differ from the national forecasts.

7.6.1 Germany

The following three tables show the biofuels volumes that can be marketed with the three biofuels marketing mixes that were developed for the EU. The first two were options to meet the NREAP scenario on EU-level, the third mix would meet the 50/50 scenario.

Looking at these tables, it can be seen that in the case of Germany, the total of these options will not meet the biodiesel demand in all three cases. Additional biodiesel blending is necessary, most likely via higher shares of the high blends in heavy-duty vehicles. An alternative option might be to use more fungible biodiesels than the EU average. In the NREAP scenario, there is no need to increase the ethanol level to E20, as even the E10 blending limit does not have to be fully exhausted to meet the NREAP goal.

The 50/50 scenario results in a somewhat more balanced picture, but Germany would have to use more than average shares of high blends in both biodiesel and bioethanol. The sales of biodiesel could be increased relatively easy, for example, by marketing B30 to captive fleets. Increasing the sales of bioethanol beyond the options listed here may be more challenging. As mentioned earlier, a somewhat different type of options would be to increasing the share of double-counting biofuels, that would also contribute to meeting the target.

Table 45 Germany: A biofuels marketing mix for the NREAP scenario (ktoe)

	Biodiesel	Bioethanol
Total demand	**4,443**	**860**
Marketing through B7 and E10 in road (100% utilization)	1,997	1,163
Fungible fuels: HVO (Option 1)	239	
Blending limit from B7 to B10 (Option 2)	239	
20% market share of B30 for trucks in captive fleets (Option 8)	931	
Blending limit from E10 to E20, 12% market share of E20 (Option 3, about half of the max. potential)		119
Total all options	**3,415**	**1,290**

NB. The definition of the options can be found in Section 6.2.

Table 46 **Germany: Alternative biofuels marketing mix for the NREAP scenario (ktoe)**

	Biodiesel	Bioethanol
Total demand	**4,443**	**860**
Marketing through B7 and E10 in road (100% utilization)	1,997	1,163
Fungible fuels: HVO (Option 1)	239	
Co-refining (Option 6)	143	
B7 in non-road (100% utilization)	38	
5-6% market share of B100 for trucks in captive fleets (Option 9, about half of the max. potential)	884	
1% market share of E85 in captive fleets (Option 11, about 20% of max. potential)		119
Total all options	**3,296**	**1,266**

NB. The definition of the options can be found in Section 6.2.

Table 47 **Germany: A potential biofuels marketing mix for the 50/50 scenario (ktoe)**

	Biodiesel	Bioethanol
Total demand	**2,651**	**2,651**
Marketing through B7 and E10 in road (100% utilization)	1,997	1,163
Fungible fuels: HVO (Option 1)	239	
B7 in non-road (100% utilization)	48	
Blending limit from E10 to E20 (Option 3)		239
ED5 in HDV (Option 7) - or ED10 in HDV (Option 5)		119
E85 in captive fleets (Option 11)		525
Bio-CNG for busses (Option 12)		48
1.2% market share bio-CNG for passenger cars (Option 13, 60% of the max. potential)		334
Total all options	**2,269**	**2,460**

NB. The definition of the options can be found in Section 6.2.

7.6.2 Sweden

The Swedish biofuels strategy in the NREAPs is characterized by a relatively share of bioethanol in total biofuel sales.

Applying the same biofuels marketing strategies on the Swedish vehicle fleet results in the biodiesel and bioethanol sales as shown in the following three tables. Again, the first two are the strategies to meet the EU NREAP scenario, the third is the strategy for the 50/50 scenario.

It is interesting to note that in the case of Sweden, the 50/50 scenario actually represents a shift from bioethanol to biodiesel, which is not very likely. Nevertheless, the same scenario definitions were applied here, in order to assess the potential range of biofuel developments.

Looking at the first two tables, it becomes clear that in Sweden, much more effort needs to be put into marketing ethanol than in the EU as a whole. However, the marketing mix of the 50/50 EU scenario would be a solution: that strategy meets the bioethanol demand given in the national action plan. As the biodiesel demand is relatively low in this plan, there is no need to develop a high blend biodiesel market, assuming that B7 can be applied year round (which may not always be the case because of winter conditions), and some HVO can be added as well.

In case of a 50/50 share of biodiesel and bioethanol, effort has to be put into marketing of high blends of FAME. However, the EU strategies for the NREAP scenarios would be more than sufficient in that case.

Table 48 Sweden: A biofuels marketing mix for the NREAP scenario (ktoe)

	Biodiesel	Bioethanol
Total demand	**262.7**	**453.8**
Marketing through B7 and E10 in road (100% utilization)	246.0	231.7
Fungible fuels: HVO (Option 1)	23.9	
Blending limit from B7 to B10 (Option 2)	0.0	
20% market share of B30 for trucks in captive fleets (Option 8)	167.2	
Blending limit from E10 to E20, 12% market share of E20 (Option 3, about half of the max. potential)		23.9
Total all options	**429.9**	**262.7**

NB. The definition of the options can be found in Section 6.2.

Table 49 Sweden: Alternative biofuels marketing mix for the NREAP scenario (toe)

	Biodiesel	Bioethanol
Total demand	**263**	**454**
Marketing through B7 and E10 in road (100% utilization)	246	232
Fungible fuels: HVO (Option 1)	24	
Co-refining (Option 6)	24	
B7 in non-road (100% utilization)	10	
5-6% market share of B100 for trucks in captive fleets (Option 9, about half of the max. potential)	143	
1% market share of E85 in captive fleets (Option 11, about 20% of the max. potential)		26
Total all options	**454**	**263**

NB. The definition of the options can be found in Section 6.2.

Table 50 Sweden: A potential biofuels marketing mix for the 50/50 scenario (toe)

	Biodiesel	Bioethanol
Total demand	**358**	**358**
Marketing through B7 and E10 in road (100% utilization)	246	232
Fungible fuels: HVO (Option 1)	29	
B7 in non-road (100% utilization)	10	
Blending limit from E10 to E20 (Option 3)		50
ED5 in HDV (Option 7) - or ED10 in HDV (Option 5)		29
E85 in captive fleets (Option 11)		119
Bio-CNG for busses (Option 12)		12
1,2% market share bio-CNG for passenger cars (Option 13, 60% of the max. potential)		
Total all options	**287**	**454**

NB. The definition of the options can be found in Section 6.2.

7.7 Conclusions and recommendations

A large share of the 2020 biofuels volume can be marketed simply by increasing the shares of FAME and bioethanol in conventional diesel and petrol, up to the limits currently allowed: B7 and E10. However, these volumes are not sufficient to meet the RED target nor the Member States' action plans. Other marketing options will also need to be implemented.

A whole range of additional blending options could be identified, both for ethanol and biodiesel. Increasing the use of biomethane was added to this list of blending options, as this is a route that is being developed in various EU countries with significant potential of sustainable feedstock. Some other types of biofuel such as BTL, bio-DME and methanol were not included, since their potential contribution to the 2020 RED target is expected to remain negligible.

The options were assessed, and biofuels marketing strategies were developed based on the results. Strategies were developed for the two scenarios that are included in this study: biofuels development in line with the Member State plans as outlined in the NREAPs, and an alternative '50/50' scenario with equal contributions of biodiesel and bioethanol.

The main conclusions are the following:
- Fully utilise B7 and E10 throughout Europe.
- B7 can also be used in inland shipping and rail, although the contribution of these routes to the RED target is very limited in most Member States.
- Arrange general compatibility of petrol engines to E20 or E30 and diesel engines to B10 to B15 as a long-term no regret measure.
- One blend is generally preferred above a combination of several blends, because of costs of vehicle development and infrastructure.
- For practical reasons, it is advisable to limit the number of fuel options per transport category to a maximum of two, plus a protection grade fuel if needed. For example, focus on bio-CNG/LNG only for city-buses, delivery trucks and inland ships (if biomethane is sufficiently available), and B30 for heavy trucks only.
- From a technical point of view, it is best to expand HVO on top of B7.
- The role of consumers will become more important in the coming years, as high blend biofuels options are further developed. Consumers – ranging from individual car owners to professional hauliers and fleet owners - will need to be persuaded to buy high blend vehicles and fuels in a market where they can also choose the low blends. Critical issues will be cost, technical compatibility (actual and perceived) and trust in the environmental benefits.
- Marketing strategies need to be developed that make these high blend options cost effective for their users. Depending on the national biofuel policy (mandates or tax incentives), this may require implementation of effective government incentives. Examples of these are CO_2 differentiated fuel taxation, lower vehicle taxes, etc.
- Increasing the share of double-counting biofuels can also be an effective means to reduce the efforts needed to develop high blend marketing solutions for the timeframe until 2020.
- Harmonisation of efforts within the EU is important to reduce overall cost of meeting the RED target. However, the differences between Member States are significant, due to differences in petrol and diesel demand and in ambitions for 2020. The EU strategies developed here may not be the sufficient or optimal for each individual country.

It is therefore recommended to develop a national biofuels marketing strategy that goes into more detail than that reported in the NREAPs.

Additional conclusions regarding the NREAP scenario:
- Additional marketing of FAME above B7 levels can best be achieved by utilising B10 (or B20) in heavy-duty vehicles and by marketing B30 (or B100) for selected fleets. Protection grade B7 for trucks may not be necessary in combination with B10, but this would need to be cleared with the truck manufacturers to ensure that the manufacturer warranties are valid for B10 and B30 blends.
- Co-refining of bio-oils, although still in the R&D phase, may be an attractive option to market additional HVO-like biodiesel. It is therefore recommended to include this option in the RED and FQD methodology.

Additional conclusions regarding the 50/50 scenario:
- Develop policies to market extra ethanol in spark-ignition engines via active promotion of E20 and E85 vehicles.
- Develop policies to shift traditional diesel categories to petrol/ethanol and to bio-CNG or LNG. Examples are taxis, vans and small trucks.
- Bio-CNG is likely to be an important part of a biofuel strategy in this scenario.
- Investigate the option to blend 5% or 10% ethanol in diesel fuel and develop these routes further.

Entirely new fuels such as methanol and DME are not directly recommended, because it would substantial increase complexity to vehicle developments and infrastructure. Bio-methanol may create environmental issues when spilled and can probably find a better application in other sectors. However, market conditions should allow the uptake of these other biofuels as well, in order to enable the stakeholders to develop innovative solutions to decarbonize transport fuels.

It is important to realise that both scenarios require very different efforts, in R&D and investments of both vehicle manufacturers and fuel suppliers, in government policy, etc. In view of the time needed to develop these routes, it is important that the uncertainty regarding ILUC implementation is resolved. This will help clarify which options are future-proof, a prerequisite for ensuring that investments are cost-effective also in the longer term.
The implementation of effective sustainability criteria (including ILUC) will also help gain the trust of consumers, and ensure their cooperation.

The following policy recommendations could be derived:

European Committee:
- provide certainty about biofuel sustainability criteria;
- support national governments with implementation of RED;
- aim for harmonisation of national strategies, otherwise (bio)fuels automatically flow to countries where the value is the highest;
- estimation of available, long-term, quantities fulfilling these criteria;
- agree on blending options and overall strategy together with vehicle and fuels industry (based on costs effectiveness);
- implement the options in pollutant emission legislation in an early stage, as at least 6 years of lead time will be required.

Member States:
- derive a biofuels marketing strategy for the period until 2020;
- assess which national policies are needed to achieve the goals of this strategy;
- implement the necessary incentives;
- ensure that vehicle owners receive adequate information about vehicle/fuel compatibility, sustainability, etc.

Vehicle industry:
- propose options for the marketing of biocomponents including possible time frames;
- support implementation of new blends in fuel standards and pollutant emissions legislation;
- ensure adequate communication with vehicle buyers and owners about vehicle/fuel compatibility.

Oil industry and fuel suppliers:
- propose (ranking of) options for marketing of biocomponents;
- provide information how this can be implemented on a European level;
- develop a communication strategy with consumers, if possible harmonized within the sector (e.g. fuel labelling at filling stations, information on vehicle/fuel compatibility, etc.).

8 Practical issues to resolve

8.1 Introduction

Realisation of the most promising biofuels marketing options requires a number of actions, typically by a range of stakeholders, governments and institutions. In this chapter, an overview is provided of the actions needed and conditions that need to be met for each of these marketing options to be implemented. A more general assessment of the way forward is the topic of the next chapter.

8.2 The various marketing options

The following options were included in the scenarios developed in the previous chapter, and will be discussed in more detail here:
- marketing of B7 and E10 in all road transport throughout the EU;
- B7 in non-road;
- increase the supply and demand for fungible fuels;
- increase the blending limit for FAME, from B7 to B10 (up to 15% of cars and 40% of HDV in the NREAP scenario);
- increase the market share of B30 or B100 for trucks in captive fleets (up to 20% B30 in 2020, or up to 6% B100);
- increase the ethanol blending limit from E10 to E20 (up to 25% market share in 2020 in the 50/50 scenario);
- further develop and implement co-refining of plant oils (up to 0.5% of the EU refinery feedstock in 2020);
- increase the market share of E85 in captive fleets (up to 5% in the 50/50 scenario);
- develop supply and demand of ED5 or ED10 in HDV (30% or 15% market share respectively);
- increase the use of Bio-CNG in busses (up to a 20% market share) and/or passenger cars (up to a 1.2% market share).

The higher blend FAME options are typically required to meet the NREAP scenario, the ethanol and CNG options are needed in the 50/50 scenario mainly.

8.2.1 B7 and E10 in road transport

B7 and E10 have been introduced in a number of Member States, where the introduction of B7 is currently more widespread than that of E10. B7 has the advantage that it can be used by all vehicles, whereas some of the older cars can not run on E10. It is therefore necessary to also offer E5 to consumers, as well as ensure adequate communication about vehicle compatibility with vehicle owners. In addition, as consumers will then have the choice between the two grades of petrol, they will need to be encouraged to buy the E10 rather than the E5.

It can therefore be concluded that the introduction of **B7** does not require specific actions or issues to be resolved, fuel suppliers can increase the level of FAME without causing vehicle compatibility problems or requiring modifications to fuel distribution, and consumers do not need to be involved.

The introduction of **E10** require more effort. First of all, fuel suppliers need to adapt their **fuel distribution**. Both E10 and protection grade E5 need to be offered at service stations, although not necessarily at all stations (with E10 phasing in, and E5 slowly phasing out over time). This means that both types need to be distributed, part of the filling points need to be converted to E10 and adequate fuel labelling and consumer information needs to be arranged.

Encouraging consumers to then buy the E10 requires **communication** as well as some form of **incentive**. Communication is important because vehicle owners need to know whether their vehicle is compatible or not, and they need to trust this information (i.e. the new fuel) before they will accept it. An incentive is needed to ensure that the consumers indeed fill up their cars with E10, rather than with the E5[37]. E10 is more expensive than E5 (cost of ethanol is higher than that of petrol), and it contains less energy, thereby increases fuel consumption. As most consumers will chose the least expensive petrol grade, some form of financial compensation is necessary to ensure that driving on E10 will be (somewhat) cheaper than driving on E5. This compensation can be implemented by fuel suppliers as part of their marketing strategy, it can also be facilitated by governments, for example by differentiating fuel taxes. At the same time, care should be taken that owners of non-compatible vehicles do not fill their cars with E10.

The E10 standard will be finalised in 2012. Vehicle compatibility will increase from 85% now to about 95% in 2020.

The B7 standard is finalized and diesel fuel with up to 7% biodiesel is supplied on a regular basis. Fulfilling the B7 specification in winter requires better quality biodiesel than in summer. Alternatively a (larger) share of HVO can be used instead of biodiesel.

8.2.2 B7 in non-road transport

From a technical point of view, introducing B7 in inland shipping, railway transport and mobile machinery requires some adaptations and fleet testing. For existing (older) ships it is necessary that the tanks are adapted with improved water separation and filtering and better accessibility for cleaning. This is also the case for tanks that are used for bunkering for non-road segments.

In addition, there are a number of non-technical issues to resolve, somewhat similar to the E10 introduction described above: potential buyers need to trust the new fuel, they should know whether or not they can use it, and whether they would need to take special precautions when they use it. This requires specific communication with the non-road fuel consumers. This process is already ongoing and in at least several countries, B5 and B7 fuels are already commonly supplied.

For the countries that are not yet supplying B5 or B7, it is advisable to start fleet tests with a low blend so that experience can be build up.
It is recommended to allow the sector a few years to make the full conversion and synchronise the biofuel blend with road-transport.

[37] Note that this incentive will be a temporary measure, and only needed as long as E5 is also available on a significant scale.

Maintaining a B0 protection grade is probably not feasible because of the unacceptable large burden on fuel distribution. Instead it would be better to offer B7 or B10 at a slightly lower price such that the ship owner is compensated for the required adaptations and possibly increased maintenance.

The adaptation for rail transport is probably somewhat easier because of the better (non-aqueous) environment and the limited number of stakeholders. Synchronisation with road transport can possibly be done somewhat faster than for shipping.

8.2.3 Increase supply and demand for fungible fuels
As blending and use of fungible fuels (HVO, BTL) is technically straightforward, at least up to the levels needed to meet the 2020 target, the key barriers to further increasing their shares are production capacity limitations and fuel cost. Their cost are currently typically higher than that of FAME, but due to their advantageous blending characteristics, potential additional fuel cost may be compensated by lower fuel distribution and marketing cost, compared to the other options.

8.2.4 Increasing the FAME blending limit, from B7 to B10
This is already an on-going activity in fuel standardisation (CEN).

For trucks the technologies are already compatible to a large extend and also for Euro VI trucks no specific issues are expected. Key is to implement the new reference fuels in the pollutant emission legislation as soon as possible for both passenger cars and HD vehicles. The data of entry into force of that legislation, is then also the start date for the phasing in of B10. The earliest possible date is 2017/2018. Implementation for passenger cars is more complex because of the technologies used for emission control. R&D programs and field testing may be necessary to further investigate and demonstrate feasibility and timing.

