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EU renewable energy targets in 2020: Revised analysis of scenarios for transport fuels

JEC Biofuels Programme

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Abstract

This study provides a robust scientific assessment of different renewable energy implementation scenarios and their associated impacts on RED 10% renewable energy target for transport. The primary focus is on road transport demand although all other transport modes (aviation, rail, inland navigation and off-road) have also been considered and would be important contributors towards reaching the renewable target and GHG reduction target.

EU renewable energy targets in 2020:
Revised analysis of scenarios for transport fuels

JEC Biofuels Programme

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This report is the result of the JEC Biofuels Programme, a joint study carried out by JRC (the Joint Research Centre of the European Commission), EUCAR (the European Council for Automotive R&D) and CONCAWE (the oil companies' European association for environment, health and safety in refining and distribution).

This report updates and revises the JEC Biofuels Study released in 2011 (EUR 24770 EN) by the JEC partner organisations.

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Executive Summary

The on-going research collaboration between the Joint Research Centre of the European Commission, EUCAR and CONCAWE has re-investigated the potential for fuels from renewable sources to achieve the 10% renewable energy target for the EU transport sector by 2020 as mandated by the 2009 Renewable Energy Directive (RED)[1]. The first JEC Biofuels Study[2] was completed in 2011 and has been updated to account for changes in the vehicle fleet, energy demand, fuels and biofuels supply, and regulatory outlook that have occurred since 2011. Associated calculations of the Greenhouse Gas (GHG) reductions as mandated in Article 7a of the 2009 Fuel Quality Directive (FQD)[3] have also been performed for four different fuel demand scenarios. In addition, consideration has been given to other relevant regulations impacting the transport sector in the coming decade.

Recent regulatory amendment proposals - including those put forward by the European Commission (October 2012), the European Parliament vote in 1st Reading (September 2013), and the Environmental Council (December 2013)[4] - have the potential to change important aspects of the 2009 RED and FQD. These proposals have been analysed in this report.

This study provides a robust scientific assessment of different fuel demand scenarios and their associated impacts on the RED 10% renewable energy and FQD 6% GHG reduction target for transport. The primary focus is on road transport demand although all other transport modes (aviation, rail, inland navigation and off-road) have also been considered and would be important contributors towards reaching the renewable energy and GHG reduction targets.

An analytical tool, called the Fleet and Fuels model that was developed and used in the 2011 JEC Biofuels Study, has been updated accordingly. The model is based upon historical road fleet data (both passenger and freight) in 29 European countries (EU27 plus Norway and Switzerland) and it projects forward the composition of the vehicle fleet to 2020 based on reasonable assumptions including the impact of regulatory measures. The modelled fleet composition leads to a road transport fuel demand and provides the basis upon which the introduction and availability of renewable and alternative motor fuels are analysed. The sensitivity of key modelled parameters on the RED 10% renewable energy and the FQD 6% GHG reduction targets are also analysed.

During the development of the Fleet and Fuels model, the most recent energy and fuel demand data were used and experts in related projects were consulted to ensure that the model had been constructed using sound data and reasoning. In addition, the JEC consortium has consulted and interacted with other modelling teams that produce studies in the same domain[5] and has consulted the European Commission's Inter-Service Group on Biofuels to refine draft results. Comments have been duly taken into consideration and have contributed to improving the quality of the study presented in this report.

Reasonable assumptions regarding the projected development of the European vehicle fleet, including different vehicle technology options and the resulting demand for fossil and renewable fuels have been made. From this starting point, the Fleet and Fuels model was used to evaluate a reference fuel demand scenario plus three further scenarios. The results based on the four different regulatory sets of provisions given the directives and proposals for amendment mentioned above were then compiled to compare the potential

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[1] RED: EU Renewable Energy Directive (Dir 2009/28/EC) of 23 April 2009

[2] JRC Report EUR24770EN-2011 ("EU Renewable energy targets in 2020: Analysis of scenarios for transport. JEC Biofuels Programme")

[3] FQD: EU Fuel Quality Directive (Dir 2009/30/EC) of 23 April 2009

[4] 2012/0288 (COD)

[5] EMISIA on behalf of the "TRACCS" consortium, E4Tech for the "2030 Auto-Fuel biofuel roadmap", TM Leuven for the TREMOVE model, and Aeris Europe Ltd. for the STEERS model

contributions of renewable energy in transport from each scenario. These have been further studied by sensitivity analysis and provide both information and material for further investigation in several research areas where energy and transport intersect.
The reference scenario was based on biofuel blends (B7, E5 and E10)[6] that are currently standardized as market road fuels in Europe. As was also the case for the reference scenario in the 2011 JEC Biofuels Study, the new reference scenario falls short of the RED 10% renewable energy target, when the renewable energy contribution from road transport is combined with an approximately 1% additional contribution from non-road transport modes.

The other three market fuel demand scenarios have also been analysed, based on higher biofuel contents and multiple blend grades, while considering the impact of shares of compatible vehicles in the fleet and increasing customer preference to choose the market fuel for their vehicle. Evaluation of these three scenarios has shown that the 10% RED target cannot be reached using either the accounting rules in the 2009 RED or the new amendment proposals. None of the proposed sets of multiple counting factors in the amendment proposals closes the gap towards achieving the RED renewable energy target, given the assumptions made in this study, including the projected supply of advanced renewable energy.

None of the considered scenarios achieves the minimum 6% GHG reduction target mandated in FQD Article 7a with the assumptions taken for the FQD calculations. Including the Indirect Land Use Change (ILUC) factors contained in the 2012 EC, 2013 EP and Council proposals has a substantial impact on the GHG reduction target.

A re-analysis of likely biofuel supply through 2020 has also been carried out using a “bottom up” approach. This re-analysis primarily focused on developments in non-conventional and advanced biofuels that are subject to specific accounting in the legislative proposals and their development is dynamic and changed since the first JEC Biofuels Study. The demand/supply analysis combines the results of the demand scenarios with biofuel availability scenarios.

Similarly to the 2011 JEC Biofuels Study, this study does not assess the viability, costs, logistics, or impact on the supply chain and vehicle industry of the different demand scenarios. Additional work would be needed before determining the commercial readiness of any one scenario.

Overall, the RED fuel demand scenario results depend on the underlying assumptions and should be considered as “theoretical”. Implementation of any scenarios would depend on a combination of factors, the associated costs and the timeliness of decisions.

Additional considerations

Consumer acceptance of biofuels, the respective market blends and a flawless market introduction of such market blends are critical elements of the fuel demand scenarios. Hence, the impact of market uptake has been evaluated in sensitivity cases. For example, the reference scenario assumes 36% of the consumers in 2020 will refuel E10 compatible vehicles in the road fleet with E10 gasoline. It is also assumed that E10 gasoline will be blended to the maximum oxygen/oxygenate limit in the EN 228 gasoline standard. Two sensitivity cases are included that evaluate the impact on the RED and FQD targets if this level of market uptake is more pessimistic or more optimistic.

On the supply side, the pace of introduction of renewable fuels presented in the scenarios depends not only on the availability of the feedstock and fuels but also on the compatibility of the supply and distribution system for all fuel products (including proliferation of blending options). It also depends on the contribution of non-road transport modes towards approaching the RED 10% target.

Realisation of some scenarios may require policy measures to enable a smooth transition from today’s situation.

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[6] In this report, biofuel contents are expressed as the percentage of bio-component in fossil fuel on a volume basis. For example, B7 stands for 7% v/v Fatty Acid Methyl Ester (FAME) in diesel fuel while E5 stands for 5% v/v ethanol (or 2.7wt% oxygen) in gasoline.

Furthermore, national contexts differ widely. It is therefore important that fuel standardisation proceeds in a co-ordinated way to reduce market fragmentation for fuels and their supply. Market fragmentation would also negatively impact vehicle manufacturing, and customer confidence. Compatibility between different fuel blends and vehicles is critical in determining the pace and uniformity of introduction of alternatives in a single European market, and avoiding a proliferation of nationally-preferred and nationally-adapted solutions. Multi-stakeholder coordination and timely decisions will be essential in order to approach the RED and FQD targets.

The 2013 JEC Biofuels study acknowledges among its findings that much more technical work will be needed to ensure the feasibility of any of the fuel demand scenarios considered. The compatibility between the market fuels having higher renewable fuel contents with road transport vehicles and those in other transport modes is not proven and the evaluation process to ensure compatibility will require time, testing and investment.

Report Outline

In this report, the potential for renewable fuels to achieve mandatory targets for renewable energy and GHG intensity reduction in EU transport by 2020 has been assessed. Contributions from the road and non-road transport sectors have been considered as well as taking the broader view on other alternative fuels. Specifically, dedicated model runs have been performed to assess air transport's contribution to the RED regulatory target.

Following a review of the EU regulatory framework in Chapter 2, Chapter 3 describes the Fleet and Fuels Model developed by JEC and includes details of the reference scenario. Chapter 4 discusses the biofuels supply outlook including advanced biofuels assumptions. Chapter 5 outlines the outcomes of the study including the reference case, comparison with JEC Biofuels Study 2011, different market fuel demand scenarios, a comparative impact of legislative proposals and sensitivity runs. Conclusions from the study are presented in Chapter 6.

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1. Introduction

1.1 What is JEC?

The JEC research collaboration between the Joint Research Centre of the European Commission, EUCAR (the European Council for Automotive Research and Development) and CONCAWE (the oil companies' European association for environment, health and safety in refining and distribution) began in the year 2000. The three organisations have collaborated in the fields related to the sustainability of the European vehicle and oil industries, providing information relating to energy use, efficiency and emissions from a broad range of road vehicle powertrain and fuel options. The JEC Well-to-Wheels (WTW) reports (JEC, 2014) and methodology have become a scientific reference in the European energy research landscape.

1.2 The JEC Biofuels Programme

The first JEC Biofuels Study was released in 2011 (JEC, 2011b) providing a robust scientific basis for decision making and a sound outlook on the implementation of EU regulation, including the Fuel Quality Directive (FQD) (EC, 2009b).

JEC partner organisations agreed to resume their Biofuels Programme based on the perceived need and the opportunity to revise their 2011 report acknowledging that it had become outdated. Reasons pertained to two sets of considerations:

- Proposals to revise the 2009 Directives at the EU level were introduced by the European Commission in October 2012 (EC, 2012b), amended by the European Parliament in September 2013 (EP, 2013) and by the Environment Council in December 2013 (CEU, 2013). These legislative concepts for RED and FQD implementation bore significant differences and – therefore – impacts on the feasibility, the efficiency and the ambition level required to achieve them.
- Market development factors (such as road fleet renewal, availability of market blends (E10), consumers' preferences determining the uptake of fuel alternatives, and the availability of advanced renewable fuels differed considerably from projections in the 2011 report.

This work does not limit its focus to the role of biofuels in road transport because the RED and FQD mandated targets do not solely focus on biofuels as alternative fuels nor do they solely focus on road transport contributions. Accordingly, in line with the RED target, other alternatives to both conventional fuels and biofuels have been investigated in the JEC Biofuels Programme: a critical assessment has been made in this revision to include all alternative renewable fuels for which realistic expectations exist in terms of market entry and relative impact towards achieving the regulatory targets by 2020. In addition, non-road transport modes have been considered for their potential contribution to the RED and FQD targets as well as complementary or competing demands for the same alternative fuel products as road transport.

This technical exercise was aimed at identifying and characterising a set of realistic and technically-feasible scenarios to achieve the RED and FQD targets and to provide an initial analysis of the advantages and disadvantages of each scenario. It was conceived and intended as a technical exercise, thus not committing JEC partners to deliver any particular scenario or conclusion included in the study and presented in this report.

Consistent with the first report published in 2011, the revision of the JEC Biofuels Study, including the methodology and activities, is defined by its objectives, scope and approach.

1.3 Objectives of the JEC Biofuels Programme

The objectives of the JEC Biofuels study 2013 revision are:

- To clarify the opportunities and barriers to achieving 10% renewable energy in the transport sector by 2020 and a 6% reduction in GHG intensity of transport fuels, by developing theoretical fuel demand scenarios which can be evaluated and compared to supply projections of renewable fuel types and availability;
- To extend the Fleet and Fuels (F&F) model to test different legislative concepts for RED and FQD amendment (such as accounting caps on conventional biofuels, multiple counting factors, and GHG savings based on specific production pathways);
- To update the EU27+2 Fleet and Fuels model baseline from 2005 to 2010;
- To update fixed demand values for non-road transport modes;
- To focus on conventional and alternative fuels and biofuel blends while accounting for growth in alternative powertrains share from 2010-2020;
- To revise the supply outlook for both conventional and advanced biofuels;
- To ensure that the introduction of biofuel blends in Europe to meet regulatory targets is analysed thoroughly and reflects market experience by introducing a ramp-up function for the uptake of blend alternatives in the vehicle fleet and also by performing sensitivity analysis on the uptake of higher blend grades;
- To ensure that the introduction of biofuel blends in Europe to meet regulatory targets results in no detrimental impact on vehicle performance and emissions, while including in the analysis the most recent updates on Well-to-Wheels (WTW) energy and Greenhouse Gases (GHG) (JEC, 2014).

1.4 Comparison between 2013 results and JEC Biofuels Study 2011

A detailed description of the differences between the outcomes of the JEC Biofuels Study released in 2011 and its 2013 revision is presented in Section 5.2. Yet, it is worth summarising those differences in Table 1-1 and briefly describing the main causes.

For Reference Scenario		RED	FQD [w/o ILUC]	FQD [w/ ILUC]
TARGET		10%	6%	NA
2011 JEC Biofuel Study	2009 RED & FQD	9.7%	4.4%	NA
2013 JEC Biofuel Study	2009 RED & FQD	8.7%	4.3%	NA
	2012 EC Proposal	7.8%	4.3%	1.0%[7]
	2013 EP 1st Reading	8.2%	NA	1.0%
	2013 Council Text	8.7%	4.3%	1.0%[7]

Table 1-1. Overview of RED and FQD results v2011 vs v2013

Similarly to the 2011 version of the study, the revised Reference Scenario does not achieve the RED or the FQD targets based on the 2009 Directives. In contrast to the 2011 study, none of the re-defined fuel demand scenarios for this 2013 version achieve the RED or the FQD targets.

[7] For reporting only

Several factors are important to note:

- The pace of development and the supply volumes of advanced biofuels, including drop-in options, are not projected to fill the existing gap;
- The proposed multiple counting factors on selected feedstock categories do not close the gap towards reaching the RED target given their projected supply;
- Market introduction, customer preferences and acceptance to use available fuel alternatives, namely E10 and its market uptake, play an important role on approaching the RED and FQD targets;
- In general, vehicle sale trends point towards a slower renewal of the vehicle fleet resulting in a limited uptake of alternative-fuelled vehicles, including both the electric alternative and higher biofuel blends thus resulting in a bigger gap towards achieving the RED and FQD target. See Sections 3.1 and 5.2.4 for more information;
- The projected increase in the diesel/gasoline ratio in the European vehicle fleet results in a lower capacity to attain the FQD GHG intensity target, caused by lower renewable energy content in diesel compared to gasoline and diesel has a higher GHG intensity compared to gasoline.

The 2013 revision of the JEC Biofuels study widens its scope to analyse the potential effects of the legislative concepts put forward by the European Commission, the European Parliament and the European Environment Council in the co-decision procedure[8] to amend the RED and the FQD. It is worth highlighting in particular that the capping of conventional biofuels in the three proposals dwarfs the capacity for higher blend grades to contribute substantially to the RED target.

1.5 Scope of the JEC Biofuels Programme

The scope of the JEC Biofuels Programme is summarised as:

- Focusing analysis on road transport energy demand while at the same time including non-dynamic analysis of other transport modes;
- Analysing possible fuel demand scenarios within the 2010-2020 time horizon focusing on the uptake of alternative fuels subject to the compatibility of fuels and vehicles and consumer preferences.
- Focusing analysis on the supply outlook of biofuels (both conventional and advanced) and their projected availability on the European market.
- An analysis on feedstock availability for conventional biofuels is not part of this study. It is assumed that Europe can secure enough feedstock for conventional biofuels production consumed in Europe. Therefore it is assumed that the production of conventional ethanol and FAME is not a limiting factor.
- Other aspects were also considered, including requirements for phasing-in of fuel standards, (fuelling) infrastructure requirements, fuel production and distribution requirements and customer acceptance.

[8] 2012/0288 (COD)

1.6 Approach of the JEC Biofuels Programme

In line with the objectives and the scope of the JEC Biofuels Study outlined above, partner organisations developed a consensus demand and supply picture of renewable fuel types towards meeting the 2020 10% renewable energy target in the transport sector adopted by the RED (EC, 2009a). The approach has therefore been one of:

- Updating the dedicated Fleet and Fuels model based on historic data and consensual assumptions of future technological developments, covering:
  - Fleet development of passenger cars (PC), light commercial vehicles (LCV)[9], and heavy duty vehicles (HDV) including alternative powertrains
  - Fuel and energy demand development
- Reviewing and analysing statistics, projections and other data for the period 2010-2020, covering:
  - Availability of bio-diesel, ethanol and other renewable fuels, including conventional and advanced products
  - Domestic biofuel production and imports
  - Most recent updates on WTW energy and GHG implications (JEC, 2014)
- Analysing possible fuel demand scenarios within the 2010-2020 timeframe and subject to the existing regulatory framework.

The analysis performed in the 2013 revision of the JEC Biofuels Study takes into account the regulatory distinction between conventional and advanced biofuels since these terms are frequently used to describe either the feedstock used to produce the final biofuel or the process conversion technology. In this JEC Biofuels study, the distinction is made on the basis of the feedstock, in order to evaluate the multiple counting factors put forward in the regulatory proposals considered in the analysis. See Sections 4.1 and 4.2.2 for more information.

To ensure accuracy of the methodology and the assumptions, JEC work was accompanied by expert and stakeholder consultations[10] as well as practical research. These consultations were used throughout the study to review the analysis carried out in the JEC Biofuels Programme, including data availability and reliability as well as the underlying reasoning to assumptions in the F&F model.

In general terms, the "vision" of the 2010-2020 decade for European road transport as portrayed by the JEC Biofuels Programme is summarised below:

- ***Vehicle technology.*** There is a plausible expectation for more advanced propulsion systems, thus resulting in a further diversification in engines and subsequently in fleet composition. Vehicles are compatible (i.e. B7) or progressively compatible with fuels containing increasing volumes of bio-components, i.e. E10. On the regulatory side, it is expected that increased attention will be on CO_2 emissions reductions in the transport sector which will result in higher costs incurred by vehicle manufacturers for compliance.
- ***Refinery technology.*** In line with road fuel development expectations and higher expected diesel demand in other transport sectors, the diesel/gasoline demand ratio in Europe is expected to increase over this time period. In refineries, this will lead to higher CO_2 emissions in order to satisfy the increasing diesel demand. The more stringent product quality specifications will also contribute to these higher CO_2 emissions. Growing attention to CO_2 emission reductions via increasingly stringent regulation will result in higher production costs in refining which could in turn contribute to pressure on European refining margins and competitiveness.

[9] Light commercial vehicles are also called vans

[10] EMISIA on behalf of the "TRACCS" consortium, E4Tech for the "2030 Auto-Fuel biofuel roadmap", TM Leuven for the TREMOVE model, and Aeris Europe Ltd. for the STEERS model, the European Commission's Inter-Service Group on Biofuels for legislative concepts and demand/supply tensions.

– ***Biofuels and other renewable energy sources for transport.*** On the regulatory side, the 10% renewable energy minimum binding target is fixed since the adoption of the RED (EC, 2009a). It is expected that conventional biofuels will be widely available but sustainability concerns will continue to exist for some products. Advanced biofuels are likely to show a slower-than-expected pace of development and there is likely to be competition for supplies of advanced biofuels between countries around the globe with renewable fuel mandates and between transportation modes (e.g. road versus air transport). It is reasonable to expect that fleet renewal and adoption of renewable fuels could differ across EU Member States due to inherent energy and transport demands and diverse energy policy priorities. As a consequence, fuel markets in the EU could become increasingly diverse. In this respect, a robust, sound and timely standardisation process (i.e. CEN specifications) is crucial to allow implementation of potential future fuel options.

1.6.1 Renewable energy terminology used

When talking about fuels produced from biomass, many definitions are used that refer to biomass origin, type of feedstock and conversion technology. The industry and the regulatory debate have considerably evolved over the years and therefore a number of fuel notations used in the past might not be as clear as today. Some of the terms used are 1st generation, 2nd generation, next-generation, advanced biofuels, conventional versus non-conventional, low ILUC versus ILUC risks[11], etc. Figure 1-1 defines different fuel notations used in this report.

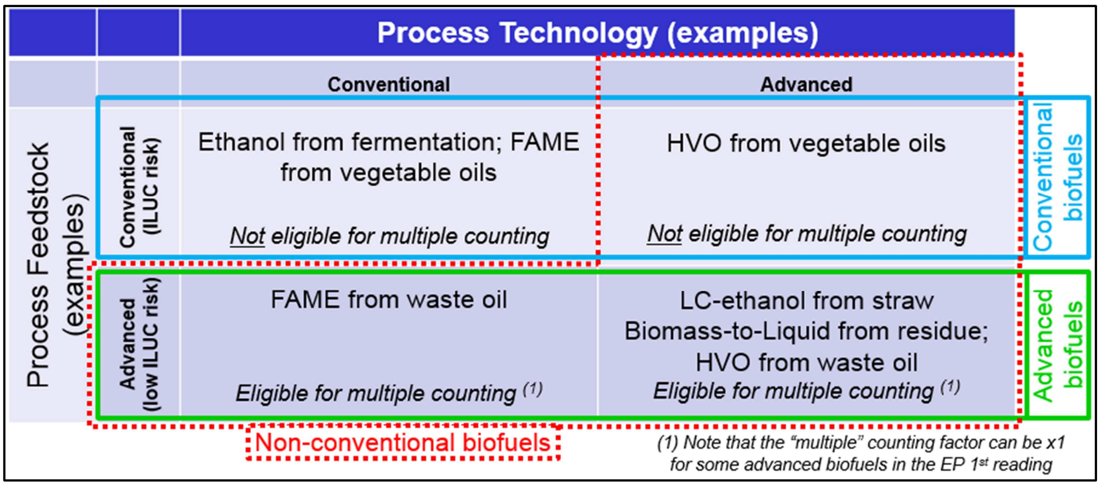

Figure 1-1. Biofuels terminology used in study

The terms conventional and advanced can be used when describing the feedstock that is used in a certain renewable energy production process. However it can also be used when a certain conversion technology is described. Figure 1-1 shows these two dimensions: process feedstock on the vertical axis and process technology on the horizontal axis. Within the feedstock dimension, conventional and advanced are also referred to as low ILUC risk and ILUC risk respectively. On the technology dimension, conventional and advanced strongly depend on technology maturity over time: today's advanced technology might be conventional tomorrow. An example is the Hydrogenated Vegetable Oil process (HVO), which is

[11] Source: Council note 2012/0288 (COD), page 10: 'Low ILUC risk biofuels' mean biofuels whose feedstocks are a) not listed in Annex V, Part A, or b) are listed in Annex V, Part A, but which were produced within schemes which reduce the displacement of production for purposes other than for making biofuels and which were produced in accordance with the sustainability criteria contained in Article 7b.'

interchangeably referred to as advanced and conventional technology depending on the process feedstock. However, this process is adopted and implemented on a commercial scale[12].

In this report, three terms are frequently used:

- Conventional biofuels: Biofuels produced from ILUC risk feedstocks regardless of the conversion technology. These include for example FAME and HVO from vegetable oils as well as ethanol from wheat.
- Advanced biofuels: Biofuels produced from low ILUC risk feedstocks regardless of the technology. These could include for example FAME from waste oil.
- Non-conventional biofuels: Biofuels produced from low ILUC risk feedstocks including advanced technology. These include for example HVO from waste oil and diesel from sugar.

In Chapter 4 the term non-conventional biofuels is used because the supply outlook also covers the HVO/co-processing[13] of ILUC risk feedstock.

[12] For example: HVO facilities of Neste Oil, http://www.nesteoil.com/default.asp?path=1,41,11991,22708,22720, accessed 04-02-2014; HVO facility of Diamond Green Diesel, http://www.diamondgreendiesel.com/Pages/default.aspx, accessed 14-02-2014

[13] Co-processing is referred to as biomass feeding in existing Refinery facilities by upgrading conventional units. Typically hydro-treating units are used for this. An example is Preem processing tall oil in Gothenburg refinery, http://evolution.preem.se/assets/upload/documents/From_tall-oil_to_Diesel.pdf, accessed 04-02-2014

2. EU Regulatory Framework

The reference regulatory framework within which the JEC Biofuels Programme was defined is the so-called "EU Energy Package", and more specifically the RED (EC, 2009a) and FQD (EC, 2009b).

2.1 The Renewable Energy Directive

The RED obliges Member States to achieve a general target of 20% renewables in all energy used by 2020 and a sub-target of 10% renewables in the transport sector.

EU Member States are required to meet a minimum binding target of 10% renewable energy share in the transport sector by 2020. All types of renewable energy used in all transport modes are included in the target setting.

Some renewable energy sources are counted differently. For example, the contribution of advanced biofuels[14] towards achieving the 10% target is counted twice[15] whereas electricity from renewable energy sources for road transport counts 2.5 times[16].

According to the RED, biofuels must meet minimum sustainability criteria as well as minimum GHG savings per energy unit (see Figure 2-1).

Sustainability Criteria of the RED and FQD Directives	
GHG impact	Minimum threshold of 35% GHG emissions saving (50% from 2017, 60% from 2018)
Biodiversity	Not to be made from raw materials obtained from biodiverse areas (including primary forests)
Land use	Not to be made from land with high carbon stocks (i.e. wetlands, forested areas, …) Not to be grown on peatlands
Good agricultural conditions	Requirement for good agricultural conditions and social sustainability

Table 2-1. Sustainability criteria RED and FQD directives

Each Member State was required to publish a National Renewable Energy Action Plan (NREAP), including information on their interim and 2020 targets for different transport and non-transport sectors.

In addition, Member States are expected to implement measures to achieve these targets, assessing the contribution of both energy efficiency and energy saving measures. From 2011 on, regular bi-annual progress reporting to the European Commission was envisaged.

Member States are responsible for ensuring compliance with the sustainability criteria. However, the European Commission can recognise voluntary sustainability certification schemes. The RED sets out the rules for the calculation of the GHG savings for individual plants and biofuels pathways. GHG emissions from cultivation (including direct land use change if it occurs), processing and distribution are included in the methodology. Emissions due to Indirect Land Use Change (ILUC) are not regulated in the original RED.

The diversity of feedstocks and the large number of biofuels pathways imply a level of uncertainty over the performance of biofuels in terms of GHG emission reductions compared to fossil fuels.

[14] See Art. 21.2 of the RED "biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material"

[15] Biofuels according to Art. 21.2 are counted twice in the numerator of the RED calculation – not in the denominator

[16] See Art. 3.4 of the RED; the factor of 2.5 is used in the numerator and the denominator

The RED places the overall responsibility for fulfilling the RED targets on the Member States.

Focus of the JEC Biofuel Programme:
- Model renewable energy in road transport.
- Use RED methodology to calculate ROAD-% contributions. These ROAD-% must be combined with assumptions for other transport sectors to calculate the RED-%.

Calculation of the contribution of road transport to the RED 10% target:

ROAD-% = All types of energy from renewable sources consumed in road transport / Petrol, diesel, biofuels consumed in road and rail transport and electricity (in transport) but excluding off-road 2)

Calculation of the overall RED-% of renewable energy in transport (Art. 3(4) of the RED):

RED-% = All types of energy from renewable sources consumed in all forms of transport1) / Petrol, diesel, biofuels consumed in road and rail transport, and electricity (in transport) but excluding off-road 2)

1) Renewable energy in Road, Rail, Aviation, Inland Navigation and Pipeline Transport
2a) Off-road means mobile machinery (forestry, agriculture, and construction)
2b) CNG & LPG in road transport are not included, BUT: Biogas (= biofuel) is included

Application of factors:
- "*Advanced Biofuels*" count 2 times in numerator (support)
  - Definition: biofuel from waste, residue and non-food cellulosic material, Article 21(2)
- "*Green Electricity*" for road transport counts 2.5 times in numerator & denominator (efficiency factor)
  - Definition: electricity from renewable sources, Article 3(4)

Figure 2-1. Renewable Energy Calculations in the RED

2.2 The Fuel Quality Directive

The FQD sets environmental requirements for gasoline and diesel fuel in order to reduce their GHG intensity. These requirements consist of technical specifications for fuel quality parameters and binding targets to reduce the fuels' life cycle GHG emissions.

By 2020, based on a 2010 baseline, the FQD requires:

- 6% reduction in the GHG intensity of fuels traded in the EU by 2020 (2% indicative reduction by 2014 and 4% by 2017);
- 2% reduction in the GHG intensity of fuels traded in the EU by 2020 from developments in new technologies, such as Carbon Capture and Storage (CCS);
- 2% reduction in the GHG intensity of fuels traded in the EU by 2020 from the purchase of Clean Development Mechanism (CDM) credits under the Kyoto Protocol[17].

The last two targets are subject to review.

The FQD places the responsibility for reducing life cycle GHG emissions of fuels traded in the EU on fuel suppliers.

The FQD Article 7a target takes into account the impact of renewable fuels on life cycle GHG emission savings of fuels supplied for road vehicles, non-road mobile machinery (including rail and inland marine), agricultural and forestry tractors, and recreational craft. The main distinction compared to the RED as regards the scope of transport activities is that the FQD excludes air transport fuel consumption whereas the RED includes it. The FQD calculation also includes off-road fuel consumption while it is excluded from the RED calculation.

[17] http://cdm.unfccc.int/index.html

Additionally, the FQD requires a 2010 reference value for life cycle GHG emissions per unit of energy from fossil fuels to enable the calculation of GHG savings from biofuels and alternative fuels.

From 2011 fuel suppliers must report annually to Member States on the life cycle GHG emissions per unit of fuel supplied.

Other regulatory acts at EU level are also relevant because they contribute to the setting of the boundaries of the projected development of both fleet and fuels demand in Europe. These are briefly outlined in Section 2.4.

GHG savings are calculated according to the FQD Annex IV C. Methodology Sub. 4 (EC, 2009b):

Calculation of the overall FQD-% GHG emissions saving in transport (Art. 7a of the FQD):

$$\text{FQD-\%} = \frac{\text{Fossil transport fuels GHG intensity 2010}^{2)} - \text{All transport fuels GHG intensity in 2020}^{1)}}{\text{Fossil transport fuels GHG intensity 2010}^{2)}}$$

Figure 2-2. FQD calculation defined by European Commission

Footnotes in above figure are explained below:

1) "All transport fuels GHG intensity in 2020" GHG intensity <u>includes</u> fuels used in road vehicles, non-road mobile machinery, rail, agricultural and forestry tractors and recreational craft, but <u>excludes</u>:

- Electricity used in rail
- Aviation fuels
- Inland Navigation fuels

2) The "Fossil transport fuels GHG intensity 2010" is given in legislation

More detailed description of the calculation can be found in Section 3.5.1.

2.3 European legislative amendment proposals

The FQD and RED Directives invite[18] the Commission to review the impact of ILUC on GHG emissions and, if appropriate, to propose ways to minimise GHG whilst respecting existing investments made in biofuels production.

The European Commission adopted a proposal in October 2012 (EC, 2012b) to minimise ILUC emissions from biofuels. This proposal aims at incentivising the transition to biofuels that do not cause ILUC emissions, mainly by: limiting the contribution of biofuels produced from food crops; improving the efficiency of biofuel production processes by raising the GHG savings thresholds for new installations; incentivising market penetration of advanced biofuels; and protecting existing investments by fixing an accounting cap on conventional biofuels.

The main features of the European Commission's October 2012 proposal were:

- Limit the contribution of renewable fuels produced from food-crops (cereals and other starch-rich crops, sugars and oil crops) to 5% towards meeting the RED target of 10% renewable energy in transport.
- Introduce ILUC emissions values per crop groups (cereals and other starch-rich crops, sugars and oil crops) as reporting obligation (i.e. the emission factors are not inserted in the sustainability criteria)
- Increase the minimum GHG saving thresholds for biofuels produced in new installations from 35% to 60% for installations built after 1 July 2014;
- Biofuels not using cropland for their production are assigned zero ILUC emissions and are incentivised by applying multiple counting factors (double or quadruple counting) for their contribution to the 10% renewable energy target in transport.

In line with the ordinary decision procedure or co-decision procedure[19], the European Parliament in first reading voted in plenary in September 2013 on a compromise proposal on amendments. In December 2013, the Environment Council failed to reach an agreement on a compromise text. The main characteristics of the three legislative proposals belonging to the same single amendment procedure are compared in the Table 2-2 below.

European Commission (EC) ILUC proposal Oct. 2012 (EC, 2012b)	**European Parliament (EP) vote Sept 2013 (EP, 2013)**	**Council compromise proposal Dec 2013 (CEU, 2013)**
5% cap on 2011 estimated share of 1st gen biofuels (energy crops not included)	6% cap on final consumption in 2020 of 1st gen biofuels and DLUC/ILUC energy crops	7% cap on final consumption in 2020 of 1st gen biofuels and DLUC/ILUC energy crops
No sub-targets for advanced biofuels	2.5% target for advanced biofuels. MS obliged to ensure renewable sources in gasoline to make up 7.5% of final energy in gasoline pool by 2020	Voluntary sub-targets at MS level for advanced biofuels
ILUC factors in Annex VIII only for reporting by MS	Not required in MS reporting	MS required to report amount of biofuels/bioliquids from ILUC feedstock groups BUT only the Commission to use the ILUC factor in its report. Not required for reporting.
Multiple counting factors for non-ILUC biofuels	Single, double and quadruple counting for feedstocks in Annex IX Parts A and B	Double-counting for feedstocks and fuels in Annex IX Parts A and B

Table 2-2. Main characteristics of legislative concepts for RED and FQD amendment

[18] Article 7d(6) of Directive 2009/30/EC and Article 19(6) of Directive 2009/28/EC

[19] The *co-decision procedure* gives the same weight to the European Parliament and the Council of the European Union on a wide range of areas (energy, transport and the environment, among others). Since the entry into force of the Lisbon Treaty in December 2009, it is the main legislative procedure of the EU´s decision-making system and has been renamed as *ordinary legislative procedure*.

2.4 Vehicle emissions

Vehicle emission reduction targets set by the EU legislator are important factors for energy demand in the road transport sector. Several targets have been introduced or are being discussed by the EU regulator. The main regulations and revisions are discussed in the following sections.

2.4.1 CO_2 emission level for new passenger cars

The regulation of CO_2 emissions from passenger cars is addressed by Regulation 443/2009 (EC, 2009c). This Regulation sets emissions performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles. Car manufacturers must reduce CO_2 emissions in the new fleet of passenger cars reaching new fleet averages of 130 gCO_2/km in 2015. For 2020, a target of 95 gCO_2/km[20] has been proposed at regulatory level[21] and submitted to the vote of the European Parliament in February 2014[22]. The Fleet and Fuels model assumes a 95 gCO_2/km target in 2020.

2.4.2 CO_2 emission level for new light commercial vehicles

Regulation 510/2011 of 11 May 2011 setting emission performance standards for new light commercial vehicles (EC, 2011) as part of the Union's integrated approach to reduce CO_2 from light commercial vehicles sets an average emissions value of 175 gCO_2/km for new light commercial vehicles reaching full coverage in January 2017. The same Regulation sets a target of 147 gCO_2/km for the average emissions of new light commercial vehicles registered in the Union from 2020. This provision is subject to confirmation of its feasibility in 2014.

2.4.3 Emission standards for passenger cars and heavy duty vehicles

Commission Regulation 459/2012 of 29 May 2012 amending Regulation 715/2007 (EC, 2007) and Regulation 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6) sets rules for emissions from motor vehicles and their specific replacement parts (Euro 5 and Euro 6 standards[23]) for passenger cars and light commercial vehicles (categories M1, M2, N1 and N2) (EC, 2001). The regulation covers a wide range of pollutant emissions with specifications for each category of pollutant emissions and for the different regulated vehicle types.

The Euro VI standard for HDV (categories N2, N3, M2 and M3) has been introduced by Regulation 595/2009 (EC, 2009d) with new emission limits in force from 1 January 2013 (new type approvals) and 2014 (new registrations)[24].

[20] see Art. 13(5) of Regulation 443/2009.

[21] 'Commission's proposal for a regulation amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO2 emissions from new passenger cars', COM(2012) 393 final 2012/0190 (COD) of 11 July 2012,

[22] European Parliament legislative resolution of 25 February 2014 on the proposal for a regulation of the European Parliament and of the Council amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO 2 emissions from new passenger cars (COM(2012)0393 – C7-0184/2012 – 2012/0190(COD)) http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2014-0117&language=EN&ring=A7-2013-0151

[23] The Euro 5 emissions standard entered into force on 1st September 2009 for type approval, and became operational from 1st January 2011 for the registration and sale of new types of cars. The Euro 6 standard will come into force on 1st September 2014 for type approval, and from 1st January 2015 for the registration and sale of new types of cars.

[24] As follow-up to the adoption of Regulation 595/2009, two implementing acts on technical aspects needed for certification (Regulation 582/2011) and on access to vehicle repair and maintenance information (Regulation 566/2011), have been adopted during 2011.

In parallel, the convergence between European Euro VI legislation and UNECE has been approved in January 2012 paving the way towards the equivalence of type-approval certificates awarded according to UNECE Regulation 49 and certificates based on the European legislation

2.5 European CEN standards

European CEN fuel specifications are also relevant to the analysis presented in this report insofar as they determine the specifications for fuel quality parameters and biofuel blending.[25] Standardisation of high-quality fuels containing sustainable renewable components is essential not only to ensure performance in the current and future European road vehicle fleet but also to enable common fuel grades in the European internal market.

Three CEN standards address the quality of automotive fuels and are periodically revised: EN590 for diesel, EN 228 for gasoline, and EN589 for automotive liquefied petroleum gas (LPG). Regarding biofuels, EN15376 and EN14214 are the European standards that describe the requirements and test methods for ethanol and Fatty Acid Methyl Esters (FAME), respectively, when blending into gasoline or diesel. In addition to stipulating provisions on the maximum sulphur content of gasoline and diesel fuel from 2005, EU Directive 2003/17/EC required to review a number of other fuel specifications for possible amendments. One specific requirement is to assess the current gasoline summer vapour pressure limits of ethanol directly blended into gasoline due to the higher volatility of ethanol blends compared to pure fossil gasoline.[26]

2.6 Member States initiatives

Initiatives at Member State level are diverse and lead to a heterogeneous situation. An example of such initiatives is the market introduction of E10, which first occurred in France in 2009, followed by Finland and Germany in 2011. Other EU Member States have postponed the introduction of E10 (GOV.UK, 2013). France also markets B30 for captive fleets. The latest versions of the reference European gasoline (EN228) and diesel (EN590) fuel standards used in Europe, allow up to E10 and B7 respectively. Similarly in Germany, B7 plus 3% renewable diesel (but not FAME) was placed on the market in 2009 even though it was still not approved at the CEN European level. B100 had been distributed for specially adapted vehicles (mainly for larger Heavy Duty (HD) trucks) and made up 60% of the biodiesel consumed in Germany in 2006/7 but has since almost completely disappeared from the market. Examples from other countries range from B20 in Poland and B30 in the Czech Republic (for captive fleets in both cases) to E85 in Austria, France, Germany and Sweden.

Blending grade	EU Member State	Brief description
E10	France	Up to 10% v/v ethanol blending in gasoline
E85	Austria, Germany, France, Sweden	Up to 85% v/v ethanol blending in gasoline for so-called flexi-fuel vehicles (FFV)
B7	France	Up to 7% v/v FAME blending in diesel fuel
	Germany	Plus 3% of renewable diesel
B20	Poland	For captive fleets
B30	France	For captive fleets
	Czech Republic	For captive fleets
B100	Germany	For specially adapted vehicles

Table 2-3. EU Member States initiatives – some historic and current examples

[25] These specifications include:

EN15376 for ethanol when used as a blending component in gasoline

EN 14214 for Fatty Acid Methyl Esters (FAME)

EN228 for gasoline containing up to 5% v/v (E5) ethanol and 2.7% oxygen

EN590 for diesel fuel containing up to 7% v/v (B7) FAME meeting the EN14214 specification

Generally, fuel specifications do not limit the addition of 2nd generation renewable diesel fuels, namely Hydrogenated Vegetable Oils (HVO) and animal fats or and Biomass-to-Liquids (BtL).