In summary the following steps need to be taken:
- Finalisation of fuel standardisation.
- Implementation as test fuels for pollutant emissions legislation.
- Vehicle manufacturers need to ensure that a large share (if not all) of the future passenger cars and trucks to be compatible with B10.
- Fuel suppliers need to supply B10 in parallel with (protection grade) B7. This will require investments in fuel stations and distribution infrastructure in a number of countries. The existing flexibility at the larger filling stations along the motorways for using the variety of pumps for cars and HDV can be used without delay.
- Consumers need to be made aware of the new fuel, and need to know whether they can use it or not.
- Consumers with compatible vehicles need to be encouraged (e.g. with financial incentivises) to buy B10 rather than B7.

8.2.5 Increase B30 or B100 market share for trucks in captive fleets
For Euro V trucks and buses, the availability of B30 and B100 vehicles is quite reasonable. For Euro VI it is more difficult to apply B30 or B100, because of the more advanced emission control systems and the more extensive requirements for legislation. A separate type approval with a possible dedicated control strategy for B30 or B100 may be necessary. This leads to uncertainties with respect to the future availability of trucks which are B30 or B100 compatible. The very limited response of truck OEMs to questionnaires indicated a preference for B30 over B100.

Customer acceptance of B30 or B100 is a main issue. The image of biodiesel has deteriorated because of environmental (ILUC) and social issues and to a lesser extent because of some technical issues with fuel quality and engine technology. If the image in not improved – i.e. by convincing fuel labelling and sustainability criteria - It will be hard to find customers willing to use these fuels. Also the fuel price on an energy basis should be equal or slightly lower than the regular blend.

Infrastructure and fuelling of trucks might not be a big issue, since many truck and bus fleets are depot fuelled (captive fleets). However, when the fleet owners also have vehicles which are not compatible (which may be quite often the case), this may become much more complex and costly.

In summary the following steps are necessary to successfully implement B30 or B100:
- Fleet owners need to be found who are interested to use these fuels. Careful marketing, fuel labelling and competitive or lower prices will probably be necessary to find sufficient fleet owners. Conditions are also that the fleet owner possesses B30 or B100 compatible vehicles and can arrange the fuelling of the vehicles.
- Truck OEMs need to be convinced to develop and make available B30 or B100 Euro VI trucks.
- B30 and B100 standardisations (CEN) need to be initiated.

8.2.6 Increase the ethanol blending limit from E10 to E20

Technically it is not very complex to make vehicles E20 compatible, since suitable materials and engine control technologies are generally available. It is important to start as soon as possible the fuel standardisation (CEN, pre-study has been done) and implement the E20 blend within the pollutant emissions legislation for cars. The date of entry into force of that legislation, is then also the start date for the phasing in of E20 fuel. The earliest possible date is 2017/2018. Earlier introduction is possible on a voluntary basis.

Together with the car and fuels industry it should be considered and studied to raise the minimum octane requirement of E20 compared to E10. In that case car OEMs can develop more efficient engine technology and customer acceptance will be easier.

In summary the following steps are necessary:
- Start fuel standardisation (CEN).
- Start implementation in pollutant emissions legislation.
- Adaptation existing engine and vehicle technology to (optimally) use E20 fuel (primarily adaptation of controls). Development new engine technology which fully uses characteristics of ethanol blend to improve engine efficiency such as more extensive engine downsizing.
- Initiate careful marketing strategy by all stakeholders such that car owners are willing to use the new fuel. This would need to include competitive pricing.
- Fuel companies and distributers need to make E20 and protection grade E10 (or E5) fuel available at the fuel stations.

8.2.7 Further develop and implement co-refining of plant oils

This option requires further R&D efforts by the oil refineries. In addition, the RED does not currently support this route, and neither do the FQD or national biofuels policies. Therefore, a methodology would need to be developed to allow the Member States and fuel suppliers to count the biomass fed into the refineries towards the target. The development of its market share then depends on the technological progress made and the cost of biofuels produced via this route, compared to the other biofuel options.

8.2.8 Increase the market share of E85 in captive fleets

E85 is well implemented in fuel standardisation and pollutant emission legislation and also the vehicle technology is well embedded within the key suppliers of fuel systems and within a number of car OEMs. So expansion of the number of available brands and models can rise if the demand of vehicles is there.
Convincing customers or fleet owners to purchase FFV vehicles and use E85 may be challenging. The price of E85 on an energy basis should be competitive with or lower than petrol. Sweden demonstrated that this is possible. Key thing is the focus on private owners with public fuel stations and/or on fleet owners with depot fuelled vehicles. In the latter case fuel pricing should be competitive with diesel or natural gas which is an even larger challenge.

8.2.9 Develop supply and demand of ED5 or ED10 in HDV

This is a challenging option with big hurdles to take in convincing vehicle manufacturers and oil companies. Some specialised fuel companies have done it on a small scale, but generally without the support of the truck OEM. It is recommended to only consider this option if other options fail.

The necessary steps include:

- convince vehicle and oil industry to pursue this route;
- start standardisation of the fuel (CEN). This would include significant R&D and also field testing;
- implement ED5 or ED10 within the pollutant emissions legislation.

8.2.10 Increase the use of Bio-CNG in busses and/or passenger cars

These options require a significant increase of the market share of gas-powered vehicles, as well significant investments in infrastructure for bio-CNG distribution. Bio-methane is normally distributed via the national gas grid, although dedicated bio-CNG filling points are also an option (see for example Sweden). The number of vehicles per fuels station varies strongly between close to 900 in Italy to less than 100 in a number of countries. For the latter group growth of the number of vehicles per fuel station is probably necessary to obtain economic distribution.

In addition, many Member States will need to increase biomethane production and supply to the transport sector. This may require adding more anaerobic digestion plants to increase overall production, and Member States may also choose to divert biomethane streams that are currently used for electricity and/or heat production towards the transport sector. The vehicle and fuel distribution technology is already available, and offered by various suppliers and OEMs. Bio-methane is well implemented within the pollutant emissions legislation and fuel standards.

8.3 Risks and uncertainties

As was discussed in the previous chapter, it is advisable to focus on a relatively limited number of options and aim to use their potential to the maximum that is practically feasible. The alternative, to implement a larger range of options than necessary, would result in higher cost and inefficiencies, and increase the risk that some of the necessary developments (e.g. technical R&D, development of new fuel and type approval standards, etc.) are not finalised in time to ensure large scale implementation of the routes before 2020.

The estimated potential of the options are considered to be feasible but often quite ambitious, and the successful development of the selected marketing options is crucial to meeting the 10% target in 2020. It is therefore useful to assess potential risks and uncertainties that may affect the successful outcome of the developments, as these also create the risks that the biofuels volumes needed to meet the 10% target of the RED can not be marketed in a cost efficient way. Monitoring of progress of the various actions and developments and extensive knowledge exchange with Member States is therefore advisable, for example in the form of regular meetings between Member State and EU representatives, as well as prompt action in case progress is less fast than anticipated.

A combination of raising the blending limits and using selected high blends or neat alternative bio-fuels is advised. Basically higher blending limits and fungible biofuels are the desired long-term strategy. High blends and neat alternative (bio) fuels are only desired to meet short-term objectives (2020 RED) or may offer other specific advantages such as lower (societal) costs, lower noise, lower pollutant emission. It should be noted that higher blending limits are implemented all across Europe (at least from the vehicle side), while Member States can chose between the different high blends or neat alternative fuels taking into account the specific national wishes and capabilities.

The following are likely to be the key risks and uncertainties that could reduce the actual contribution of the various marketing options. They are in no particular order, and some will be more relevant for specific options than others.

Cost and availability of the biofuels and high blend vehicles

- Biomass availability and conventional (FAME, ethanol) biofuel production capacity was not part of this study, but it can be a significant barrier to the realisation of the marketing options and scenarios. The NREAP scenarios can only be realised if sufficient sustainable feedstock is available (at reasonable cost), and if production capacity is increased further. The 50/50 scenario requires a very significant and rapid increase in ethanol production capacity (or global imports), as well as sufficient feedstock (again, at reasonable cost).
- Some of the options, for example the co-refining and ethanol-in-diesel (ED5 or ED10) option (for 50/50 scenario) require new technology to be developed further as well as new infrastructure. Their (future) cost and availability up to 2020 are therefore very uncertain.
- Availability of B30 and B100 trucks is currently quite reasonable. With Euro VI continued availability will be uncertain, because of much more stringent requirement with respect to (real-world) pollutant emissions.

Lack of consumer demand (for the high blend vehicles and fuels)

- As concluded earlier, the role of the consumer in biofuels marketing is currently very limited in most EU Member States, but will increase significant once the high blend options are being implemented at larger scale[38].
- Consumers will need to buy the higher blend fuels, despite the availability of the lower blend protection grades, and in some cases the options also require consumers to buy high blend vehicles where low blend vehicles are also available. The different rates of success of introduction of E10 in various Member States illustrate this: introduction in France did not cause significant problems whereas a large share of vehicle owners in Germany refused to buy the new fuel despite lower cost due to a tax incentive. Consumers reluctance can thus significantly slow down market uptake of the vehicles and fuels.

Delay in agreement and implementation of technical (fuel) standards

This is a key item for the most important measures. It is dependent on how much time and other effort the industry and other stakeholders are willing and able to invest. Some of the choices will probably require substantial development and testing. It will be a challenge to implement the raised blending limits for diesel and petrol by 2017/2018. If this is delayed by a few years no significant contribution to the RED target will be achieved.

Also the height of the blending limit plays a role in the possible introduction date. For example for the long-term strategy a B15 may have the preference over B10, but this may result in a later introduction data. A solution may be that OEMs offer such vehicles on a voluntary basis before the formal introduction date. A proper incentive program is probably then necessary to stimulate this.

Delay in implementation of the necessary policies

- As can be seen in the next chapter, quite a number of policies need to be implemented in the coming years to ensure timely market introduction of the various options. Stakeholders need to make significant investments in the appropriate technologies and production capacity, and need the proper boundary conditions before they can commit the resources. For example, in order to develop E20 or ED5 vehicles and bring them on the market, OEMs need to know the fuel specifications and potential implications on type approval. In order to invest in additional HVO or bioethanol production capacity, investors will need to have a positive outlook regarding the long-term demand of their products, as well as on the availability and cost of (sustainable) feedstock.
- Depending on the existing Member State policy framework and biofuels marketing strategy chose, it may be necessary to support the sales of higher blend vehicles and/or fuels with targeted policy measures.

[38] This holds for all marketing options, except of B7 in road transport and fungible fuels.

9 The way forward

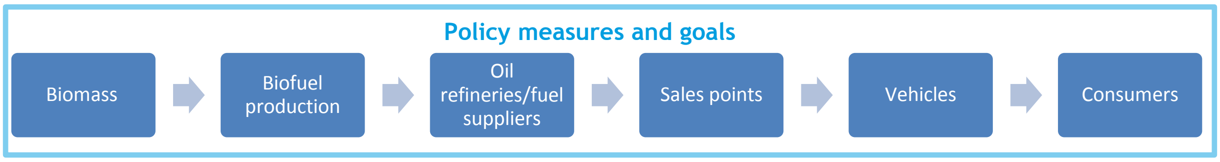
9.1 Introduction

There are two main themes that emerge from the previous chapter:
1. There is not yet a clear view on how the biofuels volumes needed to meet the 10% renewable energy target in 2020 will be marketed throughout the EU.
2. Marketing of the necessary volumes of biofuels requires coordinated, focussed and timely actions by a whole range of stakeholders.

Some of the necessary developments and actions are already emerging, such as marketing of B7 and E10 in various EU Member States, the implementation of biofuels blending obligations for fuel suppliers, etc. However, the assessment also shows that meeting the 10% renewable energy goal in all Member States in 2020 requires that
a These developments are accelerated. And
b Additional measures are implemented, for example, to significantly increase market shares of high blend vehicles and biofuels sales.

As discussed already in Chapter 2 and repeated here in Figure 22, the biofuels supply chain ranges from biomass production to the consumers. In each part of this chain, different actors and stakeholders are active, and a range of government policies and goals (both national and on EU-level) affect this chain and their actors. Some options only require action by a limited number of stakeholders (e.g. increasing the share of fungible fuels and co-refining do not require active consumer involvement). However, further developing the various biofuels marketing options typically implies that many, if not all of these steps in the chains are affected, and a large range of actors need to move towards the same direction. This call for a coordinated and integrated approach.

Figure 22 Schematic overview of the various steps and actors in the biofuels supply chain



In the following, the necessary actions are developed further. Starting point are the two blending scenarios developed in the previous chapter, where some actions will be relevant for both scenarios, and others will be specific to one of them. Where possible and relevant, the question “Who has to what and by when?” will be addressed explicitly. This will result in a step-by-step overview of the way forward in the field of biofuels marketing, with the aim to realise the 10% target in 2020.

9.2 Realising the scenarios: overview of necessary steps

Looking at the assessment and conclusions of the previous chapters, a high-level overview can be made of the key steps that need to be taken to realise the 10% target via either one of the biofuels marketing scenarios:
1. Design a robust biofuels marketing strategy for the next 10-20 years.
2. Ensure timely implementation of key policies.
3. Define vehicle and fuel standards for higher blends.
4. Encourage consumers to buy these vehicles.
5. Encourage consumers to buy the fuels.
6. Increase biofuels R&D and production of sustainable biofuels.
7. Increase biofuels use in non-road modes.

Note that this list does not imply that these steps need to be taken consecutively, many can and should be approached at the same time.

Each of these key actions and aims are elaborated and developed in more detail in the following.

9.3 Step 1: Design a robust biofuels marketing strategy

Many of the concrete implementation options that were developed for the two scenarios in the previous chapter require significant efforts and investments by a range of parties and companies. These will only be realised if both the stakeholders and governments have a clear view of the way forward, and have confidence that these investments of time and resources will indeed be useful and profitable in the longer term.

The previous chapters illustrate that first of all, the blending potential of B7 and E10 should be utilised throughout the EU. However, beyond that, there is a whole range of marketing options that could be developed, where each of these require specific actions and investments by a range of parties.

For a number of reasons, it is preferred to develop a limited number of marketing options: focussing efforts will greatly reduce cost to the vehicle and fuel industry, increase the chance of timely implementation of the necessary policy instruments and enable timely investments in the necessary R&D. However, as long as the choice of marketing options is not yet made, both stakeholders and governments are likely to be hesitant, as this increases the risk that the investments and choices made might not be right for the longer term. In this situation, there is also a risk of creating lock-in effects, in case fuels or technologies are supported that may not be desired long-term solutions after all.

It is thus concluded that speeding up developments in this field requires the development of a robust biofuels marketing strategy for the coming decade. This strategy should have broad support by the stakeholders and should be robust and flexible enough to withstand potential future developments in the transport and biofuel sector.

As the Member States have the obligation to meet the RED targets, developing this strategy would also be their responsibility. They can optimise their strategy to take national and local circumstances into account, such as specific biomass availability, biofuel production capacities, etc. It seems advisable for Member States to further develop this strategy together with stakeholders, as they have the relevant detailed technical and economic knowledge, and need to play significant role in the roll-out of the various biofuels and vehicle technologies, marketing and communication with consumers.

In addition, in view of the necessity to focus the necessary actions and investments, in R&D, actual marketing options to be implemented, etc., EU-level coordination of these efforts and therefore of the biofuels marketing strategies seems indispensable. This will reduce cost and time needed to develop the various marketing options: as it was argued before, it will be less costly and take less time for industry to develop and implement one or two marketing options rather than three or four.

These considerations lead to the following list of high-level actions that need to be taken by the various parties involved:
- **Member States**: further develop the strategy and action plans for meeting the 10% target in 2020.
- **Member States**: Ensure full implementation of RED.
- **Fuel and vehicle industry**: cooperate with EU and MSs strategy development to ensure technical feasibility and cost-effectiveness.
- **EU**: facilitate MS and industry discussions, provide guidelines to Member States.
- **EU**: enhance sustainability criteria (ILUC, possibly additional criteria on other aspects).
- **EU**: provide outlook of biofuels policy development after 2020.

The role of Member States in biofuels marketing

As Member States are responsible to meet the 10% target of the RED in 2020, they were also asked to outline their policy plans and intentions in the NREAPs. However, as was shown in Section 3.3 of this report, only a number of Member States have addressed the issue of biofuels marketing explicitly in their national action plans or progress reports. Many of these plans were not yet very specific and concrete policy measures to market FAME and bioethanol beyond the B7 and E5 levels are still lacking in most countries.

As most Member States now use biofuels mandates as the main policy measure to increase biofuels use, it might be argued that the issue of how the biofuels can be brought on the market is now the responsibility of the fuel suppliers. However, as was shown earlier, most of these marketing options are quite complex to implement, as they require actions by various stakeholders that fuel suppliers can not control: in order to reach a certain market share of any of the higher FAME, ethanol or biomethane blends, the vehicle industry needs to invest in R&D, the EU needs to define fuel and vehicle standards, and additional Member States support may be necessary (with incentives or other measures). In addition, a stable market outlook (to be provided by Member State and EU policies) is necessary to ensure that industry investments can be profitable.

This leads to the conclusion that even though stakeholders have a very important role to play in this development, the Member States still need to be aware that their support is an important prerequisite to ensure meeting the target in 2020.

9.4 Step 2: Ensure timely implementation of key policies

A number of key, high-level policies can be identified that are not yet in place but are key in the further development of the biofuels marketing options in time to meet the 2020 target.

On the EU-level, a decision on how the indirect land use change emissions are included in the RED sustainability scheme (and also in the FQD methodology) is needed to provide clarity on the future commercial attractiveness and availability of the various biofuels. From the research done so far on ILUC effect (e.g. by IFPRI, 2011), it is to be expected that implementation of the ILUC effects will cause a shift in biofuels demand and supply throughout the EU, as some feedstock-biofuels combinations will become excluded or at least less attractive. The extent of this effect, and the timing of the ILUC policy coming into force is not yet clear, which currently leaves both the Member States and the market in uncertainty.

In addition, a review of certain elements of the RED policy is due in 2014. This causes additional uncertainty in the market, as it may lead to more changes in the regulation, and therefore in the future development of biofuels policies and demand. A timely execution of the review is thus recommended.