[26] JEC has addressed this issue in two dedicated studies: “Effects of Gasoline Vapour Pressure and Ethanol Content on Evaporative Emissions from Modern Cars” (EUR 22713 EN) in 2007 and “Effect of oxygenates in gasoline on fuel consumption and emissions in three Euro 4 passenger cars (EUR 26381 EN) in 2013.

On the basis of the NREAP[27], more than 10 Member States intend to significantly overachieve the RED transport renewable energy target of 10% by 2020 (JRC, 2011). This might lead to further market fragmentation, running against the target of a harmonized uptake of E10 for gasoline blends and B7 for diesel market blends.

2.7 International initiatives on renewable transport fuels

Other countries around the world have regulated renewable fuels by developing approaches (and standardisation) which differ from the developments in the EU.

The US Renewable Fuel Standard 2 (RFS2) is a standard aimed at increasing the production and use of renewable fuel in the US by setting volumetric targets. The RFS2 applies to producers and importers of gasoline and diesel in the US: it does not regulate fossil fuels. On the contrary, it mandates the use of 36 billion US gallons (136.3 billion litres) of renewable fuel by 2022. The RFS2 determines four categories of renewable fuels: cellulosic biofuel, biomass-based diesel, advanced biofuel and renewable biofuel. It specifies a minimum GHG reduction threshold for each type of renewable fuel. To determine whether a biofuel can qualify as renewable fuel, and in which of the four categories, the carbon intensity of that biofuel is compared with the carbon intensity of baseline gasoline and diesel. The baseline reference is gasoline or diesel produced in the crude mix in the US in 2003. Life-cycle analysis has been used to estimate carbon intensity for various fuels. For biofuels, emissions from ILUC are included.

With respect to biofuel blending into fossil-based fuels, 10% ethanol blending is now widespread in the US and 20% biodiesel blending in existence. The volumes mandated by RFS2 require that these blending grades grow larger, in particular for ethanol blending into gasoline. For this reason, the US Environment Protection Agency has approved a 15% ethanol blending for vehicle model years 2001 and newer. But there is debate as to whether sufficient testing prior to EPA’s E15 waiver was completed.

Other measures at State level exist in the US. The California Low Carbon Fuel Standard (LCFS) is possibly the most renowned. It is a fuel-neutral GHG performance standard aimed at reducing GHG emissions from the transport sector by 10% by 2020 compared to 2010. Such reductions would account not only for renewable fuels but also for other alternative low-carbon fuels, such as compressed natural gas (CNG), hydrogen and electricity. To achieve the required reduction, biofuel blending is one of the options. Suppliers of such fuels can also opt in to the programme to generate credits. The standard does not apply to fuels that have been identified as having so-called “niche” uses, such as aircraft, military vehicles and equipment and ships. Similar programmes also exist in other part of the US[28] and Canada[29].

Blending mandates or targets (mainly expressed as volumetric content) exist in 62 countries around the world[30]. Beyond the EU and the US, the major players can be identified in fast-growing economies such as China (10%v/v biofuels mandate by 2020 with a current 15%v/v overall target for renewable energy for 2020), India (20%v/v ethanol mandate in place for 2017) and Brazil (where the target has already been reached, with an expected level of 15-20%v/v demand for gasoline supplied by ethanol by 2020-2022). These countries are expected to exert significant pressure on the global availability and prices of sustainably produced renewable fuels through the decade.

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[27] Art. 4 and Art. 22

[28] The Oregon Clean Fuels Program, the Washington Low Carbon Fuel Standard, the Northeast and Mid-Atlantic States Clean Fuels Standard, for example.

[29] British Columbia Renewable and Low Carbon Fuel Requirement Regulation (RLCFRR).

[30] http://www.biofuelsdigest.com/bdigest/2013/12/31/biofuels-mandates-around-the-world-2014/

3. Description of model and methodology

The JEC Fleet and Fuels model is a spreadsheet-based simulation tool covering the road vehicle fleet development and the resulting demand for fossil fuels and biofuels in aggregate for 29 European countries (EU27[31] plus Norway and Switzerland). The model has been developed to enable projections towards the year 2020 based on a set of assumptions.

The flow chart below provides a schematic overview of the blocks and flows comprising the F&F model.

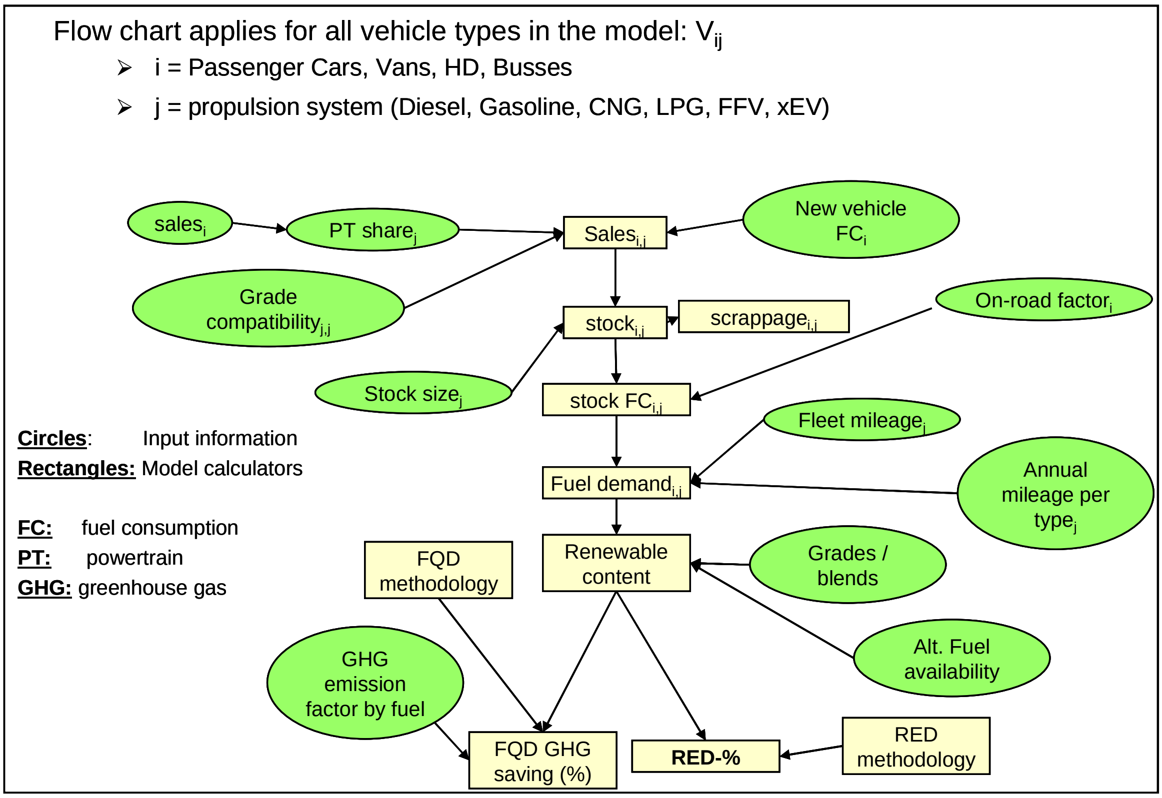

Figure 3-1. Simplified flow chart for the JEC F&F model

The F&F model is thus a scenario assessment tool based on a 2010 reference case and anticipates future trends in the fleet, fuel and market developments towards 2020. If available, the most recent data have been used, i.e. the new passenger car sales data and CO_2 emissions of new vehicles up to year 2012.

3.1 Reference data sources

In order to input historical fleet data into the F&F model, TREMOVE Version v3.3.2 alt[32] (further referred to as TREMOVE) has been used to model information on fleet composition and activity (vehicle-km for cars and light commercial vehicles and tonne-km for HD vehicles) per vintage and per year. The split of diesel fuel consumption by passenger cars, light commercial and heavy duty vehicles has been subject to a dedicated

[31] we did not take into account Croatia, which joined the EU on 1st July 2013

[32] http://www.tremove.org/documentation/index.htm

assessment. Details are documented in Appendix B. JEC WTW data (JEC, 2014) have been used for fuel specifications, e.g. energy content, GHG intensity, etc.

Although the reference source for historical vehicle fleet data was TREMOVE, the following modifications were also made:

- the "European Energy and Transport Trends to 2030 – Update 2009" (EC, 2010) was used to establish the 2020 time horizon;
- the latest ACEA[33] vehicle sales data were used.
- the latest EEA CO_2 monitoring data[34] were used for new passenger car CO_2 emission and fuel consumption information.
- Wood Mackenzie Country Report 2013 and Eurostat data were used to tune the TREMOVE to 2010 transport energy demand.

In addition, International Energy Agency (IEA) data on energy demand in the transport sector were used as a benchmark.

Comparisons of energy demand projections towards 2020 using the F&F model and the sources mentioned above were not straightforward due to differences in underlying assumptions. Despite inevitable uncertainties, considerable efforts were made while developing the F&F model to consult JEC members and obtain consensus on the modelling methodology, thereby ensuring the highest degree of transparency regarding assumptions and data used.

In TREMOVE, the road fleet composition is modified by old vehicles being removed from the fleet (scrappage, see also Section 5.2.4) and new vehicles entering the fleet based on historical new vehicle registrations per geographical coverage. It should be noted that the F&F model departs from this approach: the new vehicle sales information is an input parameter while scrappage is a function of sales and stock size. The scrappage function in the F&F model has been defined to ensure alignment with fleet turn-over in TREMOVE. This approach has also been benchmarked against ANFAC[35] data. The scrappage function therefore effectively reflects the number of vehicles in the fleet which – due to vintage (i.e. model year (MY)) – are affected by a loss of fuel 'protection grade' (e.g. replacement of E5 by E10 or even E20[36]).

The effect of this approach for treating vehicle scrappage in the F&F model is that all vehicles older than MY2000 will have a fleet share of about 12% by 2020, which is not in line with TREMOVE projections. This means that in the JEC baseline there will be approximately 28 million gasoline cars older than MY2000 in 2020, that is about 19% of the on-road gasoline car fleet in that year.

The Fleet & Fuels Model deviates from TREMOVE following adjustments in two assumptions: fleet stock 2005-2010, expected sales of new vehicles in 2020 including the impact of diesel vehicle and gasoline vehicle sales mix.

Fleet stock 2005-2010

The baseline year of TREMOVE is 2005 and therefore the stock in years 2005-2010 is projected in TREMOVE. In this study statistics are used for 2005-2012 and therefore the starting point in 2010 has changed. As an example, the 2010 sales of new cars in TREMOVE is 17.8 million compared to 13.8 million from ACEA.

[33] http://www.acea.be

[34] http://www.eea.europa.eu/publications/monitoring-co2-emissions-from-new-cars

[35] http://www.anfac.com/

[36] E20 is used in selected scenarios; see Section 5.3

Expected sales of new vehicles in 2020

This study has also updated the expected new sales in 2020. Within JEC there is consensus that new sales of 21.8 million cars in 2020 in TREMOVE is too optimistic. It is agreed that the assumed total sales in 2020 is 16 million cars. It is also agreed that the total stock of cars in Europe (275 million) is a fair projection. The underlying assumption is that due to lower economic growth people will renew their cars less frequently.

These two effects change the fleet composition in 2020 significantly. With lower projected sales and the same vehicle stock as in TREMOVE, it is a consequence that the car fleet in Europe will be older compared to TREMOVE. The result for MY2010 passenger cars are shown in Figure 3-2.

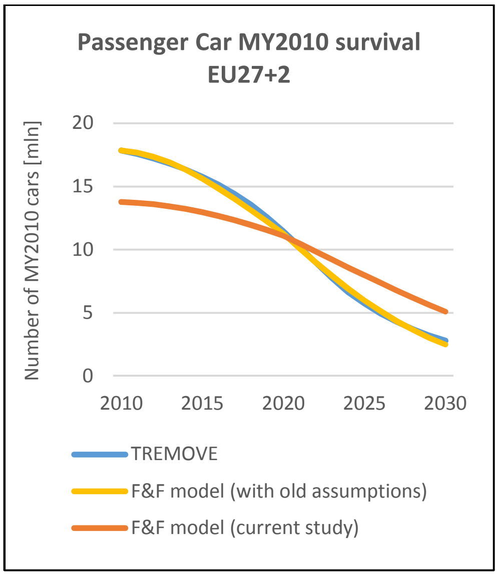

Figure 3-2. TREMOVE versus F&F model fleet composition

Figure 3-3 shows the consequences of the scrappage function and changed assumptions applied in the F&F model for passenger cars in the EU27+2 fleet.

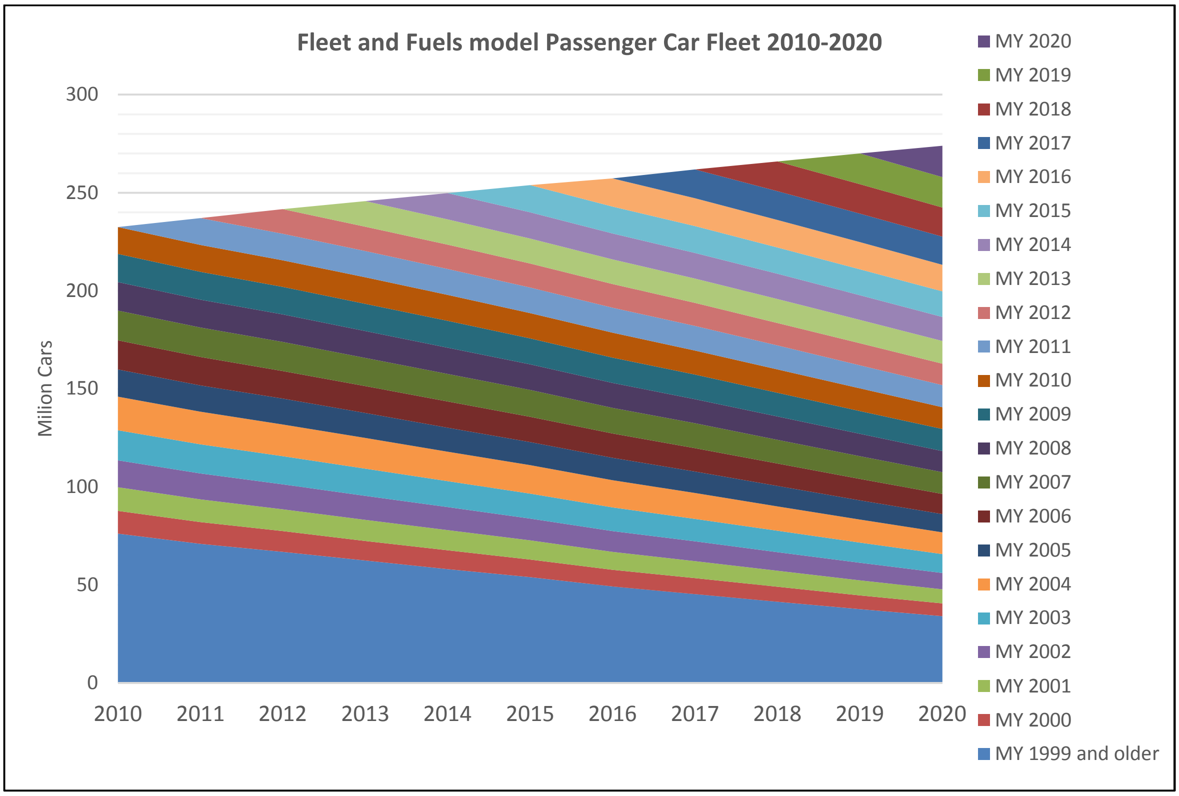

Figure 3-3. Passenger car fleet survival rates per Model Year

The F&F model further enables the assessment of different scenario to achieve the targets of the RED and FQD. Multiple counting factors for specific renewable fuels are considered as originally defined in Article 21(2) and Article 3(4) of the RED in 2009 and as laid out in the different legislative concepts for RED and FQD amendment (see Section 0). The robustness of the model and the modelling activity has been checked with a number of sensitivity analyses of main parameters considered (see Section 5.5).

As shown in Table 3-1 below, the 2020 reference scenario based on the listed data sources and with the assumptions used in the JEC F&F model is in line with other main reference data sources in this field.

EU27+2 Transport Energy Demand [Mtoe]	Statistical data		2011 JEC Study		2013 JEC Study	
	2008 EuroStat	2010 EuroStat	2020 JEC F&F Reference Case	2020 DG TREN[37] (v2007)	2020 JEC F&F Reference Case	2020 DG ENER[38] (v2009)
1. Road mode	303	307	281	350	289	316
1.1 Diesel	188	192	186		189	
1.1.1 Light Duty			69		83	
1.1.2 Heavy Duty incl. LCV			117		107	
1.2 Gasoline	100	97	66		72	
1.3 Biofuels (incl. drop-in)	10	13	21.5		20.4	
1.4 Other: CNG, LPG, LNG, H2 electricity	5	5	7.8		6.2	
2. Other modes	84	74	109		88	
2.1 Rail (Diesel & Electricity)	9.5	8	10**	10	10**	10
2.2 Aviation	54	52	73**	73	63**	63
2.3 Inland navigation	6.5	7	6**	6	7**	6
2.4 Off-road (Diesel)	14***	7*	20***		7*	
Total	**387**	**381**	**390**	**439**	**376**	**395**

Note: might show rounding effects

*** Using EUROSTAT transport diesel used in sectors "Industry" and "Other sectors". Outlook is based on the 2005-2010 increase extrapolated to 2020**

**** Using DG ENER (DG TREN) data for non-road transport sectors, Inland navigation corrected in line with statistics TREMOVE: historical data and methodology, used as basis for fleet development in Fleet and Fuels Model**

***** JEC estimate**

Table 3-1. Transport demand projections (Mtoe[39]), including JEC F&F Reference Case

3.2 Vehicle classes and fuel options

The F&F model does not lead to a single globally optimised solution but does allow a side-by-side comparison of different scenarios of fleet and fuel development. Very importantly, the F&F model does not assess or value the cost implications associated with the various scenarios.

Due to the assumptions introduced in the JEC Biofuels Study and subsequently in the F&F model as its main analytical tool, the F&F model cannot be considered as a quantitative tool for predicting the future. In fact, no model can truly do this.

On the other hand, the F&F model can be used to simulate different parameter combinations of vehicle and fuel (and thereof renewable fuel) technologies to assess fuel demand scenarios looking at:

- Total fuel demand and diesel/gasoline balance;
- Total renewable energy demand (including conventional and advanced biofuels);
- Renewable energy demand for road transport to be used for achieving the RED and FQD target.

[37] DG TREN: "European Energy and transport trends to 2030, Update 2007" (EC, 2008) Reference scenario

[38] DG ENER: "European Energy and transport trends to 2030, Update 2009" (EC, 2010) Baseline scenario

[39] Million tonnes oil equivalent (Mtoe)

The F&F model considers several vehicle classes that are named differently in TREMOVE and EU regulations. Light commercial vehicles are also referred to as vans in this study. The following vehicle classes and related fuel type options are included:

Eight passenger car types (and related powertrain / fuel type options)

- Gasoline (also known as Petrol), Diesel and Flexi-Fuel Vehicles (FFV)
- Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG)
- Plug-in Hybrid Electric Vehicle (PHEV), Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV)

Three light-commercial vehicles classes (and related powertrain / fuel type options)

- Gasoline (Gasoline, CNG, LPG, xEV[40])
- Small Diesel <2.5 tonnes Gross Vehicle Weight (GVW) (Diesel, CNG, LPG, xEV)[41]
- Large Diesel >2.5 tonnes GVW (Diesel, CNG, LPG, xEV)

Five heavy-duty vehicle classes (and related powertrain / fuel type options)

- 3.5 to 7.5 tonnes GVW (Diesel, CNG)
- 7.5-16 tonnes GVW (Diesel, CNG)
- 16 to 32 tonnes GVW (Diesel, CNG, LNG, E95[42], DME[43])
- >32 tonnes GVW (Diesel, LNG, DME)
- Buses and coaches (Diesel, CNG, E95, EV, FCEV)

3.3 Fixed and adjustable parameters

Key parameters relevant to fuel demand included in the F&F model are:

- Passenger car, LCV and HDV fleets organised in several segments as indicated in the previous section;
- Vehicle efficiency and projected efficiency improvement over time;
- Percentage of diesel cars in new car sales;
- Fleet introduction of alternative vehicles;
- Vehicle model year (vintage) assumed to be compatible with specific fuel blending grades for biofuels.

As mentioned in the previous section, the model section dedicated to past and future road vehicle fleet development in EU27+2 provides the background for analysis of adjustable parameters and their sensitivity to variation.

[40] xEV stands for PHEV, BEV or FCEV. PHEV and BEV are assumed to be capable of charging from the electricity grid.

[41] CNG and LPG vehicles are options to replace diesel vehicles in the respective class. It is not assumed to use LPG or CNG in a diesel engine.

[42] E95 fuel, 95%vol Ethanol, remainder mainly ignition enhancer

[43] DME stands for Dimethyl ether fuel

Figure 3-4. Example of F&F model output: vehicle fleet development

The F&F model includes a set of ***adjustable parameters*** that can be changed individually for each vehicle type and fuel option.

Adjustable parameters include:

– Annual growth rate for sales and stock per vehicle class and split of fuel type used;
– Vehicle activity (annual distance driven), vehicle-km driven for passenger cars and LCV, passenger-km for bus & coach and tonne-km for trucks;
– Vehicle fuel efficiency development year-on-year
– Alternative vehicle sales share in projected vehicle fleet in the year 2020
– Alternative vehicles sales start year and therefore final stock composition (fleet penetration) in the year 2020
– % replacement of gasoline or diesel passenger cars by alternative vehicles
– % use (on total activity) of alternative fuels in alternative (bi-)fuel vehicles (e.g. E85 take-up rate for FFV[44]).

[44] Flex-Fuel vehicles (FFV) could fill up with either E85 or mass market blends like E10

With regard to biofuel blending in the F&F model, it was assumed that ethanol and FAME are blended to the maximum volume allowed by the specification. To reflect laboratory test accuracies and other tolerances, 0.1% by volume was subtracted from the blending limit for each blending grade, i.e. an E5-blend would effectively mean a 4.9% (by volume) blending of ethanol into gasoline for all E5 sold in Europe. In addition, a ramp-up of market introduction and market acceptance of new blends has been implemented based on the E10 introduction in Germany, France and Finland. For the reference scenario, in 2020 36% of all European E10 compatible cars will fuel E10[45]. The market uptake of new grades across the EU requires the market introduction in the Member States and it strongly depends on the customer acceptance. This is further explained in Section 5.5.3 with a minimum and maximum sensitivity run.

The F&F model allows up to 3 different gasoline grades (a "protection grade", a main grade, and an E85) and up to 2 different diesel grades (a "protection grade" and a main grade). Additionally, for the main diesel grade, market uptake can be set differently for the HDV fleet and Light-Commercial Vehicles compared to the diesel passenger car fleet. For passenger cars, the compatibility between fuels and vehicles of a specific model year can be independently defined in the model.

The F&F model allows setting compatibility between vehicle vintage (model year) and fuel grade. HVO and BTL are included in the diesel pool assuming full backward compatibility. Advanced ethanol (lignocellulose-based) is added to gasoline in the same way as conventional ethanol and is therefore limited by the same blending grade limits as conventional ethanol in the F&F model. Other oxygenates (e.g. Ethyl tert-butyl ether, ETBE) were not modelled separately but would be allowed up to the maximum oxygen specification[46].

3.4 Non-road transport modes

In line with the overall objectives to identify and characterise fuel demand scenarios to achieve the 10% RED (EC, 2009a) and FQD 6% (EC, 2009b) target, the F&F model includes energy demand generated by non-road transport modes using historic data from Eurostat[47] as well as projections in reference sources by the European Commission (EC, 2010), as listed in Table 5-1. Data were discussed with European Commission and modelling experts.

The F&F model is mainly used to analyse the road transport fleet composition and the related fuel and biofuel demand. Nonetheless it is not sufficient to consider and analyse road transport in isolation. This is the case for several reasons:

- Fuel types and energy used in non-road transport modes are also counted as contributions towards the targets of the RED and FQD;
- Road and non-road transport modes share fuel pools and will increasingly do so, e.g. EN590 Diesel fuel;
- Non-road transport mode demand for alternative transport fuels, including (but not limited to) renewable fuels may represent a competing demand, limiting the uptake opportunity of such fuel options in the road transport sector;
- The demand from other transport modes may provide opportunities for investment in new renewable fuel plants and/or funding for advanced research and development activities (this seems to be realistic with a longer term perspective).

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[45] A standard market fuel ramp-up function has been calculated based on the E10 market introductions in Germany, France and Finland over the first 3 years after introduction. This standard ramp-up function is then used for the introduction of E10 for the remaining European countries. For the remaining countries it is assumed that E10 will be introduced in 2017 (median of 2014-2020). The combined result is a 36% of all E10 compatible cars in EU27+2 will fuel E10.

[46] As defined in FQD, Annex I

[47] http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

3.4.1 Rail

The rail energy demand projection of 10 Mtoe in 2020 is adopted from the DG ENER report (EC, 2010). The rail contribution towards meeting the RED target has been split into its electricity and diesel components. This study assumes a diesel / electricity split in 2020 of 33% and 67% respectively. The electrification trend in Rail from 2000-2011[48] has been extrapolated towards 2020. Furthermore a diesel B7 quality and 26% average renewable electricity in the grid by 2020 (EC, 2010) is assumed, accounting for 0.66% of the RED target from this mode. The renewable electricity component in rail is excluded from the FQD target.

3.4.2 Aviation

The aviation demand projection is also taken from the DG ENER report (EC, 2010) and is 63 Mtoe in 2020. In the reference scenario aviation is assumed to make no contribution to the RED target by 2020, although the sector could deliver renewable energy consumption. This has been subject to a sensitivity case in Section 5.5.5 where a certain volume of BTL and HVO is assumed in jet fuel. For the FQD GHG reduction, the aviation sector is excluded in the original 2009 FQD legislation although it is included in the RED target.

3.4.3 Inland Navigation

For inland navigation, the assumption is that road transport type of diesel will be used meaning diesel grade B7. Hence, a minor contribution to the RED target is considered due to a relatively small total fuel demand within the transport sector. Even with the assumption of full uptake of B7, inland navigation accounts for only 0.16% towards the RED target.

3.4.4 Other Off-road

Diesel for "other off-road" applications, like agriculture and earth-moving machinery is also assumed to be road transport fuel type (diesel B7). The consumption of renewable energy in this sector is not considered in the RED although it is included in the FQD.

It is important to note that non-road transport modes are not "actively" simulated in the F&F model. A fixed contribution of non-road transport modes is assumed towards achieving the 10% RED target. This non-road contribution amounts to 0.8%, which remains fixed in the reference scenario as well as in the different fuel demand scenarios.

[48] Eurostat database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database, accessed 31-07-2014

3.5 Scenario assumptions

With the support of the F&F model, a reference scenario has been defined which represents the expected energy demand development towards 2020 jointly agreed by JEC partner organisations and fully in line with the EU energy and transport regulatory and policy framework.

An additional three scenarios, all considered feasible to approach the RED 10% and FQD 6% target in 2020, were developed and analysed.

The following assumptions have been made about fleet parameters in the reference:

- Sales and stock in 2020 for all vehicle classes are as in TREMOVE except for the sales of passenger cars, which are expected to be lower based on statistical sales data for the period since the economic recession (see Section 3.1 for more information);
- Fleet activity (vehicle-km, passenger-km and tonne-km) is in line with TREMOVE;
- Efficiency improvements are specific per vehicle class;
- Alternative fuel vehicles enter the market assuming a specific start year for market introduction and a target sales share by 2020.

The assumptions for fleet parameters by vehicle class in 2020 are listed below. The more complete list of assumptions can be found in Appendix A. Note that these assumptions apply equally to the reference scenario and to the three variant scenarios:

- PC assumptions:
    - New car average CO_2 target is 95 gCO_2/km;
    - Diesel/gasoline sales share at 50%/50%;
    - Sales grow at an average of 1.5% per annum (p.a.), reaching 16 million vehicles in 2020;
    - Total EU27+2 fleet is 275 million vehicles in 2020;
    - Alternative fuel vehicles enter the market as detailed in Table 3-2;
    - Total passenger fleet mileage will increase by 1.83% p.a. from 2010 to 2020.

- LCV assumptions:
    - New LCV average CO_2 target is 147 gCO_2/km;
    - Sales reach 2.2 million vehicles p.a. with a total fleet of 31 million vehicles;
    - Alternative fuel vehicles enter the market as detailed in Table 3-2;
    - Total LCV fleet mileage grows from 2010 to 2020 by 0.7% p.a..

- HDV assumptions:
    - New truck and bus average year-on-year energy efficiency improvement is 1.48%;
    - Sales reach 0.7 million vehicles p.a. with a total fleet of 9 million vehicles;
    - Alternative fuel vehicles enter the market in specific heavy duty classes as detailed in Table 3-2;
    - Activity growth (vkm) in all HDV classes can be expected assuming increase from 2010 to 2020: 1.3% p.a.

The biofuel blending grades modelled in the reference scenario are the following:

- Ramping up to E5 (protection grade) by 2011 with no fuel/vehicle compatibility restriction;
- New E10 (main) grade from 2011 with fuel/vehicle compatibility with E10 from 2000 model year;
- Ramping up to B7 (protection grade) by 2010 with no fuel/vehicle compatibility.

Alternative Fuel Passenger Cars	In 2020 New Sales		In 2020 Vehicle Fleet		
Flex-Fuel Vehicles (FFV)	0.5%; 80,000		0.2%; 600,000		
Compressed Natural Gas Vehicles (CNGV)	3%; 480,000		0.8%; 2.3 million		
Liquefied Propane Gas Vehicles (LPGV)	3%; 480,000		1.6%; 4.5 million		
Electric Vehicles Battery Electric (BEV) & Plug-in Hybrid (PHEV)	3%; 480,000		0.8%; 2.1 million		
Hydrogen Vehicles (FCEV)	0.25%; 40,000		0.04%; 100,000		
Alternative Fuel Vans	**In 2020 New Sales**		**In 2020 Vehicle Fleet**		
Compressed Natural Gas Vehicles (CNGV)	3%; 70,000		1.2%; 370,000		
Liquefied Propane Gas Vehicles (LPGV)	1%; 20,000		0.6%; 180,000		
Flex Fuel Vehicles (FFV)	0.5%; 11,000		0.16%; 50,000		
Electric Vehicles Battery Electric (BEV) & Plug-in Hybrid (PHEV)	2%; 45,000		0.8%; 240,000		
Hydrogen Vehicles (FCEV)	0.25%; 6,000		0.04%; 14,000		
Alternative Fuel Heavy Duty Vehicles	**In 2020 New Sales**				
	3.5t to 7.5t	**7.5t to 16t**	**16t to 32t**	**> 32t**	**Bus-Coach**
Compressed Natural Gas Vehicles (CNGV)	2%	1.5%	2%	==	5%
Liquefied Natural Gas (LNG)	==	==	1%	1%	==
Di-Methyl Ether Vehicles (DMEV)	==	==	0.5%	0.25%	==
95% Ethanol (E95) Vehicles	==	==	0.5%	==	2%
Electric Vehicles (EV)	==	==	==	==	0.25%
Hydrogen Vehicles (FCEV)	==	==	==	==	0.5%

Table 3-2. Assumptions for Alternative Fuel Fleet Parameters (all scenarios)

3.5.1 FQD calculation

The FQD GHG savings are calculated based on the standard defined by the European Commission[49]. Based on the latest available version of the WTW v4 study (JEC, 2014) and the 2010 fossil fuel demand mix, the 2013 revision of the JEC Biofuels Study assumes that the fossil fuels baseline emissions value is 88.3 gCO_2/MJ[49]

The GHG savings are calculated according to the FQD Annex IV C. Methodology Sub 4 (EC, 2009b):

Calculation of the overall FQD-% GHG emissions saving in transport (Art. 7a of the FQD):

$$\text{FQD-\%} = \frac{\text{Fossil transport fuels GHG intensity 2010}^{2)} - \text{All transport fuels GHG intensity in 2020}^{1)}}{\text{Fossil transport fuels GHG intensity 2010}^{2)}}$$

Figure 3-5. FQD calculation defined by European Commission

Footnotes in above figure are explained below:

1) "All transport fuels GHG intensity in 2020" GHG intensity includes fuels used in road vehicles, non-road mobile machinery, rail, agricultural and forestry tractors and recreational craft, but excludes:

- Electricity used in rail
- Aviation fuels
- Inland Navigation fuels

[49] D016937/03 Draft COMMISSION DIRECTIVE laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC

2) The "Fossil transport fuels GHG intensity 2010" is 88.3 gCO_2eq/MJ.

The GHG intensity is calculated according to the following formula:

$$\text{Baseline GHG intensity} = \frac{\sum_{\text{a to z}} (\text{GHGi}_{\text{fuel x}} * \text{MJ}_{\text{fuel x}})}{\sum \text{MJ}_{\text{a to z}}}$$

For 2020 the baseline GHG intensity is calculated as shown above, with the GHG intensities of each fuel determined by:

- Default GHG intensities for biofuels[50], where these meet the sustainability criteria, otherwise it is improved to 50% (existing plants) or 60% (announced projects with start-up date 2014+) compared to the Fossil Fuel Comparator. It is assumed that the fossil fuel comparator does not change and is therefore kept constant at 88.3 gCO_2eq/MJ towards 2020.
- For fossil diesel and gasoline, GHG intensities are adopted from JEC WTW v4 (88.6 gCO_2eq/MJ and 87.1 gCO_2eq/MJ respectively) (JEC, 2014).
- For electricity in transport, GHG intensities are adopted from JEC WTW v4. For 2010 the EU-mix value of 150.1 gCO_2eq/MJ (for low-voltage supply) (JEC, 2014) is multiplied by the powertrain efficiency factor of 0.4. For 2020 a similar approach is taken except that the EU-mix value is 145 gCO_2eq/MJ. (The 2020 GHG intensity for electricity is calculated by JEC partner organisations based on the assumption of 26% renewable electricity in the European grid by 2020. More information can be found in Appendix F)

[50] Annex IV of FQD 2009, tables D and E

4. Biofuel Supply Outlook

This chapter is divided into two sections, the first describing how the supply outlook of advanced biofuels is determined and how this study approaches conventional biofuels. The second section shows the resulting supply outlook for the reference scenario and the sensitivity cases.

4.1 Biofuels outlook approach

The supply outlook is handled in one of two ways depending on whether it concerns conventional or advanced biofuels (see Section 1.6.1 for more information on definitions used in this report). The production of conventional ethanol and FAME is assumed not to be constrained. This study assumes that conventional ethanol and FAME will be available in sufficient quantities to meet EU demand in 2020. The supply outlook for non-conventional biofuels, including drop-in fuels, is an important factor in the result of the RED and FQD calculations. In this revision of the JEC Biofuels Study much attention is therefore given to updating the non-conventional biofuels supply outlook via a bottom up approach. As mentioned in Section 1.5, the boundary of this study is the production capacity; feedstock availability is not analysed.

Several sources have been consulted to compile a list of more than 200 announced projects worldwide. The main sources are:

- Hart Energy Outlook 2025, (Hart Energy, 2012)
- IEA Bioenergy Task 39 "Status of Advanced Biofuels Demonstration Facilities in 2012", (Bacovsky, et al., 2013)
- NER300 projects funded by European Commission (EC, 2012a)
- CONCAWE member company consultation

The projects cover a wide range of products using several conversion technologies. The main products are bio-diesel, ethanol, bio-jet, butanol, methanol, bio-oil, biogas and synthetic natural gas. The bottom up approach focuses on bio-liquids and therefore the following bio products have been used: bio-diesel, ethanol, butanol, methanol and bio-jet. The announced projects for biogas are not seen as a good representation of future biogas supply. Biogas production in 2020 is therefore estimated based on experts' opinions.

All the sources included specific information on the projects such as location, start-up date, production capacity, end product and feedstock type used. This information has been processed to determine the available non-conventional biofuels in 2020. The feedstock type is used to determine the applicability of multiple counting factors or – conversely – that of the proposed accounting cap on conventional biofuels. The feedstock type used determines the biofuel conversion pathway. The biofuel conversion pathway includes a specific disposition for co-products determining the GHG intensity of the end product[51].

4.1.1 Use of biofuels pathways

All the projects are classified according to the FQD typified pathways[52], based on announced information and the judgement of experts. Each typified pathway is attributed the default GHG emission value as defined by the FQD, and the applicable multiple counting factor depending on the different legislative concepts for RED and FQD amendment. It must be acknowledged that this is a simplification as many different conversion pathways exist and have a specific GHG intensity with GHG emission values that vary significantly. Most of these pathways are described in the JEC WTW v4 report (JEC, 2014).

[51] Many projects announce a flexible feedstock uptake, the most suitable feedstock is taken to determine the pathway.

[52] EU Fuel Quality Directive (Dir 2009/30/EC) Annex IV sub D/E.

For conventional biofuel pathways and related GHG emission values the first Renewable Energy Report of the European Commission was used (Hamelinck, 2013). The report shows the EU biofuel pathways for ethanol and FAME, including their respective GHG emissions. This study assumes that conventional biofuel pathways that do not meet the GHG savings threshold of 50% of the fossil fuel comparator will improve towards the threshold by 2020. For the advanced biofuels pathways the default GHG emission values are those of the FQD[52].

For the HVO and co-processing production capacity the reported 2012 feedstock mix of Neste Oil was used[53]. The feedstock mix in 2020 depends strongly on the world supply availability and supply prices. This study assumes that – due to the strong policy on feedstock sustainability – the mix in 2020 will shift towards more feedstock derived from wastes and residues. The assumption is that the mix will be composed of 50% conventional crude palm oil and 50% waste material. The GHG intensity of this mix is also reported by Neste Oil and used in this study:

- palm oil 44.8 gCO_2/MJ,
- rapeseed oil 42.8 gCO_2/MJ,
- waste animal fat 20.5 gCO_2/MJ[54].

It is assumed that the crude palm oil pathway will improve towards the sustainability threshold of 50% or could even be further improved to around 65% GHG savings[55] by methane capturing[56]and processing. In this study the 50% threshold is used.

This classification exercise results in an aggregated supply outlook. The resulting pathways are listed in Appendix D.

4.2 Biofuels outlook reference and sensitivity case

Inevitably, the question that accompanies the projected biofuel demand for different fuels based on the assumptions and analysis of the F&F model is whether sufficient quantities of these biofuels will be available over the current decade given concerns related to sustainability, certification, and ILUC. Perhaps of greater interest for this study is whether these biofuels will be available in Europe through 2020 and, if so, whether they will be supplied by domestic production or by imports. In addition, will they be produced globally from sustainable sources meeting GHG reduction targets?

The biofuel supply part of the analysis is based on a literature review and exchange with other research projects and is less detailed than the modelling and analytical work performed for the demand side. The latest Hart Energy report "Global Biofuels Outlook to 2025" has been used as primary source for updating the supply outlook (Hart Energy, 2012).

[53] Neste Oil website: http://2012.nesteoil.com/business/oil-products-and-renewables/renewable-fuels/renewable-feedstock-procurement, accessed 01-11-213.

[54] Neste Oil website: http://2012.nesteoil.com/sustainability/sustainable-supply-chain/greenhouse-gas-emissions-throughout-supp, accessed 01-11-2013.

[55] Neste Oil website: http://www.2011.nesteoil.com/sustainability/sustainability-of-supply-chain/sustainable-bio-based-raw-material-procu/proportion-of-certified-bio-based-raw-ma?cm_print_version=1 and considering the palm oil based products POHY1a and POFA3a, POFA3b in the WTT4a report.

[56] In the year 2012 11% of the plants supplying palm oil to Neste Oil already have equipment in place for preventing the creation of methane or recovering this gas", source: http://2012.nesteoil.com/sustainability/sustainable-supply-chain/sustainability-of-the-renewable-fuels-su

4.2.1 Ethanol and FAME

ePURE and EBB are publishing European figures on domestic production and installed capacity. In the table below the latest figures are shown (EBB, 2013) and (ePURE, 2013):

Bio-ethanol (EU27)	2010		2012
Production capacity installed	3.4 Mtoe		4.1 Mtoe
Actual production	1.5 Mtoe		2.2 Mtoe
Utilization	43%		54%
Production capacity under construction	0.9 Mtoe		0.2 Mtoe
Bio-diesel (EU27)		**2011**	**2012**
Production capacity installed	18.4 Mtoe in 2009	19.7 Mtoe	20.9 Mtoe
Actual production	6.9 Mtoe in 2009	7.6 Mtoe	-
Utilization (2008 and 2011)	37% in 2008	39%	-
Production capacity under construction	-	-	-

Table 4-1. European ethanol and FAME capacity and utilization

As shown in Table 4-1 , the European production capacity of ethanol and FAME has increased since 2010 even though the utilization rate of the plants is below 50% on average. The production capacity under construction has decreased suggesting that the investment in conventional ethanol and FAME production facilities may have come to a halt. Among other factors, the underutilization is caused by relative high feedstock prices in Europe compared to other regions in the world (Hart Energy, 2012).