In response to the RED, most Member States have put biofuels (or, more in general, renewable transport energy) policies in place, as was discussed in Section 3.3. However, many of these policies do not yet extent to 2020, but rather cover the period until 2014 or 2016. E10 has so far only been introduced in three EU Member States, and it is not yet clear when EU-wide rollout is to be expected. Defining the longer term policies is, however, likely to be a prerequisite for the timely development of many of the biofuels marketing options identified: as explained before, industry needs to have a positive outlook on the future market (of at least 10 to 15 years) for a technology or product before they put effort and resources into their further development. This somewhat hesitant approach towards the longer term biofuels policies seems to be partly due to the uncertainties regarding the EU policy decisions described above, as Member States await the outcome of the ILUC debate and perhaps even the RED review. However, also other parts of the RED are not yet fully transposed into national legislation, as many Member States are lagging behind the transposition schedule given in the RED. For example, some countries treat some types of biofuels more favourably than others (e.g. provide incentives for FAME and ethanol, but not for HVO or bio-CNG), and some have not yet included biofuels use in non-road modes in their policies.

The following key short-term policy actions can therefore be identified:

- **Member States:**
  - Implement key biofuels policies until 2020: decide on developments of mandate and incentives, implement incentives for higher blends and biofuels from waste, etc.
  - Ensure full implementation of the RED.
- **EU:**
  - Provide clarity regarding future development of sustainability criteria (ILUC).
  - Initiate and accelerate implementation of fuel standards with higher blending limits and pollutant emissions legislation based on these higher blending limits. Refer to 9.5.
  - Ensure timely execution of the 2014 review of the RED.

- Include a methodology to count co-refining of biomass towards the RED transport target.

9.5 Step 3: Define vehicle and fuel standards for higher blends

Continue and finalize current initiatives to raise the blending limits of petrol and diesel fuels. Refer also to Section 1.3.

This is a key item for the most important measure, namely raising of the blending limits. It is dependent on how much time and effort the industry and other stakeholders are willing and able to invest given the uncertainty in ILUC and future biofuel quantities. Some of the choices will probably require substantial development and testing. It will be a challenge to implement the raised blending limits for diesel and petrol such that they can enter into force by 2017/2018. If this is delayed by a few years no significant contribution to the 2020 RED target will be achieved.

9.5.1 Standards for petrol E20 or E30

The following steps are necessary:

– Decide on blending limit of E20 or E30 based on first (feasibility) CEN study due in September 2012.
– Start CEN working group for the development of the chosen blend.
– Start MVEG working group to work out recommendation on adaptation of certification test procedure (type approval regulations 70/220/EC). This may include formal testing on two fuel blends, for example E10 and E20. This is also done with other fuels where quality can vary significantly such as natural gas and E85 flexible fuel vehicles.
– European Commission to send proposal for regulation to European Parliament.

The proposed timeline is presented in Table 51.

Table 51 Proposed timeline for implementation of new fuel and vehicle standards for E20 or E30

Year	Action	Key stakeholders
Early 2013	Decision on blending limit E20 or E30	EC & industry
2013-2015	Development of E20 or E30 fuel standard	EC & industry (CEN)
2013-2015	Adaptation vehicle certification to include E20 or E30	EC & car industry
2015-2018	Adaptation of vehicle technology (across all models)	Car industry
2018/2019	Entry into force of new certification test procedure. Start production of vehicles.	Car industry

In the joint JRC, COCAWE, Eucar biofuels programme, most of the scenario's included the start of E20 vehicle sales in 2017 (JRC/JEC 2012)

The new certification procedure for cars could for example include the testing of two fuel specification, such is also done with natural gas vehicles and with E85 vehicles. The vehicle technology for E20 or E30 vehicles can be derived from vehicles on the market in Brazil and from current E85 vehicles.

For E20 (or higher), it must be decided whether the minimum octane requirement is raised compared to E10. This would enable a higher efficiency of the engines, although energy consumption at the refinery may increase a bit. A joined industry program to evaluate this should be considered. A higher minimum octane requirement would greatly stimulate consumers to use E20, because of likely advantages in power output and efficiency.

For flexible fuel vehicles it will be difficult to use the full potential of the ethanol blend, since it is uncertain which ethanol-blend will be predominantly used during the life time of the vehicle. Technologies such as advanced engine control and variable valve actuation may be able to capture a substantial part of this potential.

9.5.2 Standards for diesel B10 or B15

The following steps are necessary:
- Decide on desired blending limit for diesel cars and trucks: B10 or B15. Also decide on when CEN fuel specification can be ready (if B10 this is 2013, since this work is already on-going).
- Continue CEN working group to define B10 or alternatively B15.
- MVEG working group to work out recommendation on adaptation of certification test procedure (type approval regulations 70/220/EC for cars and 88/77/EC for trucks). Probably this will just be the adaptation of the test fuel specification (single blend)

The proposed timeline is presented in Table 52.

Table 52 Proposed timeline for implementation of new fuel and vehicle standards for B10 or B15

Year	Action	Key stakeholders
Early 2013	Decision on blending limit	EC & industry
2013-2015	Development of B10 or B15 fuel standard	EC & industry (CEN)
2013-2015	Adaptation vehicle certification to include B10 or B15	EC & car industry
2015-2018	Adaptation of vehicle technology (across all models)	Car industry
2018/2019	Entry into force of new certification test procedure. Start production of vehicles.	Car industry

The height of the blending limit plays a role in the possible introduction date. The B10 specification is already planned to be finalised in 2013. For the long-term strategy a B15 may have the preference over B10, but this may result in a later introduction data.
A solution might be that OEMs offer such vehicles on a voluntary basis before the formal introduction date. A proper incentive program such as attractive fuel prices is probably necessary to stimulate this.

9.6 Step 4: Encourage consumers to buy these vehicles

Some of the marketing options require the increased uptake of vehicles capable to run on high biofuel blends, either in captive fleets or in the general fleet. In case E20 or B10 are introduced, it is suggested to ensure that all new petrol and diesel vehicles become compatible in the future, which requires the EU to define fuel standards and type approval procedures for these blends. Consumers do not have to be actively chose a E20- or B10-compatible vehicle in that case.

In case of B30/B100, E85 and bio-CNG, however, the high blend vehicles are likely to become available parallel next to the lower blend vehicles. Consumers then need to actively be persuaded to buy the high blend vehicles. If consumers have a positive attitude towards the technology and fuels and costs are comparable (vehicle cost but also total cost of ownership), the market shares may increase without further action by governments or stakeholders. However, experience in the past has shown that without incentives, the share of consumers that actively chooses high blend vehicles remains negligible. if this is not the case, various national or local policy measures can be implemented to increase their attractiveness, such as:

- financial incentives such as differentiated vehicle purchase or registration taxes, lower taxes on high blend fuels and/or lower road charges for these vehicles;
- government procurement can be aimed at increasing the use of these vehicles, e.g. by requiring bus companies to use gas-powered busses in urban environments, by gradually increasing the share of E85 or CNG passenger cars in government car fleets, etc.;
- local policies such as environmental zoning in urban areas can also be used to encourage consumers to buy these vehicles.

Vehicle manufacturers and dealers can play an active role in selling these high blend vehicles, by marketing campaigns, pricing of the vehicles and actively providing information to potential buyers.

In addition, sufficient availability of high blend filling stations will be a prerequisite for the general public to consider buying high blend vehicles, especially in the case of bio-CNG where the vehicles can not use the conventional petrol or diesel.

And finally, the potential vehicle buyers (consumers and fleet owners) will need to trust the high blend technology and fuel, and, preferably, have a positive attitude towards them. It is therefore important to explain the reasons for the switch to high blend vehicles, and ensure that both the vehicle technology and the sustainability are guaranteed to avoid negative media reports.

Note that this issue is not relevant for the option to increase the share of fungible fuels and to introduce co-refining: the resulting fuels are compatible with the existing fleet.

Summarizing, the following key actions need to be taken in this respect:

- **EU**:
  - ensure technical compatibility and emission regulation via timely definition of fuel standards and type approval regulations;
  - ensure fuel sustainability to ensure consumer support to biofuels developments.
- **Vehicle industry**: develop marketing strategy low and high blend vehicles
  - vehicle pricing, communication, …;
  - emphasise advantages of higher blends such for fuel consumption, power output and durability;
  - target specific groups, if possible.
- **Member States**: support high blend vehicle sales:
  - via incentives, public procurement and communication;
  - if necessary, support fuel availability (see next paragraph.
- **All stakeholders**: communication to build consumer confidence in technical compatibility.

9.7 Step 5: Encourage consumers to buy the fuels

Many of the marketing options that go beyond B7 and E10 will result in various biofuels grades being offered by fuel suppliers, with the fungible fuels and co-refining as the only exceptions. Vehicle owners may thus have chosen to buy a high blend vehicle (Step 4), they then need to be persuaded to fill these vehicles with the higher blends. Most high blend vehicles will also be technically compatible with the lower blend fuels, since this is or will be secured within the pollutant emissions legislation. In certain cases, for example B100 or B30, this may not be possible and it may have a negative effect on air quality emissions (depending on the type approval regulations that will be adopted)[39]. With vehicles that can run on bio-methane, users might prefer to use (fossil) natural gas.

- **Fuel suppliers**: develop and implement marketing strategy:
  - pricing, sales point adaptions, protection grade availability, …;
  - develop communication strategy (together with vehicle suppliers and other stakeholders such as consumer and branch organisations);
  - ensure proper fuel labelling, general and specific (at sales points);
  - Communicate advantages of higher blends such for fuel consumption, power output and durability.
- **Member States**: support fuel suppliers with incentives and/or mandates and communication:
  - e.g. fuel tax differentiation, subsidies for sale point adaptations, etc.;
  - ensure effective communication to consumers.
- **EU:** ensure fuel sustainability to ensure consumer support to biofuels developments.

9.8 Step 6: Increase biofuels R&D and production of sustainable biofuels

This step is mainly concerned with further development of the technology needed to increase biofuels sales beyond current blending limits. Some of the marketing options that were identified in this report, especially the options needed for the 50/50 scenario, are still in the R&D phase, where for example the vehicle technology is only offered by one or two vehicle manufacturers and pilots projects are being performed. Moving from this status to large scale, commercial application within a limited number of years requires significant efforts.

Another issue to include here is the further development of biofuels that meet the sustainability criteria, also in case these are tightened further in the coming years. Especially new biofuels production processes that can convert waste and residues are likely candidates to further increase future biofuels supply (based on their typically high GHG savings and low risk of ILUC), examples are the so-called 2nd generation bioethanol and BTL processes. In addition, as was mentioned earlier, R&D efforts to further develop aviation biofuels could be very important for the longer term.

These considerations lead to the following list of actions.

- **Vehicle industry and fuel suppliers**: speed up the development of biofuels marketing options that are needed for 2020 and beyond (e.g. ED5 and/or ED10, Euro IV B100 trucks, biofuels for aviation).

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39 A manual software change may solve this a make the vehicle compatible with the low blend.

- **Refineries**: further develop and implement co-refining of biomass technology.
- **Biofuels industry**: continue R&D into new sustainable biofuels production technologies.
- **Member States**: provide incentives for further R&D and sales of sustainable biofuels from waste and residues.
- To increase investments in R&D and production capacity.
- EU: support R&D of new technology.

9.9 Step 7: Increase biofuels use in non-road modes

When aiming to increase the use of biofuels in non-road transport, it is advisable to distinguish between the different sectors: inland shipping, maritime shipping, railway transport and aviation. Especially shipping and aviation have relatively few (renewable) alternatives to the current fossil fuels, the development of biofuels use in these sectors - both the technology and the policy - is thus an important route also from the perspective of long-term climate policy goals.

For the non-road sectors inland shipping, rail-road and mobile machinery, it is advised to use the same fuel specification as on-road. These sectors are already using EN590 diesel and B5/B7 is accepted without significant problems in most cases. A significant part of the inland shipping sector made the shift from high sulphur fuel to EN590 low sulphur fuel, but is still supplied with B0. The next step to B5/B7 can probably be taken without significant problems, provided that the fuel additive package is optimised for this sector. Small modifications to the fuel storage tanks may be necessary to accommodate the low blends.

It is also advised to use the same strategy for a protection grades as for on-road. So if the blending limit for biodiesel is raised to B10 or B15, then B7 should remain available as protection grade for a number of years.

Even though the RED specifies that Member States should count biofuels used in non-road modes towards the 2020 target, most of the current biofuels policies of the Member States are still limited to biofuels use in road transport. It is advisable to modify the existing policies to also provide an incentive for sustainable biofuel use in the non-road sectors. This is relatively straightforward in case the national biofuels policy is an obligation to fuel suppliers – it is then sufficient to modify the legislation to allow fuel suppliers to count the sustainable biofuels used in non-road modes towards the target. This will provide fuel suppliers the opportunity to use the biofuel blending potential in these sectors. In case biofuels are supported through fuel tax reductions, however, different policy measures might have to be developed, as there are no taxes on shipping or aviation fuels.

Biofuels use in aviation is already supported by the EU ETS. They are counted as climate-neutral (in line with biomass use for power production, for example) and do not require any CO_2 emission allowances[40]. However, biofuels costs are much higher than the current price of the emission allowances, even with the zero-counting, so that the ETS is not likely to provide an effective incentive for sustainable biofuels use in the coming years. Because of this, it is

[40] Note that the ETS regulation does not require that sustainability criteria are met.

recommended to also mandate the use of (sustainable) biofuels. It is advised to start with a low percentage (e.g. 1% in 2020), because of the required high quality (synthetic) biocomponents.

In summary, the recommendations are:
– **EC or Member States** to mandate use of biofuel (blend) for non-road modes: inland shipping, rail and mobile machinery same as on-road, aviation: mandate lower percentage.
– **Engine suppliers**: develop and market engines for higher (low) blends (following on-road) for simplicity of fuel distribution.
– **Member States**: implement policies that promote these applications, e.g.:
  - allow counting biofuels use in non-road towards the target; or
  - provide financial incentives;
  - focus on aviation and shipping.
– **Aviation (fuel) industry**: continue development of biofuels for aviation.

9.10 Timeline

When looking at the various actions that need to be taken to ensure that the expected biofuels volumes can be indeed be marketed in 2020, some will need to be taken earlier than others. The more general policies and strategies need to be put in place by Member States and the EU as soon as possible, to guide industry efforts and justify investments. Once that has been decided on, a range of actions need to be set in motion in the short-term to ensure that sufficient high blend compatible vehicles will have been bought by 2020 to reach the potential of that marketing option. This should be taken into account when drafting a biofuels marketing strategy for the coming years.

The timeline for the implementation of higher blending limits for petrol and diesel are presented in Figure 23 and Figure 24. The figures are split up in ‘required actions by EC and industry’ and the actual fuel delivery.
The background of these timelines is elaborated in Section 9.5.

Figure 23 Timeline for implementation of E20 or E30 for petrol

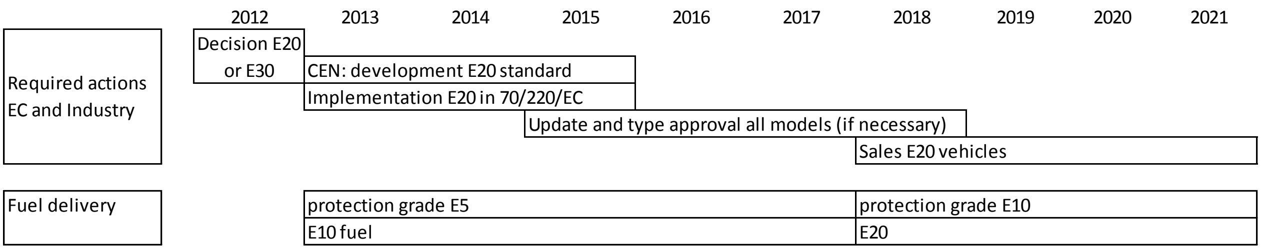
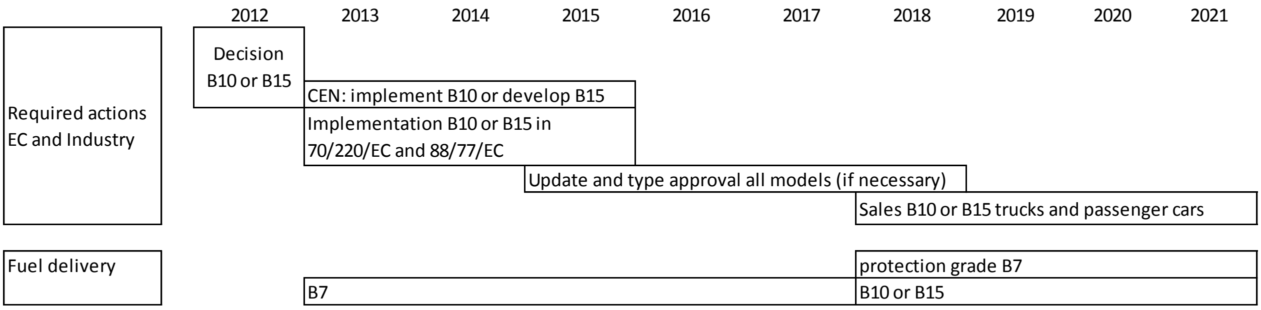


Figure 24 Timeline for implementation of B10 or B15 for diesel



10 Conclusions and recommendations

10.1 Main conclusions

Member States plan to meet the 10% renewable target in transport by a mix of renewable energy carriers in which biodiesel and bioethanol have by far the largest share: they are expected to represent 6.6 and 2.2% of the transport fuel energy, respectively. Most of this biodiesel and ethanol can be sold via the low blending levels that are allowed in standard diesel and petrol (B7 and E10) and fungible biofuels such as HVO. However, these options are insufficient to bring the required biofuels volumes onto the EU market, and other biofuels marketing options need to be deployed. So far, however, only few Member States are actively pursuing the development of higher biofuels blends, and market developments do not yet suggest that they will develop by itself under current market and policy conditions. Only few Member States have addressed this issue of biofuels marketing in their national action plans that were submitted to the EU.