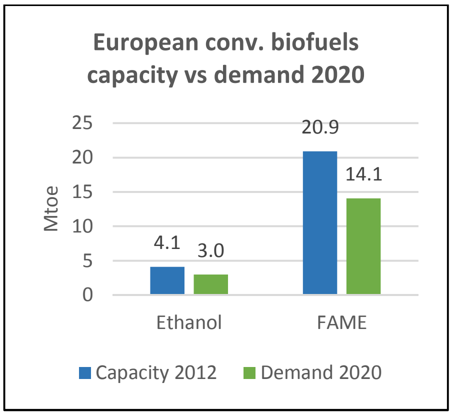


Figure 4-1. European current production capacity vs 2020 transport demand

Based on the F&F reference scenario results, the current European installed capacity of ethanol and FAME production is approximately sufficient to cover the projected demand in 2020, as shown in Figure 4-1.

The projected 2020 ethanol and FAME demand indicates that it could be covered by domestic production at utilization of 73% for ethanol and 67% for FAME.

It must be recognized that the utilization of the European ethanol and FAME capacity strongly depends on the world biofuels market conditions and trade flows.

Comparing JEC results with Hart Energy's latest report (Hart Energy, 2013), it is clear that estimates of demand for biofuels for road transport are comparable. Some differences are worth noting: Hart Energy assumes a blending level of 8.3% on a volumetric basis for ethanol compared to 7.8% in this study. Hart Energy has a more optimistic view on E10 penetration in Europe. For diesel a possible reason for the difference could be that this study assumes that the fuel grade for Rail, Inland Navigation and Off-road applications is B7. Furthermore, Hart Energy assumes a bio-diesel penetration of 5.0 %v/v whereas this study assumes 7.0 %v/v, the maximum FAME level allowed according to EN 590 (see Section 2.5) plus an additional 3.4 Mtoe of drop-in fuels, leading to a total of 8.5 %v/v.

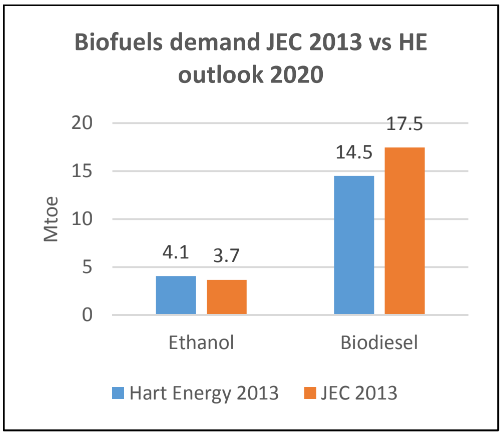
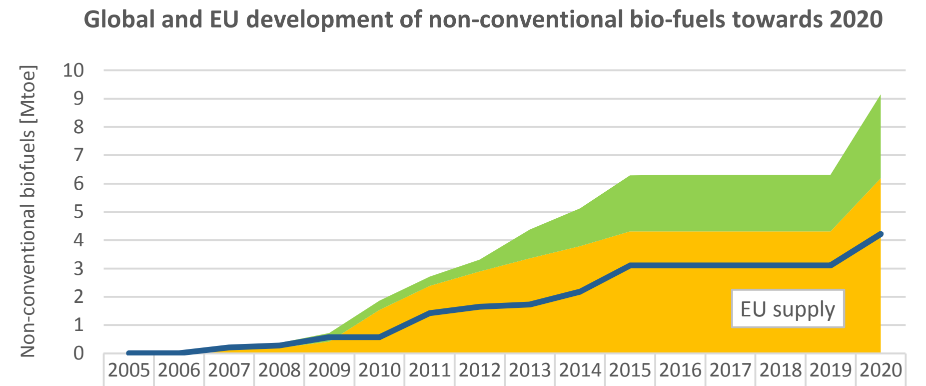


Figure 4-2. Biofuels demand cross referenced with Hart Energy

As already indicated, this study assumes both for the reference and fuel demand scenarios that in 2020 enough ethanol and FAME can be produced locally or imported to meet European demand.

4.2.2 Non-conventional biofuels

Section 4.1 explains how the non-conventional[57] biofuels outlook is defined and which sources have been used as references. The non-conventional biofuels projects are located around the world. In Figure 4-3 the outlook



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Non-conv. Bio-gasoline	0.0	0.1	0.1	0.2	0.3	0.3	0.3	0.4	1.0	1.3	2.0	2.0	2.0	2.0	2.0	3.0
Non-conv. Bio-diesel	0.0	0.0	0.2	0.2	0.4	1.5	2.4	2.9	3.4	3.8	4.3	4.3	4.3	4.3	4.3	6.2
EU non-conv. Biofuels	0.0	0.0	0.2	0.3	0.6	0.6	1.4	1.6	1.7	2.2	3.1	3.1	3.1	3.1	3.1	4.2

Figure 4-3. Global and EU non-conventional biofuels outlook 2020

for supply of non-conventional biofuels is shown which include biofuels produced from ILUC risk feedstock.

The steep increase of global non-conventional biofuels availability in 2020 is caused by projects without a definite announced start-up year. It is assumed that these projects will be operational before 2020 and for calculative purposes the start-up year is set on 2020. It remains to be seen whether all projects will be implemented; the assumption is that all announced projects will be fully operational in 2020. When looking in more detail at the biofuels mix, it must be noted that the main increase in non-conventional bio-diesel is caused by HVO/Co-processing projects. Some Biomass-to-Liquid (BTL) projects have also been announced, most of them located outside of Europe. On the bio-gasoline side several projects have been announced using wheat straw and waste wood to produce ethanol and waste wood to produce methanol. A more detailed overview can be found in Appendix C.

This study assumes that all announced projects in Europe will be realised and operate at announced capacity, which means 100% utilization. Additional potential new projects have not been considered.

For the announced projects located outside Europe, the following import assumptions have been agreed by JEC partner organisations:

Non-conventional biofuels	Maximum sensitivity	Reference case
North America	5%	0%
South America	20%	0%
Asia/Others	20%	0%

HVO/Co-processing	Maximum sensitivity	Reference case
North America	70%	0%
South America	70%	0%
Asia/Others	70%	0%

Table 4-2. Non-conventional biofuels import assumptions

This study assumes in the reference scenario that none of the advanced and HVO/co-processed biofuels will be imported into the European market. Globally there is a strong focus on using advanced biofuels in the

[57] Definition of non-conventional biofuels can be found in Section 1.6.1. It also include HVO and co-processing from ILUC risk feedstock.

transport sector. Some regions do even have incentives in place that increase the use of advanced biofuels locally instead of exporting. It must be said that the biofuel trading flows strongly depend on prices and governmental incentives.

For the sensitivity case JEC partner organisations agreed on a rather small import percentage for advanced biofuels and a higher import percentage for HVO/co-processing volumes. This is because the current trade flows of HVO show that feedstock suitable for HVO processing is imported into Europe due to its strong market demand for diesel fuel.

The following non-conventional biodiesel volumes are the result of the above assumptions and are used in the reference scenario (HVO/Co-processing is described in more detail below):

EU available volume [ktoe]	Reference case	Maximum case
Bio-diesel Waste Wood FT	390	391
Bio-diesel FT Farmed Wood	0	4
Bio-diesel Waste Veg./AF	0	52
DME Waste Wood	2	2
Bio-diesel other	0	16
HVO/Co-processing	3000	4500

Table 4-3. Non-conventional bio-diesel outlook

EU available volume [ktoe]	Reference case	Maximum case
Ethanol Framed wood	0	0
Ethanol Waste wood	67	149
Ethanol Wheat straw type	135	271
Methanol Waste wood	331	335
Ethanol others	0	16
Biobutanol	316	323

Table 4-4. Non-conventional bio-gasoline outlook

	Capacity (Mt/a)	Capacity (Mtoe/a)
Neste Oil Porvoo (HVO)	0.38	0.40
Neste Oil Rotterdam (HVO)	0.80	0.84
Neste Oil Singapore (HVO)	0.80	0.84
ENI/UOP start, Livorno, IT (HVO)	0.50	0.53
GalpEnergia, Portugal	0.25	0.26
PREEM Oil (co-processing)	0.10	0.11
UPM Finland (biorefinery)	0.10	0.11
Diamand Green Diesel USA (HVO)	0.45	0.47
Emerald Biofuels USA (HVO)	0.25	0.26
Dynamic Fuels LLC USA (HVO)	0.27	0.28
Additional HVO/co-processing (EU)	0.51	0.55
Sum (EU sites only)	**2.6**	**2.8**
Sum (Global)	**4.7**	**4.9**

Table 4-5. Global HVO/Co-processing outlook details

HVO and co-processing are well-established technologies with several projects implemented and more announced. It was recognized by CONCAWE member companies that co-processing and HVO planned projects are not always publicly disclosed at an early stage due to competition. Therefore, a confidential solicitation of CONCAWE member companies was completed which resulted in an additional declared projected capacity volume of about 0.55 Mtoe from co-processing in European refineries.

As a result the outlook for HVO/Co-processing in the 2020 reference scenario is 3.0 Mtoe[58] and an additional 1.5 Mtoe for the maximum sensitivity case. The following assumptions are made for HVO and co-processing:

- All announced commercial projects will be realised
- 50% of global HVO/co-processing production will use waste and residues as feedstocks

[58] For comparison reason 3.0 Mtoe is chosen to be in line with JEC Biofuels Study v2011.Bottom-up approach show that the HVO/co-processing is approaching the assumption of 3 Mtoe.

5. Outcome of the study

This chapter presents the results of the study and is organised in specific sections. Section 5.1 presents the results of the reference scenario with respect to the RED and FQD targets on the basis of the biofuels supply outlook. Section 5.2 compares the results of the revision carried out in this study with those of the JEC Biofuels study released in 2011. The effects of different fuel demand scenarios assuming the introduction of higher blend grades on the market are discussed in Section 5.3. Section 5.4 is dedicated to presenting the potential impacts of the different legislative concepts for RED and FQD amendment on the achievability of the RED and FQD targets. In the final Section 5.5, the results of the different sensitivity cases are discussed.

5.1 Outcomes of the reference scenario analysis

To summarize, the reference scenario includes E5, E10 and B7 as main fuel grades for road vehicles. Furthermore, a variety of alternative powertrain and fuelling options are available across all vehicle classes. All assumptions are described in detail in Chapter 3 and Appendix A.

5.1.1 Non-road transport sector

Fuel and energy demand by the non-road sectors is based on the "EU energy trends to 2030 – update 2009" baseline scenario (EC, 2010), which also discloses energy demand data for 2020. This scenario is considered to be reliable because of its consideration of macro-economic development since the economic downturn in 2008. The baseline scenario updated in 2009 shows a smaller increase in Aviation activity and a correspondingly lower aviation fuel demand compared with the previous JEC Biofuels Study. However, considerable uncertainty remains given the continuing financial turmoil.

Fuel demand non-road sectors in 2020 [Mtoe]	JEC v2011	JEC v2013
Rail fuel		
"Fossil" Electricity	4.6	5.0
Renewable Electricity	2.5	1.8
Fossil Diesel	2.8	3.1
FAME	0.2	0.2
Sum rail	**10.0**	**10.1**
Aviation fuel		
Gasoline	0.2	0.2
Kerosene	72.9	63.2
Sum aviation	**73.0**	**63.4**
Inland Navigation fuel		
Fossil Diesel	5.6	6.9
FAME	0.4	0.5
Sum inl. nav.	**6.0**	**7.4**
Other non-road fuel		
Fossil Diesel	18.7	6.4
FAME	1.3	0.4
Sum other non-road	**20.0**	**6.8**
RED Contributions non-road (%)		
Rail	0.9%	0.7%
Inland Navigation	0.1%	0.2%
Aviation	0.0%	0.0%
Other none-road	0.0%	0.0%
Sum RED-% non-road	**1.0%**	**0.8%**

Table 5-1. Non-road transport sector contribution

Note: might show rounding effects

Another important difference is the renewable electricity contribution in the Rail sector. As explained in Chapter 3, the assumed renewable share in the European electricity mix is 26% compared to 35% in the previous version of the JEC Biofuels Study. This results in a lower share of renewables used in Rail transport.

The JEC reference scenario assumes that no biofuels are consumed in the Aviation sector despite the 2011 European Advanced Biofuels Flightpath Initiative[59] setting a voluntary industrial target. (EC, 2013). Section 5.5 includes a sensitivity case accounting for market uptake of bio-jet volumes.

The overall contribution of the non-road transport sector towards the RED 10% target is 0.8% compared to 1.0% in the previous version of the JEC Biofuels Study.

[59] http://ec.europa.eu/energy/renewables/biofuels/flight_path_en.htm

5.1.2 Road transport sector

Road transport energy demand in the reference scenario is shown in Table 5-2 and Figure 5-1. Demand is projected to peak in 2015 and decline towards 2020. Given the assumptions of a growth in activity (expressed as vkm and tkm per year) and an increasing stock size, the decrease in energy demand is the result of significant energy efficiency improvements in vehicles. For passenger cars, LCV and HDV, the F&F model reflects CO_2 emission reduction targets that are capable of offsetting the impacts on total emissions and energy demand attributable to fleet and activity growth.

When looking at the split of diesel versus gasoline demand, the ratio is expected to grow towards 2020 due to three main effects: first, the share of diesel vehicles in car sales (currently 50% and higher) is still significantly higher than the diesel vehicle share in the fleet (35% in 2010). Secondly, more passenger diesel vehicles are sold in Europe with alternative powertrain vehicles assumed to replace more gasoline vehicles than diesel vehicles. Third, the gradual uptake of E10 demands more ethanol at the expense of fossil gasoline towards 2020. On the diesel side, the subsitution of fossil diesel by FAME in B7 is assumed to be almost fully leveraged in 2015 and HVO demand growth from 2015 to 2020 only shows smaller effects.

Road fuel (Mtoe)	2010	2015	2020
Gasoline fossil to Car	91	79	69
Gasoline fossil to LCV	2.5	2.8	3.0
Sum fossil Gasoline	**93**	**82**	**72**
Diesel fossil to Car	76	83	83
Diesel fossil to LCV	28	26	22
Diesel fossil to HD	88	86	85
Sum fossil Diesel	**192**	**195**	**189**
Fossil Diesel to Gasoline ratio (road only)	2.1	2.4	2.6
CNG	0.2	0.8	2.4
Of which CBG	*0.0*	*0.1*	*0.5*
LPG	2.5	2.5	3.0
LNG	0.1	0.2	0.4
H2	0.0	0.0	0.0
FAME	9.8	13.2	13.0
HVO/co-processing	0.4	2.3	3.0
BTL	0.0	0.0	0.4
Butanol	0.0	0.3	0.3
Adv. DME	0.0	0.0	0.1
Total Ethanol	2.9	3.2	3.7
Of which food/energy based	*2.6*	*2.6*	*3.0*
Of which non-food/energy based	*0.3*	*0.6*	*0.7*
Electricity	0.0	0.1	0.3
Of which Renewable Electricity	*0.0*	*0.0*	*0.0*
Sum road	**301**	**299**	**288**
RED Contributions			
Non-road			0.8%
Road			7.9%
Sum RED-%			**8.7%**
FQD GHG saving			**4.3%**

Table 5-2. Reference case road fuel demand

Note: might show rounding effects

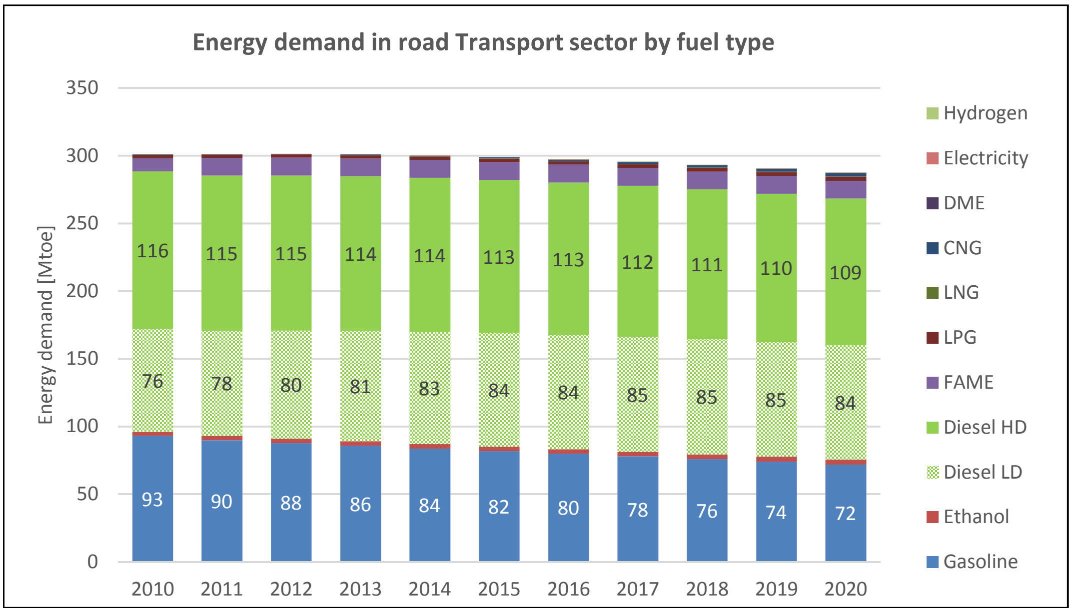


Figure 5-1. Road transport energy demand by fuel type

The contributions of alternative fuels like CNG, LPG and LNG are very small. The LNG demand is triggered by uptake in the heavy duty segment. It must be concluded that the growth potential of CNG could play a significant role in decarbonizing the road transport sector. However, the contribution of methane fuels towards the RED targets requires sustainable renewable components. The energy growth of alternative fuels is described in more detail in Appendix E.

Summary of reference scenario results

Fossil energy demand changes compared to baseline year 2010

- Gasoline demand in 2020 decreases by 23%
- Diesel demand is almost the same in 2010 and 2020 but shows a peak in 2015
- Diesel demand increases by 9% for passenger cars towards 2015 and stabilizes afterwards while the demand from commercial vehicles (LCV and HDV) steadily decreases by 8% by 2020.
- As a result, the diesel/ gasoline demand ratio increases from 2.1 to 2.6

Large biofuel volumes are needed with FAME remaining the dominant biodiesel. However, FAME demand does not grow from 2015 to 2020. The CNG fleet uptake remains strong and keeps increasing its fuel demand towards 2020. An increasing supply of renewable methane fuel (CBG) is also assumed contributing 20% of the total CNG demand and containing 50% advanced[60] biogas.

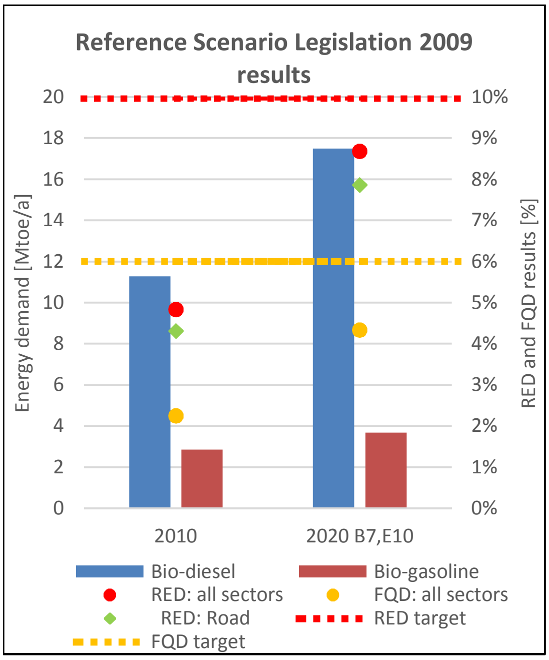


Figure 5-2. Result of Reference Scenario

The RED target of 10% renewable energy in transport by 2020 is not met, but a figure of 8.7% is achieved including a 0.8% contribution from non-road transport modes. The FQD target of 6% GHG emissions reduction is also not met, instead 4.3% savings are achieved when all relevant transport modes are included.

[60] According to Article 21(2) RED 2009

5.2 Comparison of the reference scenario with JEC Biofuels Study 2011

Updating the JEC Biofuels Study resulted in revised (and lower) estimates of the renewable content (according to the RED methodology) and GHG savings (according to the FQD methodology) that can be achieved by 2020. The JEC Biofuels Study 2011 reference scenario indicated a level of attainment of 9.7% renewable energy content (against the RED target of 10%) compared with 8.7% in this 2013 revision. It is important to outline the main causes of this difference.

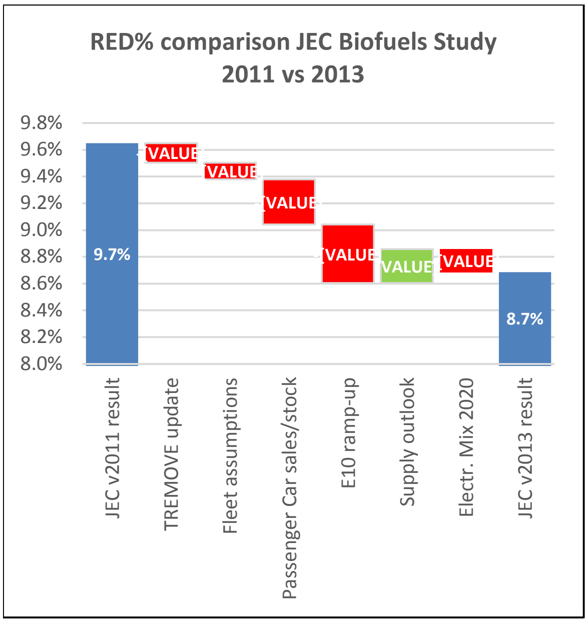


Figure 5-3. RED% comparison JEC Biofuels Study 2011 vs 2013

Figure 5-3 shows the main factors contributing to the difference:

- Europe electricity mix 2020 update
- Non-conventional supply outlook update
- E10 market ramp-up
- Passenger Car sales, stock 2020 and E10 compatibility update
- Fleet assumption updates
- TREMOVE model version update

Although the explanation is focussed in this Section on the differences with reference to the RED target, similar reasons were found for the changes between the outcomes of the two JEC Biofuels Study versions and the achievement of the FQD target.

5.2.1 Europe electricity mix 2020

The revised estimate for the share of renewable electricity in 2020 is 26% compared to 35% in the previous version of this study. This is the result of revised assumptions in the references used (DG ENER v2009 versus DG TREN report 2007). It has a direct effect on the renewable electricity used by rail transport and, to a lesser extent, by road transport. The combined effect on the attainment of the RED target is a 0.17% decrease in renewable energy.

5.2.2 Non-conventional supply outlook

The new bottom-up approach for updating the non-conventional supply outlook introduced in this revised version of the JEC Biofuels Study results in a positive effect on the RED target. The new outlook shows a higher availability of advanced biofuels mainly driven by a higher share of low-ILUC risk feedstock usage in HVO/co-processing facilities (see Figure 5-4, low-ILUC risk from 1.0 to 1.5 Mtoe)[61]. Furthermore, a higher volume of BTL is assumed in 2020 than it was the case in the 2011 version of the study. Since the previous study technology development has lowered the cost of BTL and let to an increase in investment announcements.

Both BTL and HVO/Co-processing products are drop-in fuels in the diesel pool and provide options to increase the renewable content beyond the B7 FAME-blending limit. The drop-in fuel is replacing the fossil diesel part and therefore has a strong effect on the capacity to attain the RED target.

To summarize: the same total HVO/co-processing supply coupled with a higher share of advanced feedstocks (that are counted twice towards the RED target) and larger BTL availability result in an increase in renewable content of 0.25% towards the RED target.

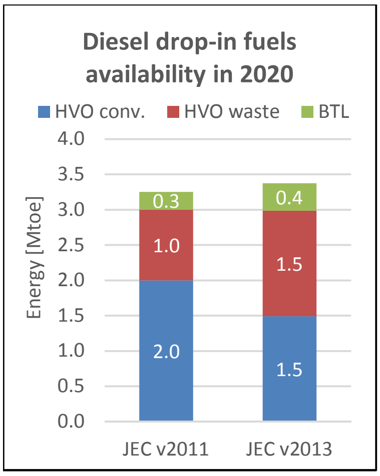


Figure 5-4. Comparison supply outlook v2011 vs v2013 (excluding multiple counting)

5.2.3 E10 market ramp-up

Since the previous study E10 has been introduced in Germany, France and Finland. The speed of market uptake in these countries has been used to define a standard ramp-up function for higher grades and has been applied in this revision (see also Section 5.5.3). JEC Biofuels Study 2011 assumed a 100% uptake compared to 36% used in this revision. This results in a lower uptake of ethanol in gasoline which decreases the attainment of the RED by 0.44%.

5.2.4 Passenger Car sales, stock 2020 and E10 compatibility update

Revised assumptions on car fleet composition exert a strong negative effect on the capacity to achieve the RED target. The 2011 version of the F&F model used the same data as TREMOVE v2.7 for the sales of new cars resulting in a prediction of 21.8 million new car sales in 2020. The total passenger car stock in 2020 was assumed to be 270 million vehicles according to TREMOVE v2.7. This has been significantly revised, taking into account the effects of the recent economic downturn.

JEC partner organisations agreed that the sales projection assumed in the revised TREMOVE v3.3.2 alt was too optimistic. Based on EUCAR members' consensual view, it was instead agreed to assume that the total new car sales of in 2020 is 16 million, the same as in 2007 before the economic crisis. The total passenger cars stock in 2020 is – in absence of better data

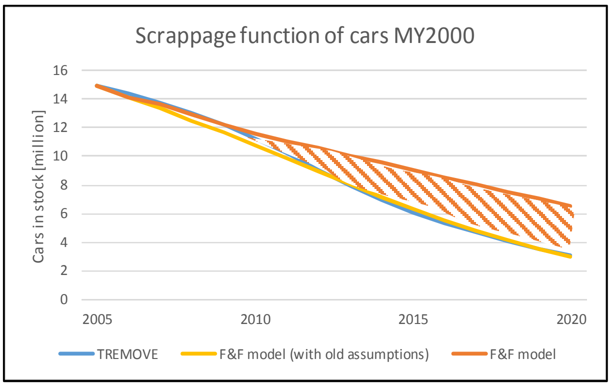


Figure 5-5. Scrappage function of cars MY2000

: attractive economic option. This study however routes the waste into

- taken from TREMOVE v3.3.2 and is 275 million. The new set of assumptions result in a car fleet characterised by a higher share of older vehicles in 2020, which is consistent with a lower turnover of cars due to low economic growth and customer confidence: people are expected to keep their cars longer before replacing them. As an example, the scrappage of cars of model year 2000 (MY2000) is shown in Figure 5-5. The yellow line F&F model (with old assumption) used in the JEC Biofuels Study v2011 show the stock reducing to almost 3 million cars left in 2020. The orange line shows the scrappage of the same MY 2000 cars with the revised assumptions. This results in a higher stock of MY2000 cars in 2020 totally 7 million cars. See also Section 3.1 and Figure 3-3.

The E10 vehicle compatibility has been revised as the JEC partner organisations agreed that passenger cars from year 2000 are compatible with E10.

The updated assumptions on sales and stock result in a lower estimate of the number of passenger cars that are compatible with E10. On the other hand, changing the baseline from MY2005 to MY2000 results in a higher share. In the JEC Biofuels Study v2011 17 million cars (13% of the road car fleet) in 2020 were not compatible with gasoline grade E10 while in the current version that figure rises to 28 million cars (19% of the road car fleet). This implies that the share of E10-compatible vehicles is lower and uptake is slower in this version compared to the previous version of the study.

Furthermore, a slower replacement of older, less efficient vehicles with newer, more efficient vehicles results in a higher overall energy demand and hence a larger denominator in the RED calculation. As some renewable fuels are assumed to be available in only limited amounts (e.g. 0.4 Mtoe of BTL in 2020 irrespective of the total diesel fuel demand), this effect should not be neglected.

The overall impact of these effects is a decrease of 0.34% in the estimate of the share of renewable energy in transport compared to the analysis provided in the previous version of the study.

5.2.5 Fleet assumptions

JEC partner organisations have reviewed the assumptions made about alternative powertrains development. These cover all vehicle classes from passenger cars to heavy duty. The main differences in the assumptions made in this study and the previous one are:

- a more conservative view on CNG uptake in several classes towards 2020.
- the slower development of flexible fuels vehicles
- lower sales of passenger cars in 2020 also impacts the introduction to the market of alternative vehicles.

The revised assumptions are based on sales data up to 2012 and the lower than expected market penetration rates of alternative powertrains towards 2020.

The combined effect of the revised assumptions about alternative powertrains is a decrease of 0.12% in the share of renewable energy in transport compared to the previous study.

5.2.6 TREMOVE v2.7 to v3.3.2 alt

The final significant difference between this study and the 2011 version is the version of the TREMOVE transport emission model that was used. The 2011 study used TREMOVE v2.7, the new study used an updated version of TREMOVE v3.3.2 alt. One of the updated parameters is the vehicle fleet development towards 2020. The passenger car fleet is older compared to TREMOVE v2.7 resulting in fewer vehicles being compatible with E10 and a slower market penetration of other alternative fuels. Furthermore, fleet development in terms of activity growth, sales of new light commercial and heavy duty vehicles has changed. Finally, the review of the diesel split between passenger cars, light commercial and heavy duty vehicles, as discusses in Appendix B, results in a lower activity for passenger cars and higher share for heavy duty vehicles.

The effect is a decrease of approximately 0.15% in the share of renewable energy in transport compared to the previous study..

5.3 Fuel demand scenarios

Besides the reference scenario, there are three additional scenarios that assume different total fuel demand composition due to the introduction of different fuel grades. In Figure 5-6 all the scenarios analysed in this revision of the JEC Biofuels Study can be found.

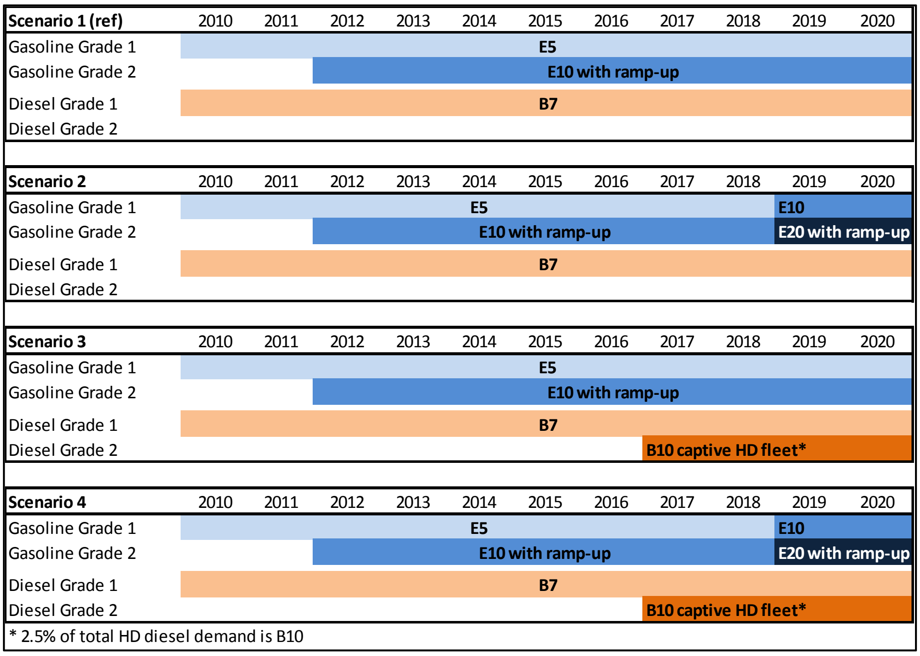


Figure 5-6. Fuel blend scenarios

There are two main differences between the reference scenario and the three fuel demand scenarios: (1) the market introduction of E20 gasoline blend and (2) the market introduction of B10 diesel blend for captive fleets representing 2.5% of total heavy duty diesel demand, which is an assumption based on experts opinion in EUCAR.

This study assumes in scenario 2 that E20 blend will be introduced in the market in 2019. All gasoline vehicles sold in 2019 are therefore assumed to be E20-compatible and from 2019 onwards all vehicles from 2018 and older are E10 compatible. The same ramp-up function is used as for the introduction of E10, see Section 5.5 for more information on customer ramp-up function. The resulting E10 uptake is 98.6% and E20 is 1.4% of total gasoline sales in 2020.

Scenario 3 assumes that the diesel grade B10 is introduced for captive fleets only, representing 2.5% of the heavy duty diesel demand.

Scenario 4 is the combination of scenarios 2 and 3, introducing E20 and B10 for captive fleet.

All other assumptions are kept the same in all scenarios, including the regulatory framework (RED and FQD).

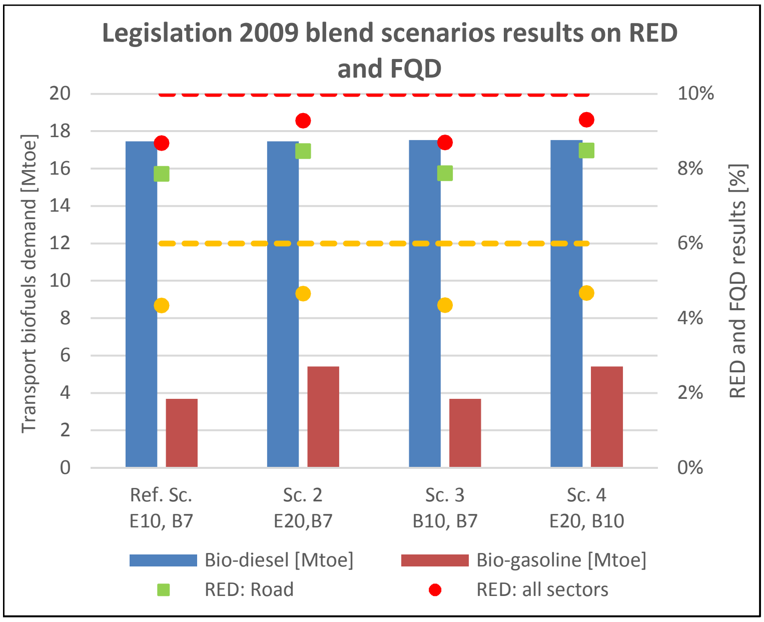


Figure 5-7. Fuel blend scenario results

It is evident that it is the <u>road</u> transport mode – with the given assumptions – that is expected to deliver the lion's share of progress towards the 10% RED target and 6% FQD GHG savings target. At the same time, the role of non-road transport modes is essential to approach the regulatory targets. This is clearly presented in Section 5.1 in terms of the contribution of road transport and all non-road transport modes towards reaching the 10% RED Directive target.

With respect to the introduction of higher blend grades, the current outlook suggest that they will make only a limited contribution towards reaching the regulatory targets. Introducing new fuel blends to the market takes time and will therefore not make an important difference by 2020. Scenarios 2 and 4 make the assumption that when E20 is introduced E10 becomes the main gasoline grade, which implies maximum possible uptake of E10: this results in the steep increase of bio-gasoline demand. In Section 5.5 a sensitivity case is calculated to show the effect and importance of a smooth market fuel introduction, not reflecting the experience with the introduction of E10 across Europe.

	Ref. Scenario	Scenario 2 [E10,E20,B7]	Scenario 3 [E5,E10,B7,B10]	Scenario 4 [E10,E20,B7,B10]
Bio-gasoline [Mtoe]	3.7	5.4	3.7	5.4
Bio-diesel [Mtoe]	17.46	17.46	17.52	17.52
RED%	8.7%	9.3%	8.7%	9.3%
FQD%	4.3%	4.7%	4.3%	4.7%

Table 5-3. Fuel blend scenario results

5.4 Comparative impact of legislative amendment proposal

Since the previous version of this study three legislative concepts have been put forward to amend the RED and the FQD. Each proposal will have a different with a potential different effect on the capacity to reach the RED and FQD targets. In Section 0 the different legislative concepts are discussed. To summarize: this study quantifies the effect each of legislative concept has on meeting the RED and FQD targets. The legislative texts analysed are:

- Current legislation RED (2009/28/EC) and FQD (2009/30/EC)
- European Commission ILUC proposal of October 2012 (EC, 2012b)
- European Parliament (EP) vote in 1st reading of September 2013 (EP, 2013)
- Council compromise proposal of December 2103 (CEU, 2013)

The main differences between the proposals relate to the introduction of an accounting cap on the eligibility of conventional biofuels to be counted towards the RED target and multiple counting factors per feedstock category. Additionally, the EP vote and the Council compromise apply the accounting cap on conventional biofuels to the FQD target calculation as well as to the RED. Furthermore, the Council compromise includes a "super-credit" for electricity used in road transport. Electricity used in road transport can be counted 5 times instead of 2.5 times as foreseen by the original RED and the FQD. Finally, The EP vote includes ILUC factors for ILUC risk feedstock[62]. In Appendix D the complete list of biofuels pathways and legislative settings can be found.

5.4.1 Blending assumptions when a cap on conventional biofuels is applied

When the cap on the eligibility of conventional biofuels to count towards the RED and/or the FQD targets is introduced, it also introduces an optimization problem. When conventional biofuels are limited by the accounting cap (the cap does not forbid higher blending of such fuels), the market will optimize the blending to maximize the GHG savings. How much and what type of conventional ethanol and FAME is used and the ratio between them is an optimization question. The optimization is done in this study based on the maximum achievable GHG saving based on individual pathways and their GHG intensity. This part of the analysis simulates the effects of different legislative concepts and options. In that perspective, the following assumptions are made when blending biofuels.

In the case of the current RED and FQD legislation:

1. Blend all available advanced biofuels (excluding drop-ins)
2. Add conventional biofuels up to biofuels demand as determined by the F&F model (E5, E10 and B7)
3. Blend all available drop-in biofuels

In the case of the European Commission ILUC proposal of October 2012:

1. Blend all available advanced biofuels (excluding drop-ins)
2. Add conventional biofuels up to biofuels demand as determined by F&F model (E5, E10 and B7)
3. Blend all available drop-in biofuels
4. Assume that fuel suppliers will do steps 2 and 3 in order to maximize the FQD GHG reduction as the accounting cap of 5% only applies to RED target.

In the case of the European Parliament vote of September 2013:

1. Blend available advanced biofuels
2. Blend conventional biofuels up to the accounting cap of 6% and not more than the biofuels demand as determined by F&F model (E5, E10 and B7)
3. Blend only advanced drop-in biofuels

[62] iLUC factors according to Annex VIII of the EP 1st reading, European Parliament Plenary sitting report A7-0279/2013, 26/7/2013. Procedure: 2012/0288(COD)

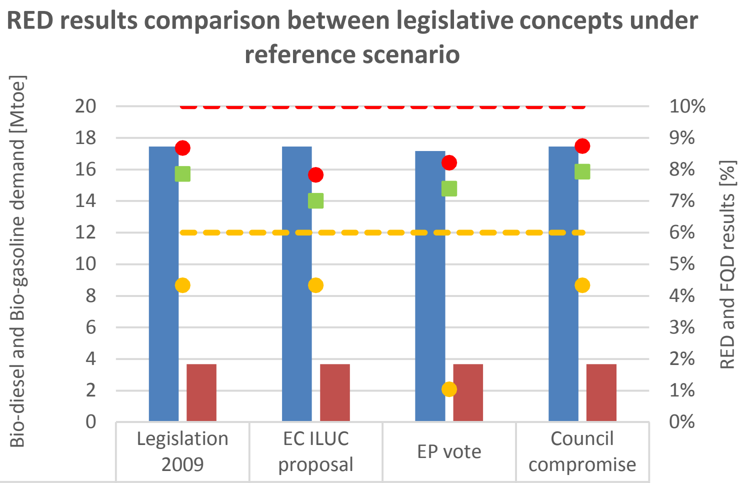
It is assumed that fuel suppliers will not maximize the FQD like in the EC ILUC proposal step 4, as the accounting cap also applies to the FQD.

In the case of the Council compromise proposal of December 2103 the same blending priorities are assumed as for the EP vote with an accounting cap on conventional biofuels of 7%.