This study explores the issue of biofuels marketing until 2020 in detail. Various promising biofuels marketing options are identified and assessed, and the potential way forward – in terms of both technology and policy – is explored. This leads to the conclusion that a number of biofuels marketing options still need to be developed and implemented in the coming years, most of which require multi-stakeholder agreement and coordination, as well as a clear and broadly supported strategy regarding the biofuels marketing options that should be developed. The latter is necessary to focus the Member States policies and stakeholder actions, and to ensure that the necessary investments will be made in time. The scenario calculations illustrate that the development of the necessary biofuels marketing routes needs to start soon, in order to ensure sufficient biofuels marketing potential in 2020.

It is furthermore concluded that the role of consumers will become much more important in the coming years, as high blend biofuels options are further developed. Consumers – ranging from individual car owners to professional hauliers and fleet owners - will need to be persuaded to buy high blend vehicles and fuels in a market where they can also choose the low blends. Critical issues will be cost, technical compatibility (actual and perceived) and trust in the environmental benefits.

Based on this assessment, the main steps to further develop biofuels marketing and thus meet the 10% target of the RED could be identified:
1. Design a robust biofuels marketing strategy for the next 10-20 years.
2. Ensure timely implementation of key policies.
3. Define vehicle and fuel standards for higher blends.
4. Encourage consumers to buy these vehicles.
5. Encourage consumers to buy the fuels.
6. Increase biofuels R&D and production of sustainable biofuels.
7. Increase biofuels use in non-road modes.

Even though meeting the RED target is the responsibility of Member States, we find a number of issues that would clearly benefit from EU guidance or harmonisation. These are outlined in Section 10.3.

10.2 Biofuels marketing in the coming years

In line with the current situation, the first step in increasing the biofuels volume onto the market is further increasing the share of FAME and HVO in the standard diesel, and of bioethanol in standard petrol, in order to use the existing fuel standards and vehicle compatibility to the maximum.

Conventional diesel can contain up to 7 vol% FAME (B7), and up to 30 vol% HVO. The current blending potential of FAME is mainly limited by fuel standards, and all diesel vehicles in the EU can use B7. The HVO blending potential is limited by the production capacity of the biofuel, which is currently much lower than that of FAME. Petrol vehicles can all run on E5 (5 vol% ethanol), and most can use E10. Increasing ethanol sales beyond E5 thus requires fuel suppliers to supply two types of ethanol blends: E10 and E5, the protection grade. B7 is currently on the market in many Member States, but E10 is currently only offered in three (status September 2012).

Note that these biofuels can not only be used in road transport, but also in non-road modes such as railways, inland shipping and mobile machinery. Using B7 in these modes can also contribute to meeting the target, although the contribution is relatively small on average (about 1 Mtoe, versus 21 Mtoe in road transport in the EU). The potential impact of these routes depends on the share of non-road diesel use in total transport energy use, and thus differs between the various Member States. If desired, fungible biofuels such as HVO and BTL can also be used in non-road modes.

Once the B7 and E10 blending options are fully exploited, higher blend options need to be deployed to bring the remaining biofuels volumes on the market. A range of feasible options are identified and assessed, and the most promising mix of higher blend marketing options is identified, for two different scenarios.

The NREAP scenario: In case the expected biofuels demand in 2020 develops in line with the Member States’ expectations in the national action plans, the optimal mix of marketing options for 2020 is the following:

1. Use the current blending limits of B7 and E10 to the maximum.
2. Use the available production capacity of fungible fuels (HVO and BTL), aim to increase production if economically justified.
3. Develop a significant market for either B30 or B100 in trucks, focussing on using this fuel in captive fleets (i.e. vehicle fleets with a filling station at their depot).
4. Increase the blending limit from B7 to B10 (or B15), where B7 needs to remain available as a protection grade diesel.
5. Introduce co-refining, where biomass (e.g. pure plant oil) is used as a feedstock for diesel production in oil refineries.
6. Develop a market for additional ethanol blending, where the most favourable option is to increase the blending limit of ethanol in petrol from E10 to E20 (whilst maintaining E10 as protection grade). An alterative would be to develop a market for E85 in captive fleets.

The 50/50 scenario: in case biodiesel and bioethanol have about equal shares in 2020, a different mix of marketing options is needed, with less focus on increasing the sales of FAME and HVO, but much more efforts on the development of ethanol and biomethane marketing options. The following mix of options is suggested:

1. Use the current blending limits of B7 and E10 to the maximum.
2. Increase the blending limit from E10 to E20, where E10 has to remain on the market for quite some time as protection grade.
3. Strongly increase the market share of E85, probably focussing on use in captive fleets.
4. Increase the use of bio-CNG in busses and passenger cars.
5. Develop vehicles to enable heavy-duty vehicles to run on low ethanol blends in diesel (ED5 or ED10), and gradually increase the market share of these vehicles and fuels.

Especially the latter option is currently still in its infancy, and only few vehicle manufacturers consider this to be viable and feasible for 2020. However, the technologically more mature options 1 to 4 can not be developed and increased fast enough to allow marketing of the bioethanol/bio-CNG volumes needed for this scenario. Possible alternative means to meet this scenario could be an increase of the share of double-counting bioethanol (expected to be 9% in these calculations), or a strong increase of the share of petrol cars. This would increase the share of petrol and thus the ethanol volume that could be brought on the market via E10, E20 and possibly E85.

Details on the required market shares of the various biofuel blends in the two scenarios can be found in Chapter 7.

Realisation of the high blend and bio-CNG options requires quite a number of decisions and actions by both governments and stakeholders: fuel standards and vehicles need to be developed, investments in biofuel production capacity and, in some cases, filling stations and fuel distribution need to be made and communication strategies and policies need to be put in place to ensure consumers will buy the higher blend vehicles and fuels.

Implementing these options is typically much more complex than the current route via B7 and E10 with a limited share of fungible fuels added. When assessing the timelines of the various procedures and development processes, it becomes clear that a number of the necessary actions need to be taken quite urgently. If these developments are not successfully finalised in the coming years, there is a significant risk that in 2020, Member States and fuel suppliers have insufficient opportunity to bring the necessary biofuels volumes on the market which is likely to result in not meeting the 10% target set in the RED.

10.3 Recommendations

The main recommendations are the following:

1. Stimulate to fully utilise B7 and E10 throughout Europe.
2. Ensure implementation of effective sustainability criteria.
3. Implement higher blending limits as a long-term no regret measure: E20 or E30 for petrol engines and B10 or B15 for diesel engines.
4. Implement the same blending limits for non-road: inland shipping, rail and mobile machinery.
5. Implement more effective measures for aviation. Consider mandate with low biofuel blend.

6. Member States: Develop a fuel taxation and/or mandate strategy such that the desired biofuel options are stimulated – including the various high blend options needed to meet the target.
7. Develop an effective and broad communication strategy to ensure consumers are aware of the changes in fuels and of potential compatibility issues.
8. Support marketing initiatives such as fuel labelling to convince vehicle owners to buy the optimal biofuel blend.
9. Consider policies to create a fuel mix shift from diesel to petrol vehicles (as a long-term no regret measure).
10. Vehicle and fuels industry: Support the implementation of higher blending limits for ethanol in petrol and FAME in diesel in fuel specifications (CEN) and pollutant emissions legislation.
11. Fuel industry: Support the marketing of biofuel blends and the realisation of a strategy around protection grades.

Some of the recommended actions depend on the biofuels mix that the Member States intend to achieve in 2020, and, to a somewhat lesser extent, on the petrol/diesel ratio in the Member State. For practical reasons, it is advisable to limit the number of fuel options per transport category to a maximum of two, plus a protection grade fuel if needed. For example, focus on bio CNG/LNG only for city-buses, delivery trucks and inland ships (if biomethane is sufficiently available) and B30 for heavy trucks only.

It is recommended that the **EU** plays an important role in these developments:
1. Ensure that the biofuels on the market are sustainable and have broad public support.
2. Ensure that Member States have implemented the RED in national legislation, and actively monitor progress towards the target.
3. Facilitate and accelerate the development of the necessary fuel and type approval standards.
4. Support both Member States and industry with the definition of effective biofuels marketing strategies.
5. Monitor progress of the various actions and developments and organise knowledge exchange with Member States, for example in the form of regular meetings between Member States.
6. Ensure adequate communication to consumers, incl. harmonised fuel labelling throughout the EU.

In addition, the EU could consider mandatory use of biofuels in non-road modes. For example, inland shipping, rail and mobile machinery could be brought in line with road transport, for aviation a lower percentage mandate could be an option.

The key role of **Member States** in these developments is defined in the RED as they have the obligation to meet the 10% renewable energy target in 2020. Specifically, the following actions are recommended:
1. Further develop the strategy and action plans for meeting the 10% target from a biofuels marketing perspective.
2. Ensure full implementation of the RED.
3. Coordinate these efforts with other EU Member States and the various stakeholders (incl. fuel, biofuel and vehicle industry) to ensure that the number of marketing options in the EU is limited (see above).
4. Implement key biofuels policies until 2020, decide on developments of mandates and incentives.
5. Support high blend vehicle sales in line with the Member State's marketing strategy, via incentives, public procurement and communication.

6. Ensure adequate and effective communication to consumers regarding the new fuels (incl. technical compatibility).
7. Support fuel suppliers with incentives and/or mandates, e.g. via fuel tax differentiation, subsidies for sale point adaptations, etc.
8. Consider policy incentives for biofuels use in non-road modes.

Various **stakeholders,** including OEMs, fuel suppliers, biofuel producers and consumer organisations, will need to play an active and preferably proactive role in the development of the necessary biofuels marketing options.

1. All stakeholders: Cooperate with EU and Member States with their strategy development, to ensure technical feasibility and cost-effectiveness.
2. Support the implementation of higher blending limits for ethanol in petrol and biodiesel (FAME) in diesel in fuel specifications (CEN) and pollutant emissions legislation.
3. Stimulate developments of technologies that are compatible with fuel with higher blending limits. Use premium properties of ethanol blend (E20, E85) to increase engine efficiency.
4. Engine suppliers: develop and market engines for higher blends.
5. Support the marketing of biofuel blends (both high blends and protection grades):
   a Vehicle industry: develop a marketing strategy for high blend vehicles, for example through vehicle pricing, communication, by targeting specific fleets, etc.;
   b Fuel suppliers: develop and implement a marketing strategy for sales of high blend fuel, for example through pricing, sales point adaptions, protection grade availability, etc.
6. Set up communication to build consumer confidence in technical compatibility, together with consumer organisations.
7. Support the development of adequate, EU harmonised fuel labelling.
8. Refineries: further develop and implement co-refining of biomass technology.
9. Aviation (fuel) industry: continue development of biofuels for aviation.

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Annex A Stakeholder consultations

The following stakeholders were consulted during the course of the project.

Automotive industry	Oil industry
ACEA	Abengoa bioenergy
Bosch	AGRANA
Citroen	AGRICOLIA UG
DAF	Alco Bio Fuel
Delphi	BIOPETROL INDUSTRIES AG
Ford	BP
Honda	CleanerG
Iveco	EBB
MAN	Ensus Limited
Nissan	Enviral
Renault	Epure
Scania	Ethanol union
Toyota	Exxon-Mobile
Volvo	Hveiti A/S
VW	Inbicon
	INEOS
	Lallemand Ethanol Technology
	Lantmannen
	Lyondell Chemie Nederland B.V.
	MERCURIA ENERGY GROUP LTD
	Neste
	Novozymes
	Port of Rotterdam
	Q8
	Shell
	Sunoil Biodiesel
	Svebio
	Total
	Vereniging Nederlandse Biodiesel Industrie
	Vesta Biofuels Amsterdam BV
	Vesta Terminal Flushing B.V.,
	Vivergofuels
	VOGELBUSCH Biocommodities GmbH
	VOPAK

Annex B EU Member State overview of biofuels policies

B.1 Biofuels policies and strategies in the Member States

The Member States were asked to elaborate in the National Renewable Action Plans (NREAPs) how they plan to meet the RED transport target in 2020, including describing the policies they plan to implement to realise the target. An overview and assessment of these policies is provided in Section 3.3, more detailed information per Member State is given in this annex.

In the following, an overview is provided of the relevant information the Member States have published in their NREAP, distinguishing between plans regarding

- biofuels mandates;
- tax exemptions and reductions;
- subsidies;
- dedicated marketing strategies of higher blends.

This overview is mainly based on the NREAPs that Member States have submitted (incl. updates), complemented by information from other sources as indicated in the text.

B.2 Mandates

<table>
<tr><th>Member State</th><th>Statement in relation to marketing strategy of biofuels as stated in the NREAPs</th></tr>
<tr><td>Austria</td><td>The Biofuels Directive has been implemented into national law within the scope of the Fuel Order Amendment (BGBl. II No 417/2004). It specifies that from 1 October 2005 a 2.5% share of biofuels or other renewable fuels (as measured by total energy content of the binding mineral oil tax introduced in federal territory on petrol and diesel fuels in the transport sector per year) must be introduced under the substitution obligation. This target value rose in October 2007 to 4.3% and in October 2008 to 5.75%. To meet the overall target, depending on the energy content, at least a 3.4% share of biofuels or other renewable fuel, measured by the total fossil petrol or diesel introduced or used in the federal territory per year, must be introduced or used under the substitution obligation. In addition, a 6.3% share of biofuel or other renewable fuel, measured by the total fossil diesel introduced or used in the federal territory per year, must be introduced or used under the substitution obligation. The substitution quota for biofuels will rise to 6.25% in October 2012, from October 2017, the target is 8.45%.</td></tr>
<tr><td>Belgium</td><td>The legal basis is the Act on the mandatory blending of biofuels in fossil fuels for consumption. This act was published on 22 July 2009 and complemented by a Royal Decree published on 10 August 2009 and a Ministerial Decree published on 30 November 2009.

Article 4, § 1 of the Act states that any registered oil company offering petrol and/or diesel products for consumption must also - in the same calendar year - offer a quantity of 4% v/v of sustainable biofuels for consumption; FAME (fatty acid methyl ester) at a rate of at least 4% v/v of the quantity of diesel products offered for consumption, and bioethanol, pure or in the form of bio-ETBE, at a rate of at least 4% v/v of the quantity of petrol products offered for consumption.

The act entered into force on 1 July 2009 and will cease to be in force on 30 June 2011 until 30 June 2013. It can be extended and modified by Royal Decree deliberated in the Council of Ministers.</td></tr>
<tr><td>Bulgaria</td><td>The National Long-term Programme for the Promotion of the Use of Biofuels in Transport 2008-2020 sets the following national indicative targets for the consumption of biofuels in the transport sector: 2008 – 2%, 2009 – 3.50%, 2010 – 5.75%, 2015 – 8.00% and 2020 –10.00%.
Pursuant to the ZVAEIB, suppliers selling liquid fossil fuels to the transport sector are under
an obligation to sell the following biofuel blends as of 01 March 2011:
– diesel fuel with a minimum 4 per cent biofuel content by volume;
– diesel fuel with a minimum 2 per cent biofuel content by volume.
Obligatory biofuel blends for transport under the draft ZEVI, %:
– for diesel from 1 March 2011: 5% of volume;
– for petrol from 1 March 2014: 2% volume.</td></tr>
<tr><td>Cyprus</td><td>The Decree of 2008 on the Biogas Content of Conventional Fuel used in Transport provides that suppliers placing conventional fuel in the market are obliged to mix in biofuels so that the average annual energy content of biogas in conventional fuel amounts to at least 2% of the total energy content of conventional fuel placed in the
market.</td></tr>
</table>

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Czech Republic	In compliance with the legislation in force (the latest amendment to the Act on Air Protection), starting from 1 June 2010 the 6.0% fossil share in diesel fuel should be replaced by a bio-component; diesel fuels will thus comprise an average of 6.0% of bio-content. The amendment to the Act on Fuels is likely to lay down the obligation to market petrol fuels with a maximal content of bioethanol up to 5% (E5) until the end of 2018 at a minimum of 50% of petrol stations operated in the territory, which means that a major percentage of petrol stations will sell (until the set deadline) in particular petrol fuels of this type.
Denmark	In accordance with the Act on Biofuels, an importer or manufacturer of petrol or diesel has an obligation to ensure that biofuels make up at least 5.75% of the company's total annual sale of fuel to land transport, measured according to energy content. This target will be phased in over a three year period: 0.75% in 2010, 3.35% in 2011 and 5.75% in 2012.
Estonia	Objective that 5% of all the fuels used in transport are from renewable sources 2015, but no concrete mandates were found.
Finland	Act on the promotion of the use of biofuels in transport (Laki biopolttoaineiden käytön edistämisestä liikenteessä, 446/2007) The statutory biofuel distribution obligation concerns the total combined energy share of the biofuels distributed on the markets each calendar year by the distributors from the total energy of all transport fuels distributed on the markets, i.e. there is no technology-specific targets as regards the distribution obligation. Our target is that biofuels needs will be domestically produced in 2020. (Biofuel progress report)
France	In the context of the French biofuels plan, the European target for the inclusion of 5.75% LHV in 2010 has been advanced to 2008 and raised to 7% LHV in 2010 in the Law No 2005-781 of 13 July 200529 of the programme setting the guidelines for French energy policy.
Germany	The amount of quota for biofuels is for diesel fuel 4.4% and for petrol 2.8% (by-energy). Since the year 2009 an overall quota applies, beyond both fuels. Initially it was 5.25%; for the period 2010 to 2014 it amounts to 6.25%. The minimum unchanged quotas for gasoline and diesel fuel continue to be applied. From the year 2015, the reference value for biofuel quotas will be changed from the current energy rates to net greenhouse gas reduction values.
Greece	*Greece does not have a mandate, but a quota system with a call for tender.* One of the provisions of L3423/2005 is the full introduction of biofuels and other renewable fuels in the Greek market at the prescribed level by the end of 2010 (Article 8(1)). According to the provisions of Law L3054/2002, as amended by Law L3769/2009 (O.G. 105A/01.07.2009) biofuel quantities are allocated every year, after a relevant call for tenders and an evaluation and allocation procedure, to stakeholders, producers or importers, who are interested in participating in this quota system. Through the evaluation procedure which is based on specific criteria and a specified formula for quota allocation, raw materials of Greek origin like energy crops, agro-industrial residues (cottonseed) and wastes (animal fats and used vegetable oils) are approved for biofuel production. According to the Joint Ministerial Decree D1/A/15555/04.08.2010 (O.G. B' 1174/2010) of the Ministry of Finance, the Ministry of Environment, Energy and Climate Change and the Ministry of Rural Development of Food, a quantity of 164,000 kiloliters of pure biodiesel was set for blending for the period of July 2010 to June 2011. The data submitted for evaluation for the 2010 call for tenders showed that more than half of the pure biodiesel produced in domestic biodiesel plants (53.8%) came from domestic energy crops, mainly sunflower and rapeseed, as well as cottonseed and used vegetable oils and animal fats of Greek origin.