This study assumes that ethanol is always maximized to the biofuels demand. Theoretically, when the accounting cap on conventional biofuels is applied and it is the constraining element due to limited advanced biofuels supply, a fuel supplier can choose not to fully utilize the E10 with conventional biofuels and use more conventional biofuels in the diesel pool.

5.4.2 Results of the legislative comparison

In Figure 5-8 the results of the different legislative concepts in the reference scenario can be found. This chapter will only cover the results for the reference scenario. The results per fuel blend scenario can be found in Appendix G.



	Legislation 2009	EC ILUC proposal	EP vote	Council compromise
Bio-diesel [Mtoe]	17.46	17.46	17.16	17.46
Bio-gasoline [Mtoe]	3.7	3.7	3.7	3.7
RED: Road	7.9%	7.0%	7.4%	7.9%
RED: all sectors	8.68%	7.83%	8.22%	8.75%
FQD: all sectors	4.3%	4.3%	1.0%	4.3%
RED target	10%	10%	10%	10%
FQD target	6%	6%	6%	6%

Figure 5-8. Legislative comparison results on RED & FQD

None of the legislative proposals result in the RED target of 10% renewable energy in transport being met. The results range from 7.83% for the EC ILUC proposal to 8.75% for the Council compromise. The Council compromise yields a slightly higher (0.07%) renewable energy share than the current RED due to super credit on electricity in road transport.

The FQD GHG savings target is also not met by any of the proposed amendments. Including ILUC according to the EP vote (EP, 2013) results in a huge shortfall in meeting the 6% target. It must be noted that this study did not review the causal effect of introducing ILUC factors on potential changes of fuel suppliers blending strategies. Therefore the FQD results in this case are rather conservative.

On the total biofuels uptake it is interesting to see that the effect of the introduction of the accounting cap on conventional biofuels by the EC ILUC proposal is different compared to that of the EP voted text and the Council compromise. The accounting cap on conventional biofuels of 7% proposed by the Council compromise has no effect as it is not a constraining factor. In other words, the biofuels demand as determined by the F&F model given the grades E5, E10 and B7 is fully utilized. This is not the case for the EC ILUC proposal and the EP voted text. In those two cases not enough advanced biofuels are available to fully utilize the blending limits. For the EC ILUC proposal the accounting cap on conventional biofuels is exceeded to maximize the FQD GHG savings. Therefore the uptake of bio-diesel and bio-gasoline is the same as in Legislation 2009 and Council compromise.

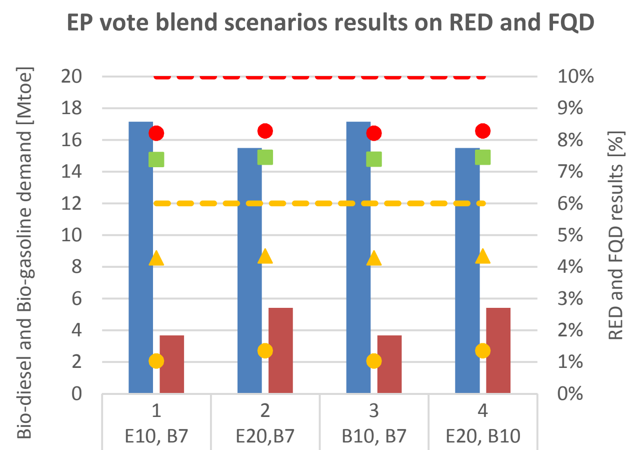
Introducing an accounting cap on biofuels from conventional feedstock will make it more difficult to attain the RED renewable energy target by 2020. Fuel suppliers are incentivised to use renewable energy from advanced feedstock by the introduction of multiple counting factors. However, the supply outlook shows that advanced biofuels is limited towards 2020. Table 5-4 shows that the proposed changes in multiple counting factors for selected feedstock categories do not close the gap in reaching 10% renewable energy by 2020 in any of the amendment proposals.

	Multiple Counting Factors		
	Excluding*	Including*	Delta
2009 RED & FQD	7.7%	8.7%	1.0%
2012 EC ILUC proposal	6.7%	7.8%	1.1%
2013 EP 1st reading	7.7%	8.2%	0.5%
2013 Council Text	7.7%	8.7%	1.0%

Table 5-4. Effect of Multiple counting factors

*Including multiple counting factors shown in Appendix D and excluding means all counting factors are 1.

Finally, when looking at Figure 5-9 it must be concluded that for the EP vote proposal, introducing higher blend grades (E20 and B10) will not affect the capacity to achieve the RED and FQD results significantly. The change that can be seen is caused by the assumption that with the introduction of E20 the main grade becomes E10 with an uptake of 100%. The share of E20 in 2020 is only 1% of total gasoline volume. The relative low effect on RED is because the accounting cap on conventional biofuels and the limited availability of advanced biofuels prevents fuels suppliers from increasing the bio-based content of the fuel. Introducing higher blends is only effective if the supply of advanced biofuels increases at the same time.



	1 E10, B7	2 E20,B7	3 B10, B7	4 E20, B10
Bio-diesel [Mtoe]	17.16	15.49	17.16	15.49
Bio-gasoline [Mtoe]	3.7	5.4	3.7	5.4
RED: Road	7.4%	7.5%	7.4%	7.5%
RED: all sectors	8.22%	8.29%	8.2%	8.3%
FQD: all sectors	1.0%	1.4%	1.0%	1.4%
FQD excl. iLUC reporting	4.3%	4.4%	4.3%	4.4%
RED target	10%	10%	10%	10%
FQD target	6%	6%	6%	6%

Figure 5-9. EP vote results on different fuel blend scenarios

5.5 Sensitivity analysis

As described in Section 3.3, the F&F model has several adjustable parameters that influence projections to the year 2020. The parameters which show the largest effects on RED and FQD are discussed. Furthermore, some additional sensitivity cases were considered to assess the effects of future uncertainties. These cases are:

- Supply outlook maximum case
- E10 ramp-up; vehicle and fuel compatibility
- European Electricity mix
- European Flight Path biofuels target

5.5.1 Adjustable parameter results

For the adjustable parameters minimum and maximum values were agreed within the JEC consortium. In the following three tables all the parameters can be found.

Passenger cars:

Passenger cars parameter	Unit	Reference	Min	Max
Total fleet	Mln cars in 2020	275	220	330
Total sales	Mln cars/a in 2020	16	13	19
CNGV sales	% sales 2020	3.0%	1.0%	5.0%
xEV sales	% sales 2020	3.0%	1.5%	10.0%
Total mileage	% YoY growth	1.83%	1.46%	2.20%
LPGV sales	% sales 2020	3.0%	2.0%	4.0%
FCEV sales	% sales 2020	0.25%	0.0%	0.5%
Diesel registration share	% of diesel	50%	40%	60%

Table 5-5. Passenger Car adjustable parameter sensitivities

Light commercial vehicles:

LCV parameters	Unit	Reference	Min	Max
Vehicle Total Mileage *	% YoY growth	mixed	-20%	+20%
LCV CNG vehicle sales	% sales 2020	3.0%	1.0%	5.0%
LCV FCEV sales	% sales 2020	0.25%	0.0%	0.5%

Table 5-6. LCV adjustable parameter sensitivities

* Subclasses gasoline, diesel <2.5t and diesel >2.5t all %YoY growth rates are decrease and increased by 20%

Heavy Duty:

Heavy Duty Parameter	Unit	Reference	Min	Max
Vehicle efficiency	% YoY growth	-1.48%	-1.18%	-1.48%
Load factor *	Load YoY growth	mixed	-20%	20%
Transport demand *	tkm/pkm YoY growth	Mixed	-20%	20%
HD CNG vehicle sales		mixed	result	result
-3.5t-7.5t	% sale 2020	2.0%	0.0%	4.0%
-7.5t-16t	% sale 2020	1.5%	0.0%	3.0%
-16t-32t	% sale 2020	2.0%	0.0%	4.0%
-Busses/coaches	% sale 2020	5.0%	0.0%	10.0%
HD LNG vehicle sales		mixed	result	result
-16t-32t	% sale 2020	1.0%	0.0%	2.0%
->32t	% sale 2020	1.0%	0.8%	2.0%
HD E95 sales		mixed	result	result
-16t-32t	% sale 2020	0.5%	0.0%	1.0%
-Busses/coaches	% sale 2020	2.0%	1.0%	4.0%
HD DME sales in 16-32 Tonnes	% sale 2020	0.50%	0.00%	1.00%

Table 5-7. Heavy Duty adjustable parameter sensitivities

* All subclasses parameters are decrease and increased by 20%

Figure 5-10 shows which of the adjustable parameters have the biggest impact on the capacity to meet RED and FQD targets given the assumptions. The complete set of results can be found in Appendix H.

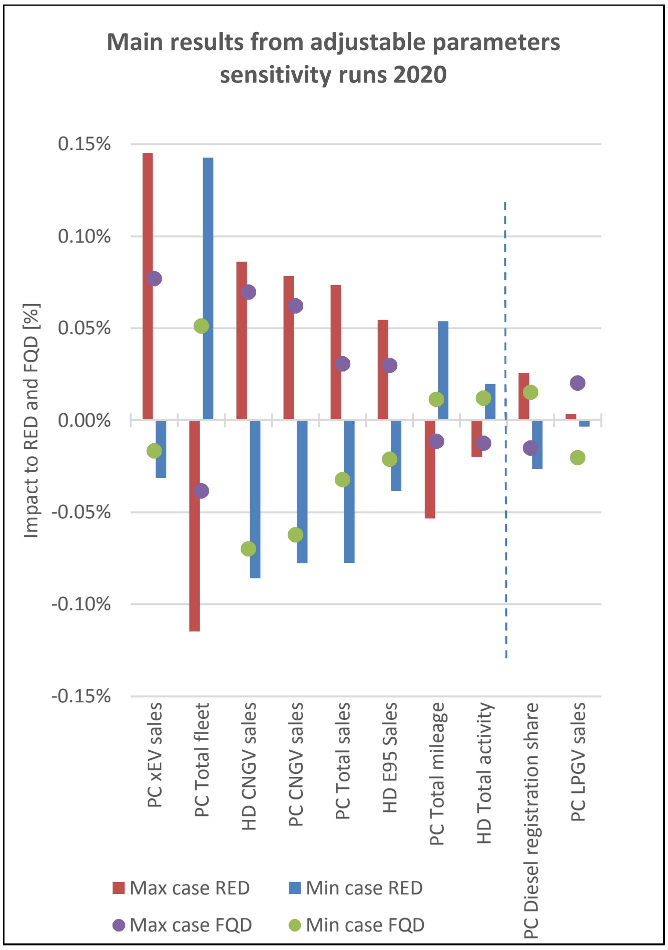


Figure 5-10. Adjustable parameters sensitivity runs main results

Based on the results of the sensitivity analysis, the main variables contributing towards the achievability of the RED and FQD targets are: the sales of alternative vehicles and the fleet renewal rate.

Both variables in fact lead to higher scrappage of older vehicles. This results in more E10-compatible cars and therefore higher bio-gasoline demand in road-transport. Note that the passenger car fleet minimum case has a positive effect on reaching RED and FQD target: a lower stock of cars with the same sales rate results in a proportionally higher scrappage of older vehicles and a newer fleet stock with relatively more alternative vehicles – but also a lower total energy demand.

The pace of increasing the share of xEV and CNG vehicles mainly and to some extend E95 vehicles is expected to impact the capacity to reach the RED and FQD targets.

Finally, it is worth mentioning that the diesel registration share has an impact on improving the GHG savings. In other words, a lowering sales share of diesel passenger cars will improve the GHG savings, due to a lower GHG intensity of gasoline (87.1 vs 88.6 gCO_2/MJ). The improved GHG saving effect is also seen for higher sales of LPG vehicles. However, both effects are smaller or similar to the GHG reduction achieved from higher new cars sales, which leads to a faster renewal of the fleet.

5.5.2 Supply outlook maximum case

In Section 4.2.2 the non-conventional supply outlook for the reference scenario and the sensitivity cases has been described. The supply outlook used in the sensitivity analysis may be considered to be optimistic as it assumes higher volumes imported to Europe. This assumption strongly depends on the legislative development in Europe but also on regulation and market developments in the rest of the world. To summarize the sensitivity case assumes the following volumes:

EU available volume [ktoe]	Max. sensitivity case
Bio-diesel Waste Wood FT	391
Bio-diesel FT Farmed Wood	4
Bio-diesel Waste Veg./AF	52
DME Waste Wood	2
Bio-diesel other	16
HVO/Co-processing	4500
Total	**4965**

EU available volume [ktoe]	Max. sensitivity case
Ethanol Framed wood	0
Ethanol Waste wood	149
Ethanol Wheat straw type	271
Methanol Waste wood	335
Ethanol others	16
Biobutanol	323
Total	**1094**

Table 5-8. EU available non-conventional biofuel

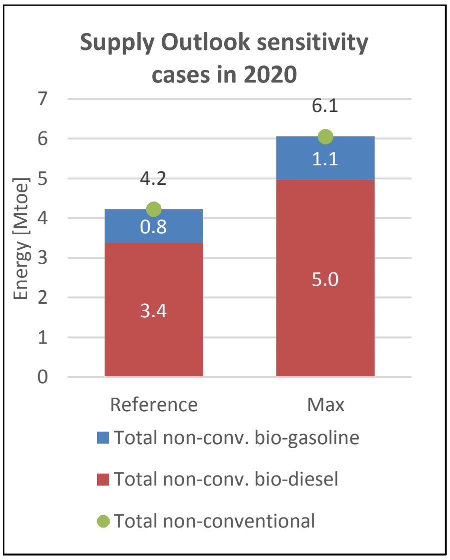


Figure 5-11. Supply outlook sensitivity run

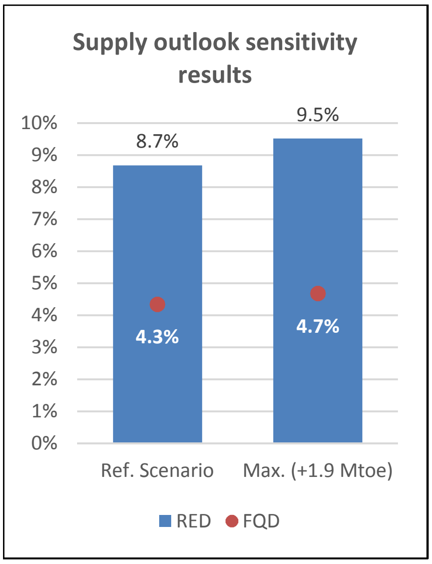


Figure 5-12. Supply outlook sensitivity result

Figure 5-11 show the total non-conventional biofuels supply used in the reference and maximum sensitivity case (+1.9 Mtoe). Even with this optimistic supply outlook, the RED and FQD targets will not be met, but the gap narrows. This impact emphasises the importance of investing in advanced biofuels and accelerating the setup of new production plants in Europe.

The results for the maximum supply outlook are 9.5% renewable energy and 4.7% GHG savings.

5.5.3 E10 ramp-up and vehicle compatibility

The introduction of fuel grades E5 and B7 in the European market cannot be compared with the introduction of higher fuel grades, like E10 and B10. The main difference is that E5 and B7 are today the main grades and their biofuels content was slightly increased over an extended time period. Most of the customers in Europe did not notice any changes which were not the object of widespread information campaigns. All the vehicles on the market were able to be fuelled with E5 and B7. Conversely, with the introduction of higher blends customers do have a visible choice at the fuelling station. As a consequence, with the introduction of E10, E20 and higher diesel grades it cannot be assumed that all customers that drive a compatible vehicle will fuel the highest grade available. This might be different for scenarios assuming the introduction of higher diesel blends in captive fleets where the users are more effectively informed. This choice depends on several factors, like perceived quality and price setting. Customer preference has become an increasingly important factor in the market ramp-up of new fuel grades.

Recent examples of E10 introduction have made this factor evident. Three sources show the uptake of E10 in Germany, France and Finland since their introduction:

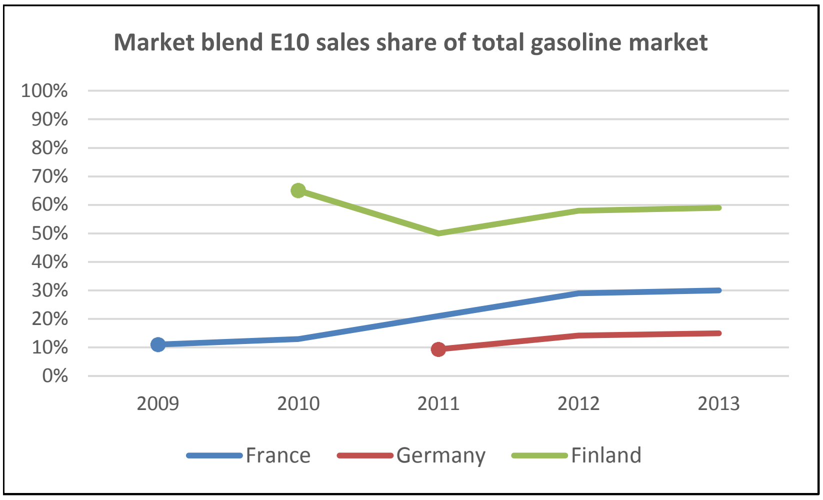


Figure 5-13. E10 market ramp-up in Germany, France and Finland[63]

As shown in Figure 5-13, the market ramp-up of E10 is slow in Germany at around 15% after 2 years since its introduction, in France at around 30% after 5 years and in Finland at 60% after 2 years.

A minimum sensitivity case has been assumed of 17% market uptake of E10 in 2020 in EU27+2 and a maximum case of 100%. The minimum case assumes that no addition Member States will introduce E10 and only Germany, France and Finland will slowly increase uptake towards 2020 (2010 share was 1%). The maximum case assumes that all E10 compatible cars (MY2000+) in Europe will fuel E10. The reference scenario assumes a 36% uptake by 2020. This values is calculated based on a standard ramp-up function applied to all countries. The standard ramp-up function is calculated based on the Germany, France and Finland market introduction trend over the first 3 years after introduction. For the reference case it was assumed that the rest of the European countries will introduce E10 by 2017 (median of 2014-2020). Some of the countries will introduce it earlier and some later, but on average in 2017.

[63] Sources:

Germany: http://www.bafa.de/bafa/de/energie/mineraloel_rohoel/ausgewaehlte_statistiken/index.html, accessed 17-10-2013

France: http://www.cpdp.org/, accessed 18-10-2013

Finland: http://www.oil.fi/fi, accessed 18-10-2013

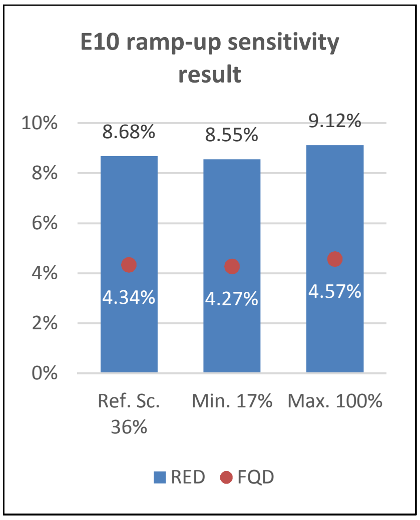


Figure 5-14. E10 ramp-up sensitivity result

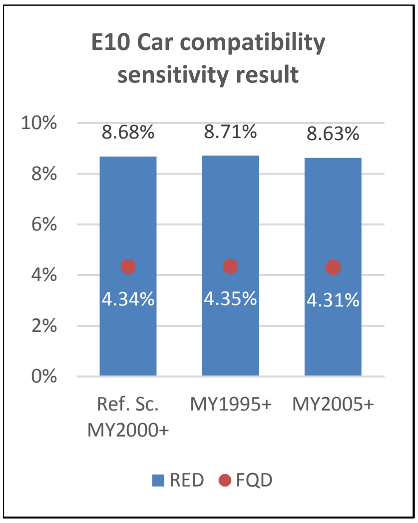


Figure 5-15. E10 Car compatibility sensitivity result

The minimum case show a decrease in the capacity to achieve the RED target by 0.13% and the maximum case an increase of 0.44%, see Figure 5-14. Therefore, a European-wide smooth introduction of a higher fuel grade appears as an important factor which needs to be achieved via the involvement and the support of the main industry parties and the regulators. Towards 2020 a focus on increasing E10 uptake is necessary to approach the RED and FQD targets.