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Hungary	The current requirement with regard to mixing biofuels into petrol and diesel is for a minimum of 4.8% v/v (in terms of energy content, 3.2% for petrol and 4.4% for diesel). It is obligatory to mix in 4.8% v/v biofuel in both petrol and diesel or to sell a volume of biofuel corresponding to 4.8% v/v of the fuels sold to be used in transport. Fuel distributors may also meet this obligation by selling E85 fuel while not mixing biofuel into certain fuel qualities.
Ireland	The Biofuels Mineral Oil Tax Relief schemes were designed as interim measures to accelerate the level of biofuels in the fuel mix, in advance of the introduction of a biofuels obligation. From June 2010 fuel suppliers in Ireland had to meet the 4% biofuel obligation. From January 2013 this obligation has increased from 4 to 6%.
Italy	In order to promote the use of biofuels for automotive purposes, national legislation currently provides for an obligation to make a quota of biofuels available for consumption, in relation to the amount of fuel made available for consumption during the previous year. This obligation must be fulfilled by fuel suppliers who have made petrol and diesel available for automotive purposes during the previous year. The legal basis for the obligation is found in Decree-Law No 2 of 10 January 2006 which was amended and converted by Law No 81 of 11 March 2006. Article 2c establishes the percentage of biofuel which must be made available at 1, 2 and 3% respectively for 2007, 2008 and 2009, and sets a target of 5.75% for 2010. The Decree of 25 January 2010 raised the obligatory quota for the years 2010 to 2012 (see point (c) below). According to F.O. Licht GmbH (2012) the trajectory until 2013 is: – 5.00% cal. in 2013; – 4.50% in 2012; – 4.00% cal. in 2011.
Latvia	In order to promote the consumption of biofuel in Latvia and, in accordance with the provisions of the Law on Biofuel, to ensure that its consumption by 31 December 2010 is not less than 5.75% of the total amount of fuel in the economy for transport, the mandatory admixture of 5% biofuel in fossil fuel was implemented on 1 October 2009.
Lithuania	The Government of the Republic of Lithuania or institutions authorised by the Government shall prepare measures ensuring that the share of biofuels would account for not less than 2% and 5.75% of the total energy quantity of petrol and diesel fuel intended for transport available in the market of the country by 31 December 2005 and 31 December 2010, correspondingly.(NREAP) No 1-311 of the Minister for Energy of the Republic of Lithuania of 22 December 2011 amending Order No 1-346 of the Minister for Energy of the Republic of Lithuania of 14 December 2010 approving the Rules for trade in petroleum products, biofuels, bio-oils and other combustible liquid products in the Republic of Lithuania (submitted for publication in Valstybės žinios (Official Gazette). The amended Rules for trade in petroleum products, biofuels, bio-oils and other combustible liquid products in the Republic of Lithuania prescribe that as of 1 January 2012 diesel (except arctic fuel of classes 1 and 2) must contain 5-7 per cent of biofuel (permissible error is ±0.5), while making sure that the mandatory share of biofuel in diesel accounts for 6.25 per cent from 1 January 2012, 6.5 per cent from 1 January 2013 and 7 per cent from 1 January 2014. The content of biofuel in diesel must be above 7 per cent where the dieselbiofuel mixture is in compliance with the mandatory quality standards of diesel and is marked in accordance with the procedure prescribed by the Rules for trade in petroleum products, biofuels, bio-oils and other combustible liquid products in the Republic of Lithuania. (Progress report 2011)

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Luxemburg	Currently there is an admixture requirement for all diesel and petrol in effect which should lead to an increased use of energy from renewable sources in the transport sector. The 'Loi du 18 décembre 2009 concernant le budget des recettes et des dépenses de l'Etat pour l'exercice 2010' provides for, in this sense, that in 2010, biofuels make up at least 2% of the old fuels, calculated on the basis of the heat value of the fuel. Up to now the admix rate has been established annually. The present Action Plan should serve as a guideline for the use of the instruments of the admix rate in the years 2011 to 2020. The admix obligation should be expanded as soon as possible with sustainability criteria contained in the Directive 2009/28/EC.
Malta	The Malta Resources Authority is proposing that the system of tax exception upon biofuels is partly replaced by a regulation on mandatory substitution obligation. The entry into force of the Regulation will oblige importers to put a fixed pre-determined percentage of biofuels into their market share. Substitution obligation legislation for the inclusion of biofuels is undergoing public consultation. An obligation is imposed on the importer and supplier of fuels to import and distribute a percentage of the fuels deriving from biofuels.
Netherlands	A minimum mandatory quota applies to petrol and diesel. Substitutes in the years 2010-2013 (from 4.0-5.0%) with a minimum separate mandatory share for petrol and diesel of 3.5% based on energy content.
Poland	7.10% cal. in 2013; 6.65% cal. in 2012; 6.20% cal. in 2011 (F.O. Licht GmbH, 2012)
Portugal	Not known, but B7(vol) has been introduced according F.O. Licht GmbH, 2012
Romania	5.00% vol. Minimum blending obligation for fuel ethanol and biodiesel each from 2011; rising to 7.00% vol. each from 2013. (F.O. Licht GmbH, 2012) Fuel suppliers only place on the market petrol and diesel with a biofuel content as follows: a as of the date of entry into force of the decision (11 November 2011), diesel with a biofuel content of at least 5% by volume; petrol with a biofuel content of at least 4% by volume and at most 5% by volume; b as of 1 January 2013: diesel with a biofuel content of at least 6% by volume; petrol with a biofuel content of at least 6% by volume; c as of 1 January 2015:diesel with a biofuel content of at least 7% by volume; petrol with a biofuel content of at least 8% by volume d as of 1 January 2017, petrol with a biofuel content of at least 9% by volume; e as of 1 January 2019, petrol with a biofuel content of at least 10% by volume. (Biofuel Progress report 2011)
Slovakia	Regulation of the Government of the Slovak Republic No 246/2006 on the minimum quantity of fuel produced from renewable sources in petrol and diesel fuel placed on the market of the Slovak Republic (effect: 1 May 2006). In 2020 all fuels should have a 8.5% share of biofuels (based on energy content), where diesel should have a 11.5% share biodiesel and petrol a 7% share bioethanol.
Slovenia	The annual targets in the Decree on the promotion of the use of biofuels and other renewable fuels for the propulsion of motor vehicles (Off. Gaz. RS, No. 103/07) for the value of the share of biofuels in the market for the propulsion of motor vehicles are as follows: 6.0% in 2012, 6.5% in 2013, 7.0% in 2014 and 7.5% in 2015.

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Spain	Additional Provision 16 of the Hydrocarbon Sector Act, Law 34/1998 of 7 October 1998, sets annual targets for biofuels and other renewable fuels for transport which are compulsory as from 2009, reaching 5.83% in 2010. It also authorises the Ministry of Industry, Tourism and Trade to enact the provisions needed for regulation of a mechanism to promote the incorporation of biofuels and other renewable fuels used in transport. Royal Decree No 459/2011 of 1 April 2011 lays down the minimum obligatory annual targets for biofuels for 2011, 2012 and 2013. The Decree sets out three targets, expressed as minimum energy content for petrol, diesel and for total petrol and diesel sold or consumed: 4.1% for petrol, 7% for diesel and 6.5% total petrol and diesel
Sweden	Sweden does not apply quotas for renewable energy in the transport sector.
United Kingdom	"Under the Energy Act 2004, the Renewable Transport Fuel Obligations Order 2007 introduced a scheme in April 2008 to increase the percentage of renewable fuel used in road transport in the UK. The order obligates refiners, importers and any others who supply fossil based road transport fuels at the point at which Her Majesty's Revenue & Customs (HMRC) excise duties become payable, to produce evidence that a specified percentage of their fuels for road transport in the UK comes from renewable sources. Suppliers of biofuel will earn certificates to be used as evidence of meeting the obligation. The Renewable Transport Fuel Obligation (RTFO) covers suppliers who supply at least 450,000 litres per year. The RTFO places a requirement that the following percentages of road transport fuel are obtained from renewable fuels: 2008/09 – 2.5% - actual supply 2.7% 2009/10 – 3.25% 2010/11 – 3.5% 2011/12 – 4.0% 2012/13 – 4.5% 2013/14 and onwards – 5%"

B.3 Tax exemptions and reductions

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Austria	– reduction tax rate per CN code with a certain amount of biogenic content; – a bonus - and so a tax reduction - is granted for the purchase of vehicles with low pollutant emissions (< 120 g/km CO_2 emission) and with environmentally-friendly power; – supply motors (E85, methane in the form of natural/biogas, liquid gas or hydrogen).
Belgium	– a reduced rate of excise duty for petrol containing at least 7% v/v of bioethanol (pure or ETBE) and diesel containing at least 5% v/v of FAME. The tax-exempt quotas will be granted until September 2013; – an exemption from excise duty for pure rape-seed oil originating from the own production of a farmer or from a cooperative which markets directly to the end user also exists.

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Bulgaria	"Tax Reduction for Biofuels" schemes provides the following financial incentives to promote the use of biofuels: – a reduced rate of excise duty for unleaded petrol when bioethanol falling within CN code 2207 20 00 with 4 to 5% of volume has been added; – a reduced rate of excise duty for gas oil when biodiesel falling within CN code 3824; – 90 99 with 4 to 5% of volume has been added. The reduced rates are valid for 2 years from the date of approval of the scheme notified.
Cyprus	n.a.
Czech Republic	As far as the high-percentage blends E85, E95, SMN 30 and B100 (i.e. 100% FAME), pure natural oils and biogas are concerned, excise tax reduction applies to the biocontent. On the contrary, motor fuels and diesel oil with low bio-content (E5, E10 and B7) are not tax-advantaged.
Denmark	– biofuels are exempt from the CO_2 tax levied on mineral petrol and diesel; – tax exemption for electric vehicles up to and including 2015.
Estonia	Biofuel shall be exempt from excise duty until the end of the authorisation granted by the Commission. Authorisation No 314/2005 for the exemption of biofuels from excise duty expires on 27 July 2011. Estonia has not planned to apply for renewal of the exemption. (Biofuel progress report 2011). A higher share of economic fuel efficient vehicles could be achieved by the imposition of tax on CO_2 emissions. This issue is of large social aspect. A large number of resident in rural areas without public transport depend on their car and cannot afford more fuel efficient vehicles. Therefore, at the moment it is difficult to find consensus in the society for the implementation of the measure.
Finland	– Act on excise tax on liquid fuels (Laki nestemäisten polttoaineiden valmisteverosta, 1472/1994). – Energy tax reform from 2011 based on energy content and (lifecycle) carbon dioxide emissions. – The carbon dioxide tax takes into account the carbon dioxide emission reductions that can be achieved using biofuels. If the biofuel used meets the sustainability criteria of the RED, the carbon dioxide tax is reduced by half. Carbon dioxide tax is not levied on Article 21(2) biofuels. (Progress report 2011)
France	– France supports the implementation at European level of a climate contribution system, which will subject all fossil fuels to taxation. – An additional levy of the general tax on polluting activities (TGAP) must be paid by operators (refiners, supermarkets and independents) who do not meet the annual biofuel targets. – a tax exemption through the partial exemption of the Domestic consumption tax (TIC) for biodiesel and bioethanol and a total exemption for pure vegetable oils used as fuel in agricultural and fishing. It only applies to biofuels produced by approved units. Article 138 of Law no. 2010-1657 of 29 December 2010 on finance for 2011 sets the amounts of tax exemption granted respectively to bioethanol and biodiesel and produced in approved production units at € 14/hl and € 8/hl until 2013.
Germany	– for conventional pure biofuels a proportional tax exemption is granted, for a transitional period until the end of 2012, provided that these are not used to meet the quota obligation; – second-generation biofuels, biogas and bioethanol fuel (E85) are tax-deductible until 2015; – BioKraftQuG) came into force to replace the previously existing widespread tax benefits for biofuels by a regulatory requirement.
Greece	Annual circulation taxes on passenger cars do take into account CO_2 emissions.

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Hungary	– Biofuels admixed to fossil fuels are not granted support or tax benefits; the former excise tax benefit was replaced by a distribution obligation in 2009. – The Hungarian standards allow the distribution of E85 fuel, the bioethanol component of which is exempt from excise tax. The tax benefits granted under the legislation have a narrow scope, applying to E85 fuel and the use of pure biodiesel in machinery, but not in transport.
Ireland	The Biofuels Mineral Oil Tax Relief schemes I and II, which were launched by the Department of Communications, Energy and Natural Resources (DCENR) in 2005 and 2006, allow specified biofuel producers to produce specific volumes of biofuel on which excise relief will be awarded for a specific period. The schemes were designed as interim measures to accelerate the level of biofuels in the fuel mix, in advance of the introduction of a biofuels obligation.
Italy	There are specific excise rates, per unit of weight or volume, for conventional energy products such as petrol, kerosene, diesel, fuel oil, liquefied petroleum gas, natural gas, coal, lignite and coking coal. When other energy products are used as motor fuel or fuel, they are taxed “per equivalence”, i.e. they are subject to excise in accordance with the rate for the equivalent product (motor fuel or fuel) which has been replaced in that particular use. “Innovative” motor fuels and fuels are also considered other products, including: biodiesel (diesel-type methyl ester extracted from a vegetable oil, to be used as motor fuel); – bioethanol (ethanol extracted from biomass or the biodegradable fraction of refuse and waste, to be used as motor fuel); – biomethanol (methanol extracted from biomass, to be used as motor fuel); – Ethyl tert-butyl ether or ETBE (ETBE obtained from bioethanol), considered to be a biofuel at 47%; – additives and reformulators produced from biomass for petrol and diesel. In this regard, national legislation includes several provisions aimed at reducing the final cost of biofuels, through a tax reduction (excise reduction): the tax measures concentrate on biodiesel and fuels which can be obtained from ethanol of plant origin.
Latvia	Pursuant to the Law on Excise Duty, the following reduced rates of excise duty were applied to oil product mixtures with biofuel as from 1 February 2009: – for unleaded petrol, its substitutes and components to which ethanol obtained from agricultural raw materials and which is dehydrated (with alcohol content of at least 99.5% by volume) has been added, if the absolute alcohol content makes up 5.0% by volume of the total quantity of product – LVL 256 per 1,000 litres; (E5); – for unleaded petrol, its substitutes and components to which ethanol obtained from agricultural raw materials and which is dehydrated (with alcohol content of at least 99.5% by volume) has been added, if the absolute alcohol content makes up between 70-95% by volume of the total quantity of product – the unleaded petrol rate (LVL 269 per 1,000 litres) was reduced in proportion to the amount of absolute ethanol, that is from LVL 13.45 to 80.70 per 1,000 litres;(E85); – for diesel (gas oil), its substitutes and components to which 5-30% (not inclusive) by volume of the total amount of oil product, of rapeseed oil or biodiesel obtained from rapeseed oil has been added – LVL 223 per 1,000 litres; – for diesel (gas oil), its substitutes and components to which at least 30% by volume of the total amount of oil product, of rapeseed oil or biodiesel obtained from rapeseed oil has been added – LVL 164 per 1,000 litres; (B30); – for rapeseed oil sold or used as fuel or automotive fuel, and biodiesel obtained totally from rapeseed oil – LVL 0 per 1,000 litres. B100).

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Lithuania	Benefit on excise duty is applied to energy products containing a portion of additives of biological origin (in terms of per cent) amounting to or greater than 30%. Besides, benefit on environmental pollution tax can be applied. Benefit on excise duty applicable to energy products containing a portion of additives of biological origin (in terms of per cent) amounting to or greater than 30%. In this case, the established excise duty rate reduced by the portion proportional to the portion of additives of biological origin in the product (in terms of per cent) shall be applied, or products shall be released from excise duty when the products are produced only from the products specified in the Law of the Republic of Lithuania on Excise Tax. Benefit on environmental pollution tax. According to the Law of the Republic of Lithuania on Environmental Pollution Tax, natural and legal persons using biofuels meeting established standards shall be released from environmental pollution tax in respect of pollutants emitted from mobile pollution sources.
Luxemburg	Biofuels and bioliquids marketed in Luxembourg which contribute to national target compliance must comply with the prescribed sustainability criteria. If the sustainability criteria are not met, the biofuels and bioliquids in question are not granted the tax exemption under the Act establishing excise duties and taxes of similar effect on energy products, electricity, manufactured tobacco products, alcohol and alcoholic beverages of 17 December 2010.
Malta	Malta has so far opted for the first mode of promotion and currently the biomass content (i.e. the percentage element) in biodiesel is exempted from the payment of excise duty. Currently this makes biodiesel cheaper than petroleum diesel retailed in filling stations and therefore a fiscal incentive provides one of the driving forces for the biodiesel sales. MRA is proposing a system whereby full or partial excise duty is paid on the biofuel needed to reach the targets set by the mandatory substitution obligation, whereas any additional biofuel which is placed on the market is given some other form of incentive, always provided that the 'Sustainability Criteria' set by the EU directives are met.
Netherlands	Since 1 April 2010, the tax authority has applied a lower excise duty tariff to E85 within the 'Uitvoeringsregeling Accijns' (rule of law relating to the application of excise duty'). This tariff takes account of the lower energy content of ethanol compared with lead-free petrol.
Poland	Until 30 April 2011, State Aid scheme N 57/08 "Pomoc operacyjna w zakresie biopaliw", approved by the European Commission on 18 September 2009, was in effect in Poland. The scheme included exemption from excise duty on liquid biofuels with biocomponents and biocomponents as pure fuels as well as exemption from fuel charge on biocomponents as pure fuels. Products being a blend of petrol with biocomponents, containing more than 2% of biocomponents – excise duty rate for motor petrol (PLN 1,565/1,000 l) is reduced by PLN 1.565 per 1 litre of biocomponents added to this petrol, provided that the amount of excise duty may not be lower than PLN 10.00/1,000 l. Products being a blend of diesel oil with biocomponents, containing more than 2% of biocomponents – excise duty rate for diesel oils (PLN 1,048/1,000 l) is reduced by PLN 1.048 per 1 litre of biocomponents added to these diesel oils, provided that the amount of excise duty may not be lower than PLN 10/00/1,000 l. Biocomponents which is fuel in its own right used for fuelling internal combustion engines – PLN 10/1,000 l. On the demand side, fiscal arrangements will continue to play a very significant role in ensuring the cost-effectiveness of biocomponent and liquid biofuel production in comparison with fossil fuels. The Project contains the aforementioned arrangements concerning exemptions from excise duty, corporate income tax and the fuel fee.

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Portugal	– the current model to support biofuels, established by means of Decree Law Nos. 62/2006, of 21 March, and 66/2006, of 22 March, whose period of effect concludes on 31 December 2010, is based on the attribution of ISP tax exemptions for two different groups of biodiesel producers; – it can be noted that the electric vehicles likewise benefit from exemptions from Automobile Tax and the Road Tax.
Romania	n.a.
Slovakia	Biofuels are promoted with reduced excise duty. It follows from the key measures of the approved aid scheme that: – excise duty exemption applies to a fuel mixture of petrol with ETBE and diesel with esters; the reduction in excise duty for these fuel mixtures is established up to a level of 7.05% volume for a mixture of petrol and ETBE and 5% volume for a mixture of diesel and esters; – a reduction in the excise duty on biofuels is granted, in the tax territory, to all companies releasing biofuels for consumption in the tax territory; – this measure should be applied for six years (from the date on which the Act on Excise Duty on Mineral Oil enters into effect) under specified conditions; the reduction in excise duty is provided from state resources and is designed to support companies that produce the fuel, import it from third countries or receive it from other Member States.
Slovenia	Provides that biofuels used as motor fuels are exempted from the payment of excise duties, if they are used in their pure form, and if they are mixed with fossil fuels, an exemption may be claimed up to a maximum of 5%, or more if it is standardised fuel containing biofuel.
Spain	The Special duty Act provides that, under the hydrocarbon tax, a special tax rate of 0 euro per 1,000 litres will be levied on biofuels until 31 December 2012. This special rate will apply solely to the volume of actual biofuel, even when it is mixed with other products. The Special duty Act provides that the manufacture or import of biofuels intended as automobile fuel, full-strength or mixed with conventional fuels, are exempt from the special duty on hydrocarbons for purposes of pilot projects for the technological development of less-polluting products.
Sweden	Biofuels and peat (except for crude tall oil) are exempt from tax. All biofuels and peat are exempt from energy and CO_2 tax. Passenger cars that fulfil the requirements for green cars, and which enter into service for the first time in Sweden, are exempt from vehicle tax for five years from the vehicle's entry into service. The vehicle owner thus does not need to pay vehicle tax for those years. The purpose of this measure is to encourage the purchase of fuel-efficient cars and cars that can run on biofuels or electricity. The definition of a green car contains the following requirements: – for conventional passenger cars, including electric hybrids, average CO_2 emissions may not exceed 120 g CO_2/km (for diesel cars, there is an additional requirement that particle emissions do not exceed 5 mg/km); – for passenger cars that run on alternative fuels (other than petrol, diesel and LPG), fuel consumption may not exceed 0.92 litres of petrol/10 km or 0.97 m^3 of gas/10 km; – for electric cars, electric energy consumption per 100 km may not exceed 37 kWh. The definition of a green car in this respect differs from that which applies for a reduction in preferential taxation (see below). The Swedish Government has announced a revision of the definition of green cars for the purpose of possibly making energy-efficiency requirements even stricter. (Progress report 2011)

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
United Kingdom	In a separate UK Government initiative, biofuel produced from Used Cooking Oil (UCO) is also eligible for a duty rebate. This is a tax rebate of 20ppl and is in place for a period of two years. It is currently possible for all biofuel producers to earn RTFO certificate as well as benefitting from the Duty Incentive (20ppl). From April 2010 only biofuel produced from Used Cooking Oil can benefit from both support mechanisms at the same time. This scheme for biodiesel produced from used cooking oil is a duty incentive of 20ppl on biodiesel produced from used cooking oil (UCO). The existing biofuels duty differential (20ppl for all biofuels) will be removed form 1 April 2010, but the scheme will continue for UCO biodiesel only, for a limited period of two years from 1 April 2010 to 31 March 2012. This is intended to provide additional temporary support for suppliers of this sustainable fuel until the 2009 Renewable Energy Directive (RED) sustainability criteria can be fully implemented.

B.4 Subsidies

Member State	Statement in relation to subsidies for biofuels as stated in the NREAPs
Austria	In the progress report 2012 Austria states that no subsidies are provided for biofuels from waste and residues. The reason for this it that the double-counting of these fuels is already in place and the fact that Austria would like to avoid market distortions as result of valorisation of waste.
Belgium	n.a.
Bulgaria	Financial support for producers of energy crops (per hectare supplement payments for the areas under energy crops if they have concluded a contract for the sale of such crops with approved purchasers and/or processors of energy crops). The grant amounts to EUR 45 per hectare.
Cyprus	Support Schemes for purchase of electric vehicles, FFV/dual propulsion vehicles and low-carbon emission vehicles (120 g CO_2/km), utilisation of biomass and biogas production for transport. Besides this, a vehicle scrappage and replacement scheme exists.
Czech Republic	n.a.
Denmark	– from 2007-2010, a total of DKK 200 million has been granted for the development and demonstration of second generation biofuels; – DKK 180 million has been earmarked for research and demonstration projects for energy efficient transport solutions, including electric vehicles and second generation biofuels, as part of the “Green transport policy” transport agreement; – besides support for biofuels a research scheme for electric has been set up with a framework of DKK 53 million for the period 2008-2012.
Estonia	– development of the financing scheme, including considering the establishment of obligations to use renewable energy as a condition for government subsidy in procurements for passenger transport (2013); – development (2012) and implementation of measures and financing scheme aimed at extending the use of vehicles using other alternative renewable energy sources (not sure whether this financing scheme will grant subsidies or tax exemptions; – in a situation where the price of more environmentally friendly means of transport exceeds that of conventional vehicles, people are not eager to spend more money. Therefore ways must be found to encourage buyers to prefer environmentally friendly solutions when choosing vehicles.

Member State	Statement in relation to subsidies for biofuels as stated in the NREAPs
Finland	The investment support scheme will be used to support biogas plants that produce gas for transport use. In the next few years, the investment support of the Ministry of Employment and the Economy will be used for supporting the construction of 1–2 large-scale transport biofuel pilot plants. In 2012, investment subsidies were as follows: – € 34 million for renewable energy; – € 100 million for a demo plant of transport biofuels; – € 7 million for the development programme of biofuels; and – € 15 million for energy-efficiency. (Progress report 2011)
France	A research demonstrator fund has been launched in 2008, with a budget of € 325 million for the period 2008-2012, to finance research demonstrators in new energy technology sectors, like transport vehicles with low-carbon emissions and second generation biofuels. (Progress report 2011)
Germany	n.a.
Greece	n.a.
Hungary	n.a.
Ireland	Only financial aid for electric vehicles (full electric and plug-in hybrid electric vehicles.
Italy	n.a.
Latvia	– to promote biofuel production, the Ministry of Agriculture has drawn up and implemented the State aid programme 'Support for biofuel production'; – in accordance with Cabinet Regulation No 303 of 18 April 2006 'Procedure for the monitoring and administration of direct State aid for production of the annual minimum required amount of biofuel', biofuel producers were granted aid for 17 186 003 litres of bioethanol and 35 855 150 litres of biodiesel in 2009; – financial support quotas for biofuel (Cabinet Regulation No. 280 of 15 April 2008 "Regulations on Financial Support Quota for Biofuel").
Lithuania	A portion of the price of rape oil intended for the production of rapeseed methyl (ethyl) ester (RME) and a portion of the price of rape seed and cereal grain purchased for the production of dehydrated ethanol shall be compensated. Amendment of the related legal act is planned for August 2010 with a view to establishing the compensable quanity of raw materials for 2010.
Luxemburg	– investment assistance for companies is granted. Companies can benefit from support for all technologies in the area of energy production based renewable energy sources, including the production of sustainable biofuels; – investment assistance for agricultural operations.
Malta	n.a.
Netherlands	– subsidy scheme to set up a nationwide network of filling stations where alternative fuels are available, like natural gas/green gas, E85 and or B30; – Subsidy scheme to stimulate (production of) innovative biofuels Subsidy is an amount per ton of avoided CO_2 eq. (compared with conventional biofuels).
Poland	A scheme envisages investment aid (as regards the production of biocomponents and liquid fuels) from national public funds and EU funds.
Portugal	n.a.
Romania	Financial support for processing of agricultural products in order to obtain biofuels.
Slovakia	n.a.
Slovenia	n.a.

Member State	Statement in relation to subsidies for biofuels as stated in the NREAPs
Spain	n.a.
Sweden	Financial support for investment for biogas facilities (all potential investments to produce, store and process biogas, etc.)
United Kingdom	No specific subsidies for biofuels, but a Green Bus Fund exists which assists bus operators and local authorities to buy around 350 new low-carbon buses (hybrid and electric busses).

B.5 Dedicated marketing strategies of higher blends

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Austria	E10 was expected in 2012, but the decision on E10 introduction was postponed. B10 expected in 2017.
Belgium	n.a.
Bulgaria	From 2015 Bulgaria wants to require distributors and retailers of petroleum-derived liquid fuels to have available pumps which sell pure biofuels.
Cyprus	n.a.
Czech Republic	The amendment to the Act on Fuels is likely to lay down the obligation to market petrol fuels with a maximal content of bioethanol up to 5% (E5) until the end of 2018 at a minimum of 50% of petrol stations operated in the territory, ……it will be necessary to introduce petrol fuels with bio-content up to 10% (E10), which is a limit laid down by Directive 2009/30/EC as well as by the proposed EN 228, or the E 85 fuel. The planned increase in bio-components in motor fuels aimed at replacing fossil petrol and diesel oil will have to be satisfied by combining “ordinary” fuels (pursuant to EN 590 and EN 228) with high-concentration biofuels (E85, SMN 30, B100). As far as the high-percentage blends E85, E95, SMN 30 and B100 (i.e. 100% FAME), pure natural oils and biogas are concerned, excise tax reduction applies to the biocontent. On the contrary, motor fuels and diesel oil with low bio-content (E5, E10 and B7) are not tax-advantaged.
Denmark	n.a.
Estonia	Performance of surveys to find and apply the maximum % for blending.
Finland	n.a.
France	The authorisation of fuels with a high biofuel content, with in particular E85 in the petrol sector and B30 in the diesel sector.
Germany	Tax benefits for pure biofuels, but these expire to a large extent at the end of 2012.
Greece	n.a.
Hungary	The Hungarian standards allow the distribution of E85 fuel, the bioethanol component of which is exempt from excise tax. In the future we plan to support the purchasing of mass transportation vehicles able.
Ireland	n.a.
Italy	Measures will be introduced aimed at supporting the wholesale use of a 25% biodiesel mix (for example in public transport fleets) and steps will be taken, including through national regulations, to revise the technical regulations to ensure a gradual increase in the percentage which can be mixed in the network.
Latvia	Reduced rate of excise duties is applicable to E85, B30 and B100 (the latter produced from rapeseed oil).

Member State	Statement in relation to marketing strategy of biofuels as stated in the NREAPs
Lithuania	Benefit on excise duty applicable to energy products containing a portion of additives of biological origin … amounting to or greater than 30 %. In this case, the established excise duty rate reduced by the portion proportional to the portion of additives of biological origin in the product (in terms of per cent) shall be applied, or products shall be released from excise duty when the products are produced only from the products specified in the Law of the Republic of Lithuania on Excise Tax.
Luxemburg	n.a.
Malta	n.a.
Netherlands	A subsidy scheme (TAB) filling points for an alternative fuel such as natural gas/green gas, E85 (bioethanol) and/or B30 (biodiesel).
Poland	Biocomponents which is fuel in its own right have been excluded from the group of products subject to the fuel fee referred to in the Act of 27 October 1994 on paid motorways and National Road Fund. Projects to increase demand for liquid biofuels. Measures of this type include, inter alia, the introduction of ecological public transport areas (in which public transport can be based solely on vehicles using ecological fuel, i.e. liquid biofuels, LPG and CNG, or powered by electric or hybrid engines) and the creation of a system of exemption from parking charges for vehicles which run on these fuels. The duration for which the vehicle is exempt from parking charges is assumed to be proportional to the total biocomponent content of the liquid biofuel used.
Portugal	n.a.
Romania	n.a.
Slovakia	n.a.
Slovenia	n.a.
Spain	Government vehicle procurement: "Analyse and adapt the existing fleet of vehicles, before 31 December 2010, so that they can run on biofuels. This does not apply to hybrid vehicles. Include biofuel compatibility as a compulsory criterion in all purchases of new vehicles in those segments of the sector where there is an adequate supply of automobiles already equipped with this technology so that by 31 December 2012, 50% of the fleet will consume mixtures with a high biofuel content (30% diesel and 85% bioethanol). … Inclusion of a biofuel availability clause in all fuel supply contracts by 31 December 2010.
Sweden	Passenger cars that fulfil the requirements for green cars, and which enter into service for the first time in Sweden, are exempt from vehicle tax for five years from the vehicle's entry into service. … The definition of a green car contains the following requirements: – For passenger cars that run on alternative fuels (other than petrol, diesel and LPG), fuel consumption may not exceed 0.92 litres of petrol/10 km or 0.97 m^3 of gas/10 km. Sweden also provides subsidies for E85 vehicles and promotes the use of biogas by subsidies, also to realise connections to the grid.
United Kingdom	n.a.

Annex C Factsheet: FAME

Introduction and fuel specifications

FAME (fatty acid methyl esters) is produced from oils or fats.
The characteristics of this biodiesel will depend to some extend on the type of oil or fat used as a feedstock.
Biodiesel can be blended with diesel, or used as neat (100%) fuel in engines suitable (in many cases adapted) to run on neat biodiesel. Most conventional diesel engines can run on blends up to 10 or 20%, but not all car manufacturers provide warranty if blends higher than 7% are used. According to the current fuel specifications, diesel may contain up to 7 vol% of FAME (B7).

Table 53 **Fuel specifications**

Energy density	Unit	Diesel	B7	B10	B30	B100
Per litre	MJ/l	35.8	35.6	35.5	34.8	32.5
Per kg	MJ/kg	42.7	42.3	42.1	40.9	37.0
Range	km	600	596	594	583	545
Cetane #	-	40-59	-	-	-	46-67

Biofuels production

FAME is mostly produced from vegetable oils such as
- rape seed oil;
- sunflower oil;
- soybean oil;
- palm oil;
- used cooking oil.

FAME production processes are mature. The current production capacity in the EU is almost 20 Mtoe (2011 data, European Biodiesel Board), current EU production is 8.4 Mtoe (2010, Eurobserver, 2011).

Blending in base fuel road transport (current situation); B7

B7 can be used in all road transport with a compression ignition (diesel) engine.

Up to B7 there are no significant engine issues or impact on pollutant emissions.

These blends are allowed in all base (diesel) fuel sold in the EU, so no marketing issues arise.

Potential to increase current limits: B10, B20

Acceptance of high blends for Euro VI and later vehicles is still very uncertain.

Stringent emission requirements and type approval procedure make it necessary to have a separate type approval and possibly calibration for blends higher than B7.

Regarding application of B10 and B20 in passenger cars, the technical issues with blends higher than B7 are strongly related to the common way of regeneration of diesel particulate filters (DPF). The system with post injection can lead to accelerated lubricant deterioration an can lead to engine failures.

B7 will be needed as protection grade.

If issues are resolved, the potential impact on vehicle costs are low.
The following technological developments are necessary:
- development of different regeneration system of DPF (for example post injection in exhaust) (optional);
- development of improved engine lubricants (special additives);
- further development and testing of fuel injection systems.

The cost of FAME is higher than that of fossil diesel, which means that B10 and B20 will be more costly than the protection grade B7. To ensure sufficient demand, the price of B10 or B20 would need to be competitive or lower.
Cost of fuel distribution will also increase, as the B10 and B20 need to be distributed separately from the protection grade B7. Many filling stations are only equipped to supply one type of diesel.

In addition, careful communication of stakeholders (car manufacturers, fuel suppliers, consumers organisations and government) with vehicle owners is necessary, to ensure that consumers know whether their vehicle is compatible with B10 or B20, to prevent misfuelling and to create trust and interest in the high blend fuel.

If, in the longer term, the base fuel is adapted (from B7 to B10 or B20), these marketing issues will disappear.

High blends in road transport: B30, B100

Light duty vehicles
The majority of diesel passenger cars are not compatible with high biodiesel blends. About 10% of the current cars is expected to be B30 compatible.
The effort to implement the new technologies which would make high blends possible is quite large.

Heavy-duty vehicles
The compatibility of heavy-duty vehicles with higher blends is much better than for light duty vehicles. Especially the heavy-duty vehicles with larger engines have high potential, the larger engines are mostly fitted with a fuel injection system with better compatibility than the fuel injection system of the smaller engines.

The estimated market share of HD vehicles which are currently compatible with biodiesel blends and neat biodiesel is quite high and presented in the table below. The percentages are based on a consultation with 7 large HD vehicle manufacturers regarding biodiesel capability (Norris, 2011), the compatibility is weighted with the new registrations share of the 7 manufacturers (Hill, 2011).

Table 54 **Estimated compatibility with biodiesel blends of HD EUV vehicles, current situation (2012)**

	B7	B20	B30	B100
Estimated market share	100%	85%	80%	60%

It should be noted that there are specific conditions to use high blends:
- maintenance intervals are usually shorter;
- the biodiesel need to comply with EN14214;
- in some cases several components need to be added and/or replaced.

The following problems can possibly occur with high blends:
- fuel injection system wear/injector fouling;
- EGR system fouling, EGR valve sticking;
- catalyst face plugging;
- (SCR) catalyst deactivation;
- DPF failures;
- OBD impact and higher NO_x;
- damage body work of truck near exhaust pipe;
- corrosion, sticking, lacquering;
- lubricant dilution;
- fuel system clogging in winter.

Vehicle costs (purchase and maintenance) are typically somewhat higher due to the shorter maintenance intervals.

The cost of FAME is higher than that of fossil diesel, which means that B30 and B100 will be more costly than the protection grade B7. To ensure sufficient demand, the price would need to be competitive or lower. Cost of fuel distribution will also increase, as the high blends need to be distributed separately from the protection grade B7.

There is potential to market this via dedicated fleets (e.g. city buses). This would resolve the issue that many filling stations are only equipped to supply one type of diesel, which makes it difficult and costly to offer both the high blend and a protection grade at the same time.

Opportunities in non-road transport
FAME can be used in shipping and rail transport, to a limited extent.

Main advantage compared to road transport:
- Requirements for emission control are lower which makes the impact of biodiesel (FAME) blends lower.

Disadvantages compared to road transport:
- There can be other diesel fuel consumers on board a shop or train such as heaters which may be more sensitive to the fuel properties.
- There may be materials (elastomers and metals) issues.
- Storage times of fuel in fuel tanks is often (much) longer. Biodiesel has more storage issues such as microbial contamination accelerated by possible attraction of water.

FAME can not be used in aviation. Fuel composition requirements for aviation are to high to allow biodiesel (FAME) as blend. The lower specific energy of FAME (energy per unit of mass) is also especially disadvantages for aviation.

Potential of optimizing engine efficiency
FAME has no significant influence on engine efficiency.

Annex D Factsheet: Ethanol

Introduction and fuel specifications

Bioethanol is produced from crops such as sugar cane, sugar beet, wheat and maize, and can be blended with petrol. As a blend is also acts an octane number improver. Most petrol cars in Europe can run on ethanol blends of up to 10 vol% (E10), but part of the fleet needs to be fuelled with E5.

Research is on-going to expand the use of ethanol to heavy-duty vehicles, either as ED95 (95% ethanol, 5% ignition improver) or in low blends with diesel (ED5 or ED15).

Table 55 **Fuel specifications**

Energy density	Unit	Petrol	E5	E10	E20	E30	E70	E85	E100
Per litre	MJ/l	31.8	31.3	30.7	29.7	28.6	24.4	21.9	21.2
Per kg	MJ/kg	43.0	42.2	41.3	39.6	38.0	31.6	27.9	27.0
Range	Km	500	492	483	467	450	383	344	333
Octane # (RON)	-	>95	-	-	-	-	-	110+	110+

Energy density	Diesel	ED95
Per litre	35.8	20.14
Per kg	42.7	25.41
Range	600	338
Octane # (RON)	-	-
Cetane #	40-59	10

Biofuels production

Bioethanol is currently mainly produced from
- sugar beet;
- wheat;
- maize;
- sugar cane;

Research is on-going to expand the potential feedstock to more woody, non-food biomass, which would provide the opportunity to use residues and waste streams as feedstock for ethanol production, such as:
- wheat straw;
- waste wood;
- farmed wood.

This technology is not yet in commercial, large scale operation but R&D is on-going in various parts of the world incl. the EU, and pilot and demonstration plants are in operation.

The current bioethanol production capacity in the EU is almost 3.7 Mtoe, current EU production is 1.9 Mtoe (data from ePure).

Blending in base fuel road transport (current situation): E10 + E5 protection grade

E5 and E10 can be used in passenger cars and LCV with a spark ignition engine. A large part of the fleet can run on E10, but not all cars are compatible. Especially some of the older vehicles are only compatible with E5. E5 is therefore offered as protection grade.

Technical feasibility is not an issue. Emissions stay beneath limits, and there are no problems expected for Euro 6.

There is no significant impact on vehicle costs (purchase and maintenance).

Ethanol cost are higher than that of petrol.
Introducing E10 and then increasing E10 sales over time requires a financial incentive at the pump and adequate communication of stakeholders (car manufacturers, fuel suppliers, consumers organisations and government) with vehicle owners. Consumers need to be aware of whether their vehicle is compatible with the E10, misfuelling needs to be prevented and consumers need to trust the higher blend fuel.

If, in the longer term, the base fuel is adapted (from E5 to E10), these marketing issues will disappear.

Potential to increase current limits:
E20-E30 for passenger cars ED5/ED15 for trucks and buses

E20-E30 for passenger cars.
E20 and E30 could be used in passenger cars and LCV with a spark ignition engine. Most adaptations are already implemented for the use of E10. Currently no E20 capable vehicles exist (with the FFVs as an exception). Calibration of the fuel/ignition management software is most likely needed.

ED5/ED15 (Ediesel, O2 Diesel) for diesel vehicles:
ED5 or ED15 might be an option to use ethanol in heavy-duty vehicles. Their higher vapour pressure and low flashpoint may present a safety issue. These fuels have a high volatility which can cause cavitation to the injection system. In addition, ED has a relatively low viscosity which can possibly lead to fuel pump and injector leakage. The necessary additives may contribute to injector fouling, the quality of the additives is very important. (*Dieselnet Technology Guide, Alternative Diesel fuels, Ethanol Diesel Blends, 2006)*

For a certain period the protection grades E5 or E10 are needed in case of E20-E30. In case of ED5 or ED15, protection grade B7 diesel is needed.

Successful marketing of these fuels require the higher ethanol blends to be economically competitive compared to E5/E10 or the B7 respectively.
In addition, stakeholder communication is necessary regarding issues such as fuel/vehicle compatibility.

It takes time to replace a substantial part of the current vehicles fleet to E20, it will be a challenge to have substantial E20 capable vehicles on the road in 2020. The same holds for the ED-blends.

High blends in road transport

Passenger cars and vans (spark ignition) can run on E85 in combination with a Flexible Fuel Vehicle (FFV) technology. This technology is offered by various vehicle manufacturers.

Options for trucks and buses (compression ignition):
- Medium-high blend: ED15/ED30 (E diesel, O2 Diesel);
- High blend: ED95 (ethanol with ignition improver).

The additional price of FFV ranges from zero to about € 2,000 per vehicle (see Table 56) depending on the manufacturer and model. The sales volumes of FFVs are low, hence the additional costs are relatively high. Most likely the additional costs decrease when sales volumes increase.

Table 56 2011 price differences for consumers per brand in the Netherlands between a flex-fuel vehicle and a comparable conventional vehicle

OEM	Price difference	
	Range (€)	Average (€)
A	775	775
B	1,000	1,000
C	0-1,600	800
D	300-1,300	800
E	0-500	250
F	2,000	2,000
G	400	400
Total	0-2,000	861

Source for price differences: www.autoweek.nl.

TNO estimated for the Dutch Ministry of Infrastructure and the Environment the additional production costs for a flex-fuel vehicle in mass series production, to be lower than € 25 (components and software). This was based on the assumption that all future produced vehicles would be FFVs.

The maintenance costs for FFV vehicles are currently higher. The oil and oil filters must be changed 1,5–2 times more often when running on E85.

Marketing of ED95 can best be done via dedicated fleets of trucks and/or buses, to reduce marketing and distribution cost.

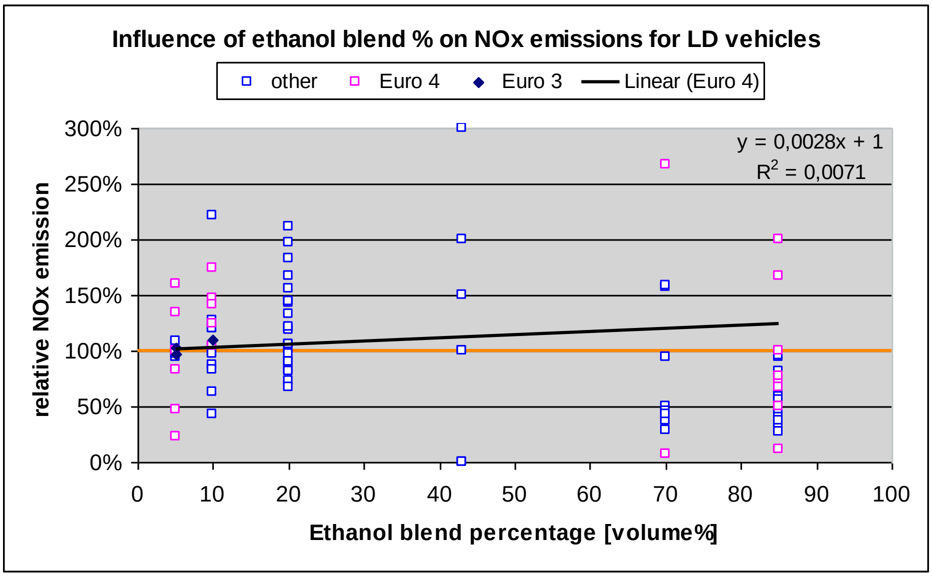
Regarding future potential of E85: the market share does not increase unless there is an economically benefit for purchasing FFVs. There are currently no indications for a big leap FFVs sales in the EU, under current policies.

Effect on pollutant emissions

In TNO/CE Delft (2010) data was collected about the effect of ethanol blends on the pollutant emissions NO_x and PM compared to petrol (E0). This was chassis dynamometer data of a large variety of Euro 4 cars and some Euro 3 cars. The results are presented in the two figures below. The low blends up to 20% show the effect with normal cars while the high blend percentages, 40 to 85%, show the effect with FFV vehicles. The figures show a large scatter with both large reductions as well as increases in NO_x and PM. For E70 and E85 more vehicles actually show an improvement as apposed to a deterioration.
On average there is however an modest increase.

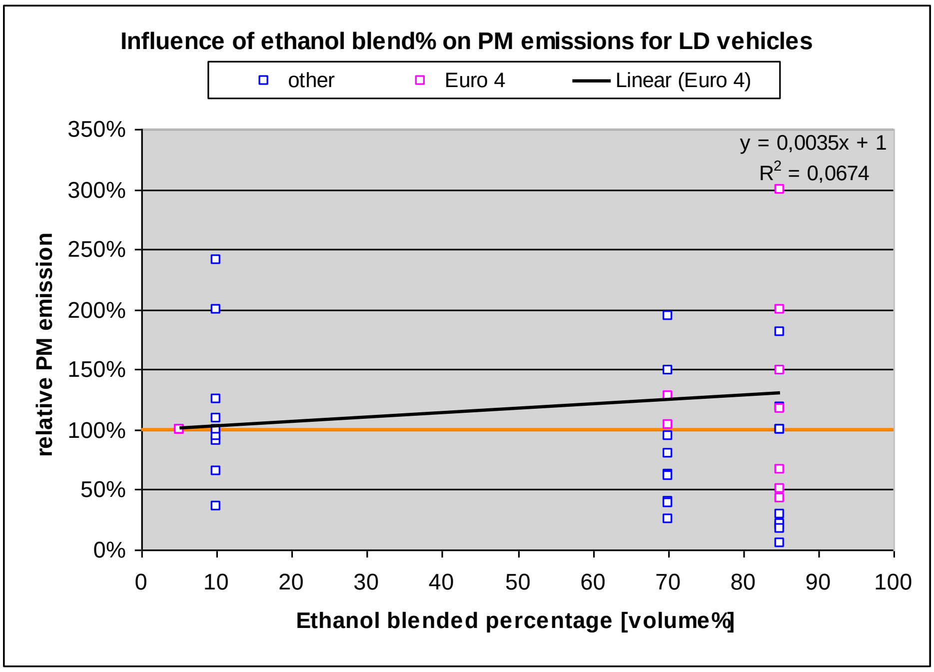
With E20 many vehicles show a deterioration, but it should be noted that these vehicles were never developed for E20.

Figure 25 **The influence of ethanol blend% on NO_x emissions for LD vehicles (E0=conventional gasoline =100)**



Source: BOLK II.

Figure 26 **The influence of ethanol blend% on NO_x emissions for LD vehicles (B0=conventional gasoline)**



Source: BOLK II.

For the future no issues for FFVs are expected with pollutant emissions, because of the planned improvement with the type approval procedure with Euro 5 phase B entering into force (2012).

Then FFVs need to fulfil the same requirements on the high ethanol blend (E85) as on petrol. The emissions are then expected to be very close to those of gasoline vehicles.

Opportunities in non-road transport

ED5 to ED15 can be considered in shipping and rail transport but the (negative) impact is most likely quite large, for example regarding strain on materials (elastomers and metals). It can not be used in existing or older engines because leakages are a safety hazard, therefore a protection grade fuel is required. Ethanol will attract moisture with can create additional problems such as microbial contamination (especially with longer storage times).

Ethanol blends can not be used in aviation due to the specific fuel requirements in that sector. The lower specific energy of ethanol (energy per unit of mass) is also a significant disadvantage for aviation.

Potential of optimizing engine efficiency

Passenger cars:

Ethanol has a very high octane number (110+). An efficiency improvement in the order of 5% is likely if an engine is specifically optimised for high blends (dedicated ethanol E85 engine).

Annex E Factsheet: ETBE

Introduction and fuel specifications

Ethyl Tertiary Butyl Ether (ETBE) has been applied as a gasoline octane number improver. ETBE is produced from bioethanol (37%) and isobutylene (63%), where the isobutylene fraction cannot be marked as a biofuel. An ETBE blend of 17 vol.% in regular gasoline therefore results in a 5.6 vol% biofuel content. ETBE has a high RON number and low and stable RVP and the specific energy content is closer to that of gasoline than of ethanol. The density is very close to gasoline density. From a technical point of view ETBE is a blending component with very good properties.

Table 57 **Fuel specifications**

Energy density	Unit	Petrol	ETBE	MTBE
Per litre	MJ/l	31.8	26.8	26.7
Per kg	MJ/kg	43	36	35.2
Range	km	500	421	420
Octane # (RON)	-	>95	118	110-118

Biofuels production

ETBE is produced from ethanol, see Annex D for an overview of the feedstock for bioethanol.

ETBE production processes are mature, and existing MTBE production processes can be converted to ETBE production if commercially attractive.

Blending in base fuel road transport (current situation)

ETBE can be applied in all passenger cars and LCVs with a spark ignition engine.

As long as the legal limit is not exceeded (about 17% of petrol), no technical or marketing issues exist. Fuel suppliers will use ETBE is costs are favourable, compared to bioethanol or other biofuels.

Potential to increase current limits

ETBE/MTBE is currently limited to about 17% due to the maximum oxygen content of 3.7% of petrol.

There is currently no real interest to increase the current blending limit, mainly since ETBE is only partly renewable.

High blends in road transport

Not applicable

Opportunities in non-road transport

Use of ETBE is limited to petrol engines, and therefore not attractive for the shipping sector.

Petrol with ETBE or MTBE can be used in small planes with piston engines, but this is a very small market.

Potential of optimizing engine efficiency

The high octane number of ETBE and MTBE can be used to increase the overall octane number of the fuel. This makes it possible to increase specific power output and/or compression ratio, which can lead to a higher engine efficiency.

Annex F Factsheet: HVO

Introduction and fuel specifications

Hydrotreated Vegetable Oil (HVO) is produced by thermal hydrotreatment of either a mixture of diesel and vegetable oil or animal fats, or of pure vegetable oil or animal fats. Characteristics are very similar to fossil diesel.

Table 58 **Fuel specifications**

Energy density	Unit	Diesel	HVO
Per litre	MJ/l	35.8	34.4
Per kg	MJ/kg	42.7	44.0
Range	Km	600	577
Cetane #	-	40-59	80-99

Biofuels production

HVO can be produced from a whole range of vegetable oil and animal fats, where palm oil is the main feedstock at the moment.

Neste Oil is currently the main producer in the EU, with HVO production plants in Porvoo, Finland (380 ktoe/year total capacity) and in Rotterdam (800 ktoe/year capacity). A 800 ktoe/yr production plant is also in operation in Singapore.

Blending in base fuel road transport (current situation)

HVO is fungible with diesel, and can currently be blended up to 30% in standard diesel, according to EU legislation. There are therefore no technical or marketing issues that need to be addressed.

Increasing the use of HVO in the base fuel will depend on HVO cost, compared to that of other biofuels.

Potential to increase current limits

In view of current production capacity and potential demand, there is currently no need to consider an increase of the HVO blending limit.

High blends in road transport

Higher blends of HVO (above 30%) may require adaption of engine calibration due to the lower density (optimisation can be for power output or NO_x control).

Higher HVO blends of up to possibly 100% are possible provided the specific EN590 fuel standards are met.

Opportunities in non-road transport

HVO can be used in shipping, there are no technical concerns. For inland shipping the tendency is to use EN590 and also the same fuel as for on-road transport.

The aviation sector is also interested in HVO, as kerosene with HVO is a very suitable jet fuel. Pilot projects are being carried out.

Increasing HVO use in these sectors will depend on the (additional) cost of the fuels, in combination with potential incentives.

Potential of optimizing engine efficiency

The engine efficiency with HVO is almost identical to diesel. A few percentage point improvements may be possible if the engine is specially optimised for the high octane number of HVO.

Annex G Factsheet: Biomethane (bio-CNG and bio-LNG)

Introduction and fuel specifications

Biomethane is derived from renewable materials such as sewage, landfills and agricultural waste by means of anaerobic fermentation. Depending on the source the composition of biomethane differs greatly, with methane contents vary between 65-85% for biogas from agricultural waste, and 30-70% for landfill gas.

For use in modern vehicles it is generally required to upgrade raw biogas to natural gas quality. After upgrading biogas the resulting product is often called biomethane, which can be blended with natural gas. Several gas qualities are used in Europe.

For passenger cars the biomethane (or natural gas) is always stored as Compressed Natural Gas (CNG). For trucks this can either be CNG or as Liquefied Natural Gas (LNG). The LNG storage is at a cryogenic temperature of about -160˚C. In that case more energy can be stored, which results in a significantly longer driving range.

Table 59 **Fuel specifications**

Energy density	Unit	Petrol	Diesel	NG	Bio-CNG	Bio-LNG
Per litre	MJ/l	31.8	35.8		7.9	20.5
Per kg	MJ/kg	43	42.7	38-50	38	45
Range	km	500	600		250	
Octane # (RON)	-	>95	-	120	>120	>120
Cetane #	-	-	40-59	-	-	-

Biofuels production

Various types of feedstock can be used to produce biogas via anaerobic fermentation, such as municipal organic waste, wet or dry manure, maize, etc. In addition, biogas can be recovered from, for example, sewage treatment plants.

This type of production technology is mature, and in place throughout the EU. In most cases, the biogas is then used to produce electricity or heat, only few Member States use biogas (or rather biomethane) in the transport sector.

Biogas cost depend on the scale of the plant, and the cost of the feedstock.

Passenger cars

Bio-methane compatible light duty vehicles are only available in spark ignition engines in combination with CNG. The CNG vehicles are possible in the following two variants:
- dedicated: mainly use CNG as a fuel. A very small petrol tank is only used for ‘limb-home’ on petrol;
- bifuel: can use both CNG and petrol.

Dedicated CNG vehicles are always OEM systems, bifuel can be either a OEM system or a retrofit system, however, retrofit systems have a negative effect on exhaust emissions. Compared to conventional petrol engines, CNG engines have somewhat higher NO_x emissions.
The market share of CNG vehicles is very small due to the small amount of available vehicles and the limited infrastructure. Five manufacturers in Europe are offering two or three CNG models. Three of them are currently offering both bifuel and dedicated versions.

An investigation done in the Netherlands on several types of CNG vehicles showed that durability of CNG vehicles was good with similar or lower maintenance costs as for diesel vehicles. Also the pollutant emissions level showed little deterioration, even after several hundreds of thousand kilometres (Kadijk, 2010).

The additional purchase price for (bio)CNG passenger cars ranges between € 2,000 and € 7,500

The current market share of CNG for road transport in Europe is around 0.3% (Seidinger, 2011). Italy has with 1.5% the largest market share in Europe. The share of bio-CNG is not known, but likely to be very low.

It is expected that in the best case the market share can grow to about 2% in 2020 under the following conditions:
- more car models with (bio) CNG engines will become available;
- the infrastructure continues to develop;
- the price differential between (bio)gas and diesel or petrol remains such that the higher vehicle purchase price is compensated by lower fuel costs;
- the owners of gas-powered vehicles fill their cars with bio-CNG (and not CNG).

HD vehicles
Most of the larger HD vehicle manufacturers offer vehicles with natural gas engines. Most of them are spark ignition engines, although two manufacturers are offering dual fuel engines based on the compression ignition or diesel cycle. In the latter, diesel is used to start the combustion of the natural gas. The natural gas replaces about 25-75% of the diesel depending on the engine type and the operating conditions.

An overview of the manufacturers is shown in Table 60.

Table 60 Overview of the manufacturers

HD vehicle manufacturer	(bio) CNG/LNG HD vehicles
Daimler	Spark ignition
Renault	Spark ignition
MAN	Dual fuel - compression ignition
Volvo	Dual fuel - compression ignition
Scania	Spark ignition
Iveco	Spark ignition

The operating range of bio-methane vehicles is lower compared to conventional diesel vehicles, the vehicles are therefore mostly used in regional or urban transport. Bio-methane is also often used in buses.

The benefit of trucks and bus fleets is that they often have their own tank facilities, hence the limited infrastructure is a smaller issue.

(Bio) CNG/LNG HD vehicles have shown some technical problems in the past. In several programs, the pollutant emissions levels for Euro V and EEV spark ignition vehicles were compared to those of diesel vehicles. The gas engines were generally quite good and better than the diesel vehicles.

This has not been demonstrated for Euro V dual fuel vehicles. Legislation to formally allow these vehicles is currently being developed. Marketing of these vehicles types by truck manufacturers will probably increase in the future when the legislation is finalised.

Currently Euro VI diesel vehicles are entering the market. In this respect the (bio) CNG/LNG vehicles are lagging somewhat behind.

The share in vehicle and biomethane fuels sales in 2020 and beyond depends on several aspects:
- Will the fleet owners continue to value the positive environmental perception of biomethane or natural gas vehicles? This includes GHG, pollutant and noise emissions levels.
- How does the total costs of ownership compare?
- How much biomethane is actually available?

Expectations of the vehicle share in 2020 is several percentage points. As can be seen in various cities throughout the EU, a high market share is possible for city bus application, with favourable national and European policy measures.

Opportunities in non-road transport
(Bio) LNG is a good fuel option for shipping (inland and coastal shipping). The sector is quite interested in LNG, mainly because of low price and low emissions. Bio-LNG would need to have a competitive price in order to be successful. Several engine technologies are available: dual fuel with diesel (20-30% diesel), with pilot diesel (≈2% diesel) and spark ignition. Aviation (bio) LNG or CNG is not an option for aviation due to large storage volume of the fuel and other storage issues (packaging and weight).

Potential of optimizing engine efficiency
Considerable differences in engine efficiency are seen, depending on the engine type and also the application. For typical spark ignition engines for passenger cars, trucks and buses, the engine efficiency is generally 20% to 30% lower than a comparable diesel engine. On the other hand, when a turbocharge natural gas engine is compared to an average petrol engine, the efficiency is somewhat higher.

If (bio)methane is used in dual fuel engines for trucks, typical diesel engine efficiencies will be reached. Also with stationary or ship methane engines, the engine efficiencies are very close to those of diesel engines (for both compression and spark ignition engines).

In heavy-duty applications, both stoichiometric and lean burn ($\lambda > 1$) engine concepts are used.

Annex H Factsheet: Co-processing in refineries

Introduction and fuel specifications
In this option, part of the fossil fuel (crude oil) feedstock into refineries is replaced by liquid biomass or biofuel. The resulting product is a HVO diesel, with relatively high cetane value, but also higher cloud point. The cloud point depends on the type of plant oil that is used.

This feedstock could be various types of (pre-processed) plant oils, including tall oil (used as feedstock in the PREEM refinery in Gothenburg).

Biofuels production
The biomass feedstock can be fed into the hydrotreaters of the refineries.

This process has been applied and tested so far in a number of refineries in the EU and USA, by various oil companies including BP, Shell and Total. It requires some adaptions to the refinery processes (e.g. to the catalytic agent).
The maximum share of biomass feedstock is not yet known, but likely to be 5 to 10%, with variations depending on the season (CE Delft, 2010).

Blending in base fuel road transport (current situation)
The resulting fuel is a diesel which is produced from a blend of fossil and bio-based feedstock. As mentioned above, the maximum share of the bio-feedstock is probably about 5 to 10%. This is determined by the refinery processes, and the diesel fuel specification.

Potential to increase current limits
Not relevant.

High blends in road transport
Not relevant.

Opportunities in non-road transport
The resulting diesel can be used in non-road transport as well. This process also results in some other refinery products, including aviation fuel.

Potential of optimizing engine efficiency
The engine efficiency is almost identical to conventional diesel. Some improvements may be possible if the engine is specially optimised for the high octane number of the resulting HVO, but this will be negligible at the low blend levels that can be achieved in the coming years.

Annex I Factsheet: Bio-methanol

Introduction and fuel specifications
Bio-methanol can be produced through gasification, and has similar characteristics to ethanol. However, not much effort has been put in place to promote the production and use of bio-methanol, mainly because of its toxicity, aggressiveness to materials and low energy content. Car manufactures do not allow high blend methanol in current vehicles.

Methanol from renewable sources can also be used as a feedstock for production of FAME, bio-MTBE and bio-DME.

Table 61 **Fuel specifications**

Energy density	Unit	Petrol	M20	M85	M100
Per litre	MJ/l	31.8	28.6	18.0	15.6
Per kg	MJ/kg	43	38.1	23.0	19.7
Range	km	500	449	283	245
Octane # (RON)	-	>95	-	-	>110

Feedstock
A whole range of biomass types can be used to produce bio-methanol, including farmed and waste wood, grass and black liquor. A Dutch methanol plant uses glycerine as a feedstock, a by-product of FAME production.

Biofuels production
Production of bio-methanol is a mature process, but not all potential types of feedstock can be used on a commercial scale yet, as gasification of ligno-cellulosic biomass is still in development.

Blending in base fuel road transport (current situation)
The EU Fuel Quality Directive (Directive 98/70/EC as amended) permits the use of up to 3% methanol in petrol with appropriate stabilizing agents.

In addition, the bio-methanol can be used to further reduce the environmental impact of FAME production, and to produce bio-MTBE or bio-DME. Petrol may contain up to 15% MTBE (or ETBE), which corresponds to about 47% of methanol. In the last 10-15 years, MTBE production is seen to decline, where ETBE production is increasing.

Potential to increase current limits
In order to increase the current methanol blending limits, materials compatibility and engine control need to be addressed. Methanol may be more corrosive than ethanol. A protection grade fuel might then be necessary. Vehicle cost of higher blend vehicles will be somewhat higher due to materials compatibility.
Fuel marketing issues may then arise because it may create problems with non-compatible vehicles, and customers may prefer the lower blend.

High blends in road transport

A number of blending options can be identified.
Passenger cars and vans (spark ignition):
- medium-high blend: M20 or M30;
- high blend: M85 to M100 in combination with a Flexible Fuel Vehicle technology. Similar to E85 but there are differences in engine control parameters and materials compatibility.

Trucks and buses:
- MD95 compression ignition: ethanol with ignition improver combusted in a diesel cycle engine;
- M85 spark ignition can be considered for light/medium duty-duty trucks and busses.

The higher blends may require specific attention to prevent soil and groundwater pollution if methanol is spilled (see, for example, Concawe, 2012).

Passenger cars and vans:
M85 (85% methanol) to M100 vehicles were developed in the eighties. Combustion and emission control is quite similar to petrol. No significant risks but development and (field) testing would require substantial time. Issues with corrosion and lubricant deterioration would need to be addressed. Also special development of direct injection fuel injection systems is necessary.
All materials need to be methanol compatible. Shorter maintenance intervals (such as oil drains) are likely, at least during the development stage of this technology.

Heavy-duty vehicles:
Compression ignition with ignition improver similar to ethanol ED95, but development of entirely new high pressure fuel injection system for a range of engines will take a long time.
M85 spark ignition engines may be based on natural gas engines.

Possible industry wide market introduction of MD95 engines or M85 engines for the majority of the trucks manufacturers is not realistic before 2020. Development teams are already heavily loaded with the extensive requirements of EURO VI (including OBD and in-service conformity).

Impact on vehicle costs (purchase and maintenance).
Passenger cars and vans:
Two options for high blend:
- medium-high blend: M20 or M30: low additional costs for a petrol vehicle;
- maximum several hundred Euro is expected;
- high blend: M85 in combination with a Flexible Fuel Vehicle.

Quite similar additional costs as an FFV vehicle for ethanol (E85).

Heavy-duty vehicles:
Impact on vehicle price likely similar to increase of ED95 currently offered.

The energy content of methanol is lower, which would need to be compensated in the methanol price.

Passenger cars and vans, possible marketing options:

- Medium-high blend: M20 or M30: marketed as a 'base fuel' (large volumes), available at each petrol station.
- High blend: M85 marketed as fuel for flexible fuel vehicles, able to run on petrol and any mixture of petrol and methanol. Complete geographical coverage at fuel stations is then not required.

There might be potential to market this via dedicated fleets such as busses, M85 for taxis, etc.). Dedicated fleets are preferred in order to control vehicle costs and fuel distribution costs.

Opportunities in non-road transport

Shipping: no, risk of spillage and engine technology.
Aviation: no, not compatible with kerosene.

Potential of optimizing engine efficiency

Methanol is an excellent spark ignition fuel which also serves as octane improver: 0-5% potential improvement in energy efficiency.

Methanol may be suitable for new combustion systems such as HCCI with a potential large improvement in efficiency. Issues are then: emission control and engine control.

Compression ignition: same efficiency as with diesel fuel expected.

Annex J Factsheet: Bio-DME

Introduction and fuel specifications

Bio-DME is a gas which liquefies at about 6 bar and has similar properties as LPG. It can be produced through gasification of biomass.
It is also used as a propellant for cosmetics cans.

Table 62 Fuel specifications

Energy density	Unit	Diesel	DME
Per litre	MJ/l	35.8	18.8
Per kg	MJ/kg	42.7	28.0
Range	Km	600	315
Cetane #	-	40-59	55-60

Bio-DME production can use the same feedstock as bio-methanol production (see previous factsheet).

Biofuels production

Production of bio-DME is still in its infancy, with a first pilot plant currently in operation in Sweden. It uses black liquor as as feedstock, a byproduct of pulp and paper production. This pilot project is carried out by Chemrec, Volvo, Preem, Total, Haldor Topsoe, Delphi and ETC, where Volvo is working on vehicle technology.
Further growth of production capacity is currently difficult to predict.

Blending in base fuel road transport (current situation)

DME is only used as a pure fuel.

Potential to increase current limits

Not applicable.

Pure DME in road transport

DME has a low auto-ignition temperature and can consequently be combusted in a compression ignition engine. It needs a special injection system, because of its very different properties compared to diesel fuel. Volvo has developed an engine which is used in several demonstration trucks.
Before DME engines can be commercialised, it is important that several engine manufacturers develop engines and the infrastructure is developed. This is not expected to be happening within 5 tot 10 years.

DME can be distributed and stored in a very similar way as LPG. Also the vapor pressure is similar to LPG. DME is not toxic and does not pose a environmental danger when spilled.

Engine development is challenging, because the compressibility and the sensitivity of the DME properties to temperature variations. The lubricity is also low.
Vehicle cost are expected to become similar to normal diesel engines when series are large.

Energy density is about 50% of diesel fuel, so DME is les suitable for long haulage trucks

Market via dedicated fleets is the most likely way forward during the market development phase.

The market is expected to remain limited in the coming 5-10 years.

Opportunities in non-road transport

Shipping: Could be possible. Cargo space is lost because of lower energy density and more difficult packaging of the tanks.
Aviation: No, bio-DME is incompatible with kerosene. Storage space would be too large.

Potential of optimizing engine efficiency

Similar efficiency compared to the diesel fuelled engine.

Annex K Factsheet: BTL

Introduction and fuel specifications

BTL (biomass-to-liquid) is a synthetic diesel, produced by gasification and Fischer-Tropsch synthesis of biomass. Properties can vary substantially depending on the process technology and product streams being blended. Generally, GTL and BTL fuels have favourable characteristics for use in CI engines, it has good auto-ignition characteristics, low sulphur content and low aromatics and it is suitable for use in unmodified diesel engines. Synthetic diesel can be used as blend in standard diesel fuel in order to upgrade the cetane number or as a pure fuel with high cetane number.

Similar to conventional diesel fuel, GTL/BTL fuels represent a generic type of fuel, rather than a fixed fuel specification. As a result, there are potentially an infinite number of FT fuels that each could have their own unique fuel specification (i.e. density, cetane number, etc.).

Table 63 Fuel specifications

Energy density	Unit	Diesel	BTL
Per litre	MJ/l	35.8	34.0
Per kg	MJ/kg	42.7	44.0
Range	km	600	570
Cetane #	-	40-59	84-99

Feedstock

Many different types of biomass could be used in the future once the gasification technology is sufficiently developed, including waste wood and farmed wood, agricultural residues, etc.

Biofuels production

BTL is still in the R&D phase, although progress has been made in the past years, especially in the USA. A number of demonstration plants have been built or were announced, but to our knowledge none is currently in operation (www.biofuelstp.eu/btl.html).

Blending in base fuel road transport (current situation)

BTL can be used in both light and heavy-duty vehicles with compression ignition engines. Engine compatibility is very good and quite similar to HVO

High blends in road transport

BTL can also be used as high blend fuel once production capacity has been built.

Opportunities in non-road transport

Shipping: Yes. Very well compatible, also for ship. For inland ship the tendency is to use EN590 and also the same fuel as for on-road transport.
Aviation: Yes, BTL compatible to kerosene can be made.

Potential of optimizing engine efficiency

Engine efficiency with BTL is almost identical to diesel. A few percentage point improvement may be possible if the engine is specially optimised for the high octane number of BTL.

Annex L The REST model

L.1 Introduction

The main aim of the calculation model is to calculate the influence of different biofuel blending strategies on the achievement on the RED target as well as on the FQD target.

L.2 Input

The data used as input for the model can be categorised in a category country specific data and data in line with the calculation methodology of the Renewable Energy Directive as well as the Fuel Quality Directive.

Both categories will be explained shortly:

Country specific data

The predictions on the composition of the vehicle fleet from PRIMES-TREMOVE v.2 baseline scenario for the year 2020 were used as a starting point for the model. Predictions are provided in PJ or ktoe for each individual Member State and for total EU27. The vehicle categories were used to list the possible options to blend biofuels for each category. Both low blends in regular vehicles (bulk) and high blends in niche vehicles (niche) are included.

Besides data from PRIMES-TREMOVE v.2 baseline other country specific data were used as input for the model, namely:

- the average share of renewable electricity in 2020 (taken from ECN, 2011);
- the emission factor for electricity generation (taken from the FQD Directive).

Calculation methodologies of the RED and FQD

The methodology for calculating the greenhouse gas emissions of biofuels and the contribution to the 10% target were already laid down in the Renewable Energy Directive.

The following data were obtained from the RED:

- multiplication factors for biofuels from waste and residues and for renewable electricity in road transport;
- energy content for biofuels as well as conventional fuels;
- GHG emissions factors per biofuel (the average was taken in case the Directive included emissions factors per feedstock).

Variables

The model makes it possible to vary a wide range of variables. The main variables in the model, which are used in this study, are:

- composition of low blends (in vol% per biofuel);
- composition of high blends (in vol% per biofuel);
- market share of niche vehicles (in %).

L.3 Outcome

Depending on the variables the model provides different outcomes. On the one hand the contribution to the RED and FQD target is an important part of the outcome in combination with the quantities of biofuels and renewable electricity needed to meet the targets. Quantities are provided per type of biofuel and a distinction is made between single- and double-counting biofuels. The amount of renewable energy in the transport sector is also provided for non-road as well as road transport. Per category the actual blended amount of biofuel/energy as well as the contribution to the target is presented. The sum of all those categories is presented as the total renewable energy (in PJ or ktoe) together with the total amount of energy in the transport sector.