Besides customer preference, vehicle compatibility is essential. In this study, it is assumed that vehicles from model year 2000 are compatible with E10. Nevertheless choosing a given model year for the entire vehicle fleet does not entirely mirror reality, as compatibility depends on the choices made by vehicle manufacturers and even vary by vehicle model and specific engine type. For that reason, two cases have been defined: a minimum case with model year 2005 and a maximum case with model year 1995.

The renewable energy content as per RED varies between 8.63% and 8.71% whilst the GHG reduction as per FQD varies between 4.31% and 4.35%, see Figure 5-15.

5.5.4 European Electricity mix

The electricity mix in 2020 has been changed compared to the previous version. This version takes the forecasted mix from the baseline scenario in the DG ENER report (EC, 2010) while version 2011 adopted the 2020 mix from European Renewable Energy Council 2008 (EREC, 2008) and Renewable Energy Snapshots 2009 (JRC, 2009). The electricity mix parameter strongly depends on the future economic situation and forthcoming regulatory targets on CO_2 reduction. The projections of Renewable Electricity Sources (RES) share in 2020 in published reports differ considerably[64]. Therefore, a minimum case of 21% and a maximum case of 31% have been tested (i.e. +/- 5%) to show the sensitivity of this parameter. The minimum and maximum values show the sensitivity of the parameter. They were not set to cover neither the full spectrum of existing projections nor data provided by Member States via the National Renewable Energy Action Plans and their updates.

Power generation technology class	Year 2010 share	Year 2020 share
Fossil	53%	**49.5%**
Nuclear	28%	**24.5%**
RES	19%	**26.0%**

Table 5-9. European electricity mix 2020

Both the renewable electricity share and the GHG intensity were updated in the sensitivity runs. In Figure 5-16 the results can be seen.

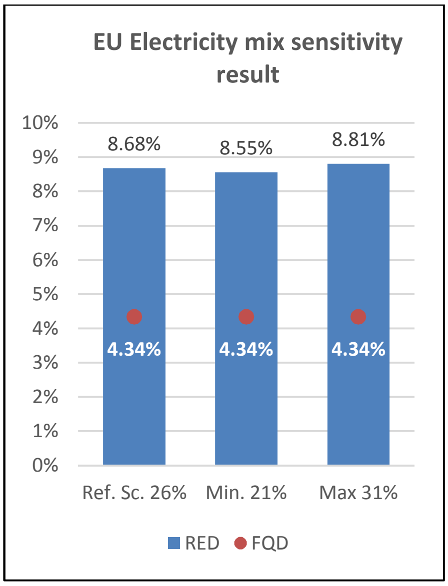


Figure 5-16. European Electricity mix 2020 sensitivity results

The share of renewable sources in the electricity mix has a measurable impact on the overall renewable energy content in transport fuels; the difference is 0.26% between the minimum case and maximum sensitivity case. However, the FQD spread is not significant due to small change in GHG intensity between the minimum and maximum case.

[64] DG TREN v2007 baseline vs reference scenario (EC, 2008), DG ENER v2009 baseline vs reference scenario (EC, 2010), JRC Renewable Energy Snapshot (JRC, 2009) and (JRC, 2013)

5.5.5 European Flight Path biofuels target

Key players in the aviation industry and biofuel suppliers have agreed upon a voluntary biofuels target of fuelling air transport with 2 million tons of biofuel in 2020 (converted to 2.06 Mtoe[65]). The "European Advanced Biofuels Flightpath" was launched in 2011[66]. Intermediate milestones and steps have been defined, including the definition of financial mechanisms for the construction of advanced biofuels plants. Technological challenges, financial mechanisms and European competitiveness have been under discussion since the launch of the "Flightpath" initiative.

This study assumes that the biofuel supply used in aviation is in competition with the road-transport sector, which means a shift of available supply volumes from one sector to the other. However, for the sensitivity case, the impacts of an additional amount of biofuels are assessed. This hypothesis is based on the consideration that the bottom-up supply outlook has tracked projects for bio-jet plants. An example is the GreenSky project from British Airways and Solena building a bio-jet plant near the city of London using municipal waste[67]. From the supply outlook it is assumed that for the aviation sector an additional 0.1 Mtoe of biofuels is produced from waste with an average GHG intensity of 35.3 gCO_2/MJ (60% reduction compared to Fossil Fuel Comparator).

The impact on the capacity to achieve the RED target is positive; the renewable energy share increases by 0.07%. The calculation on the FQD target is not relevant as aviation is not included in the FQD.

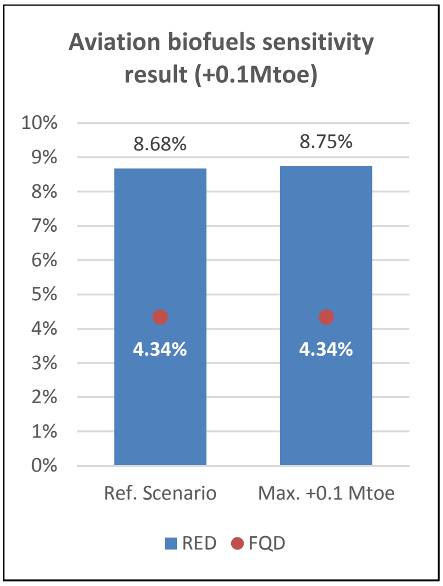


Figure 5-17. Aviation (+0.1Mtoe) sensitivity result

5.5.6 Key findings of the sensitivity cases

- The pace of development of advanced biofuels (BTL and advanced ethanol) and HVO significantly impacts the ability to reach the RED and FQD targets, this is the most significant sensitivity among all cases;
- Sales assumptions for alternative fuel passenger cars, namely xEV and CNG vehicles, impact the capacity to reach the RED and FQD target;
- The total car sales and fleet stock towards 2020 impacts the fleet renewal rate and therefore impacts the capacity to approach the RED and FQD targets;
- Sensitivity assumptions for both light commercial and heavy duty vehicles do not make a significant difference in terms of reaching the RED and FQD targets. However, CNG/LNG in heavy duty vehicles is an exception;
- Timely implementation and uptake of higher biofuel blends have significant impacts. For instance, increasing the uptake of E10 grade in the minimum case from 17% to 100% uptake in the maximum case would increase the renewable energy share according to the RED from 8.6% to 9.1%;
- Renewable electricity in rail transport can contribute significantly to achieving the RED target. The share of Renewable Electricity Sources in the European electricity mix in 2020 is an important factor.
- Biofuels in air transport will only help achieving the RED target providing (1) additional production capacity is built and (2) feedstocks are available. HVO availability for the road transport sector may be

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[65] Assumed Lower Heating Value of 43.15 MJ/kg

[66] http://ec.europa.eu/energy/renewables/biofuels/flight_path_en.htm, accessed 06-02-2014

[67] http://www.greenaironline.com/news.php?viewStory=1627, accessed 06-02-2014

reduced by the demand from the global aviation sector alongside increasing market competition for vegetable oils and waste oils for FAME production.

6. Conclusions

The outlook towards 2020 for European road transport is expected to be characterised by the implementation of legislative targets that will impact car manufacturers (vehicle technology), refiners (refinery technologies, fossil fuels and final market fuels) and renewable energy producers. The outcomes of the JEC Biofuels Study and its F&F model can be evaluated by focussing on these three aspects of the impact of EU policy.

- ***Vehicle technology.*** In the current decade vehicle manufacturers will be faced with tighter regulations on emissions of CO_2 and air pollutants (PM, NOx, etc.). Hence, vehicles can be expected to be equipped with more advanced powertrain and after-treatment systems, while at the same time we will see further diversification in powertrain technology (conventional, hybrid, battery electric, etc.) and fuel types.

  Total fuel consumption of the entire fleet is expected to fall towards 2020 whereas the total diesel demand volume is likely to show slight growth until 2014-2016 but can be expected to fall or stabilize towards 2020. Continued efficiency improvements and dieselization of the passenger car fleet will trigger a continued decline in gasoline demand.

  Current vehicles are already compatible with E10 (in the F&F model assumed from model year 2000 onwards) and B7. Compatibility with higher biofuel blends is still to be proven and this will require time, testing effort and investment.

  Increasing pressure from the EU and national regulators on limiting emissions is expected to lead to higher associated costs. Customer preferences may potentially be in conflict with transport and energy policies.

- ***Refinery technology.*** Fuel production at refineries is expected to be confronted with the current trend characterised by an increasing diesel/gasoline demand ratio. This trend leads to higher CO_2 emissions due to more energy-intensive processing to satisfy the increasing diesel demand and the more severe product specifications.

  Tightening specifications for non-road diesel fuels will add additional pressure. EU regulations may further limit CO_2 emissions which will likely increase associated costs, as outlined above under vehicle technology.

  It is uncertain whether existing logistics infrastructure will be compatible with higher biofuel blending grades. A coordinated development of CEN specifications is needed for higher grades to match the needs and/or payback investments needed to adapt the infrastructure.

  The scenario and sensitivity analyses show that higher blends need to be fully utilised in order to approach the EU targets mandated by the RED and FQD.

- ***Biofuels and other renewable energy sources for transport.*** In the first place, the 10% (energy basis) mandatory target by 2020 is a fixed goal. Conventional biofuels are widely available but are accompanied by sustainability concerns. This concern is heightened by the slower than expected pace of development of advanced biofuels.

  The different pace of development and varying priorities across EU Member States lead to a proliferation of fuel varieties and specifications. For that reason, the attractiveness of implementing different fuel demand scenarios of this study is likely to vary by Member State.

  As a counter side to that, the standardisation process (CEN specifications) is striving to keep pace with the regulatory targets, which are more quickly adopted. Therefore a robust and reliable standardisation process (CEN specifications) is necessary to enable the implementation and success of future fuel roadmaps to achieve the RED and FQD targets.

Customer confidence in the fuel and in the renewable fuel strategy is identified as a critical factor, particularly in view of a multiplicity of fuel blend grades available to the consumer.

Significant questions remain regarding the sustainability of conventional biofuels, the pace of development of advanced biofuels and the balance between EU domestic production and imports. Given these uncertainties, leveraging the current market blends only with conventional bioethanol and biodiesel is assessed as not sufficient to achieve the RED 10% target.

In particular, open questions remain concerning the pace of development of non-conventional and advanced biofuels and other renewable fuels. It is clear from this study that the only way to meet the 2020 targets is by blending in more advanced biofuels.

On the assumption of an accounting cap on the contribution of conventional biofuels towards the RED and FQD targets – drop-in biofuels produced from conventional feedstocks will lose their added value as enablers to blend beyond the grade limits.

6.1 Key messages

A revised reference scenario and three fuel demand scenarios have been developed and tested on the legislative concepts proposed by EU institutions to modify the RED and FQD regulation with a view to including ILUC concerns. The revised reference scenario has been compared to the outcomes of the JEC Biofuels Study in 2011 to identify and characterise the main drivers behind different results on the capacity to attain the RED and FQD targets. The main conclusions to be drawn from the analysis performed in this revised version of the JEC Biofuels study using the F&F model and a revised bottom-up supply outlook for advanced biofuels are:

- None of the scenarios, tested against the legislative concepts, will achieve the RED and FQD targets
- The introduction of an accounting cap on conventional biofuels towards achieving the RED target will diminish the potential impact of higher biofuel blends. It will also affect the use of drop-in fuels from such sources to blend beyond the current (diesel) grade.
- Switching to low-ILUC risk feedstocks has the potential to have a major impact on achieving the FQD and RED targets but is expected to be limited by feedstock availability.

The following considerations complement the key messages above:

Considerations on the policy and regulatory context:

- The results of the 2013 JEC Biofuels Study are not intended to suggest a direct link between lower policy ambition levels and the smoother achievement of the targets mandated by RED and FQD;
- By increasing the ambition level of using sustainably produced, low-ILUC risk biofuels via the inclusion of counting concepts in the EC proposal and the legislative concepts of the EP and the Council, achieving the RED target becomes harder for the same biofuel implementation scenarios;
- None of the proposed sets of multiple counting factors in the amendment proposals closes the gap towards achieving the RED renewable energy target, given the assumptions made in this study, including the projected supply of advanced renewable energy;
- While the JEC Biofuels Study is focused on EU proposals, the impacts from other areas, like Member State initiatives, could also prove to be important. At the same time, initiatives at the national level must not increase fuel disparity among Member States which would further complicate vehicle and fuel developments and potentially lead to customer frustration;
- Any decision on future transport fuels policy measures must be based on sound and detailed impact analysis, covering all vehicle, powertrain and infrastructure challenges as well as global sustainable renewable fuel, feedstock supply situation.

Considerations on the limitations and uncertainty of the analysis performed:

- Costs and investments could be significant and have not been evaluated in this study;
- Uncertainty remains with respect to assumptions made about input parameters, modelling approaches and with projecting market development into the future;
- The supply of non-conventional biofuels is identified to be of major importance to achieve the RED and FQD targets;
- Customer choice and the attractiveness of specific market blends (E10 introduction) impact the attainment of the RED and FQD targets;
- The share of renewables in electricity is an important factor given the continuing electrification of both the road and the rail transport modes;
- The pace of renewal in European vehicle fleet is one of the parameters exerting a major impact on the capacity to approach the RED and FQD targets. These are two main reasons for this: in general, new vehicles are expected to be more fuel-efficient compared to the vehicles they replace and, more specifically, fleet renewal implies market uptake of fuel alternatives, including higher biofuel blends;
- Alternative vehicles and fuels can contribute to reaching the RED and FQD targets, subject to the availability and quality of renewable fuels.

Considerations on non-road transport modes:

- Potential exists for higher bio-diesel blends to be used in non-road transport modes to meet the regulatory targets but this will require time, testing and investment;
- Questions remain about the uptake of HVO/BTL by the aviation sector and the potential role of the "European Advanced Biofuels Flightpath" initiative in incentivising the production of additional volumes of advanced biofuels;
- The contribution of non-road transport modes to achieving the RED and FQD target is important, although the current JEC estimate for this contribution is 0.8%: the greatest contribution towards achieving the target is expected to come from road transport; Implementing higher blending grades before 2020 with the assumed supply outlook will not have a significant impact on the capacity to approach the RED target according to the EC and EP legislative concepts given the accounting cap limiting the contribution of conventional biofuels towards the targets.

Given the evolving state of the policy considerations[68] and the market features impacting on the analysis carried out in the JEC Biofuels Programme, JEC partner organisations will continue revising and updating projections aimed at assessing the attainment of the EU renewable energy targets at and beyond 2020.

[68] "A policy framework for climate and energy ub the period from 2020 to 2030", COM(2014) 15 final of 22 January 2014.

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Appendix A. JEC Fleet and Fuel Model for Europe (2020) – Annotations and Assumptions

The "JEC Fleet & Fuel Model" was developed to estimate potential passenger car, light commercial and heavy duty vehicle fleet progressions and the corresponding fuel demand in Europe assuming certain fleet and fuel scenarios. For setting up the model several fleet parameters were defined and assumptions were made with respect to their values. These are listed in the following table along with some explanatory remarks. A "Reference scenario" was defined to reflect "most probable" expected trends. For testing the sensitivity of the model with respect to selected parameters significantly lower and higher values compared to the "Reference scenario" were assumed. These are denoted in the table as "low scenario" and "high scenario".

We aligned the **passenger car, light commercial** (called vans in TREMOVE) and the **heavy duty fleet** with TREMOVE information and applied historic data TREMOVE, Eurostat and other sources where available and appropriate (see Chapter 3). For the time towards 2020, we mainly applied linear growth rates of major fleet parameters towards 2020 TREMOVE data points in the "Reference scenario". Even though the model is setup to calculate in 2010-2050 timeframe, the model is only equipped with input for the time until 2020 and intended to deliver scenarios in the 2010-2020 time frame exclusively. This enables us to effectively run "low" and "high" scenarios by varying the 2020 data point.

What the model can do:

The model should be seen as a scenario tool that enables the user to make rough estimations of the total fuel and renewable fuel demand in the transport sector in Europe for 2020 assuming certain vehicle fleet and market development trends (scenarios). The focus is on road transport. It further allows the evaluation of the sensitivity and impact of certain vehicle fleet parameters on the fuel demand.

What the model cannot do:

Due to simplifications made and estimates used, the model is not a precise projection tool.

It will not lead to one optimized strategy but rather allows looking at a variety of scenarios of fleet and fuel development. Therefore the assumptions made are not a forecast of or commitment to the future availability of vehicle technologies or vehicle features.

In particular, the "JEC Fleet & Fuel Model" results do not allow or reflect any cost optimizations, e.g. reaching a certain 2020 passenger cars (PC) sales average CO_2 efficiency might require the application of costly technologies; on the supply side, cost of (bio-)fuel to market, e.g. BTL or HVO production, distribution and retail is in no way cost-optimized.

Parameters described in this document:

Type of parameters referred to in this document:

- Passenger car (PC):
  - PC fleet parameters
  - Alternative powertrains
  - Average annual mileage
  - Vehicle CO_2 efficiency and fuel consumption vs. reference gasoline vehicle
- Heavy duty (HD):
  - Heavy duty vehicles fleet parameters
  - Alternative powertrains

  - Vehicle efficiency vs. diesel vehicle efficiency
- Light commercial vehicles (LCV)
  - LCV fleet parameters
  - Alternative powertrains
  - Vehicle efficiency vs. diesel or gasoline vehicle efficiency

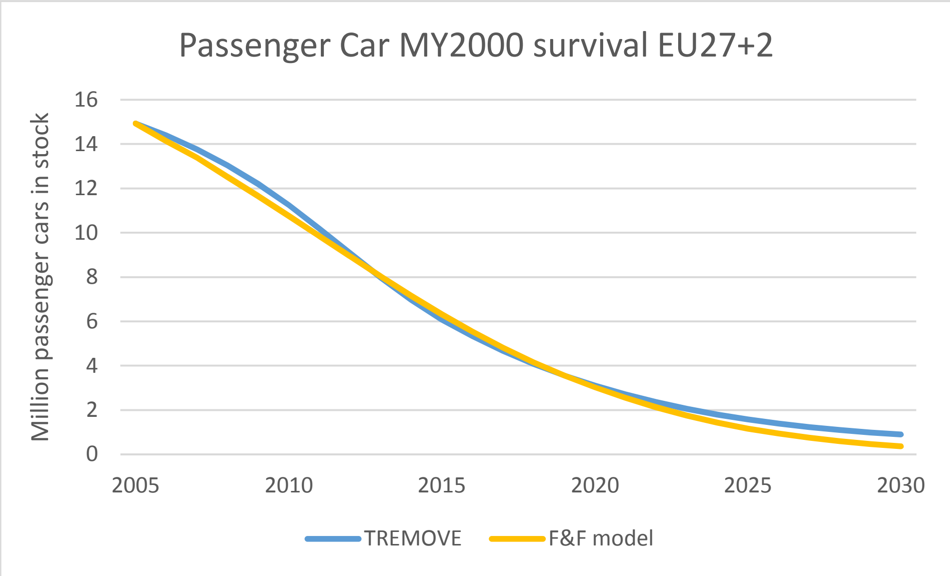
The parameters used in the model can be distinguished as:

- Fixed parameter
- Variable parameter (which show a "high" and "low" variant)

Passenger Car (PC) Fleet Parameters

Model Parameter	Unit	Explanation/Annotation	Values in 2020
PC Sales (new PC)	million cars/a	Sales figures are currently taken from TREMOVE [69] data base. Considered growth rates: Until 2012: TREMOVE/ACEA data 2013-2020: we used linear growth towards assumed 2020 number. This is lower than in TREMOVE, which itself is close to the "high" value of 19.2 million.	Base: 16 Low: -20% (12.8) High: +20% (19.2) (variable parameter)
PC Stock size (total PC population)	million cars	Stock size figures currently taken from TREMOVE data Considered growth rates: Until 2010: TREMOVE data 2011-2020: we used linear growth towards 2020 TREMOVE figure of 270 million. vehicles	Base: 270 Low: -20% (216) High: +20% (324) (variable parameter)
PC Stock mileage (total PC activity)	billion vkm p.a.	Stock mileage currently taken from TREMOVE data base Considered growth rates: • Until 2010: TREMOVE data • 2011-2020: we used linear growth towards 2020 TREMOVE figure of 3386 bil. vkm/a Growth rate: 1.83% p.a. • Low: 1.46% p.a. • High: 2.20% p.a.	Base: 3386 Low: 3264 High: 3511 (variable parameter)

[69] For this appendix, "TREMOVE" refers to "TREMOVE v3.3.2 alt"

Scrappage function: Sales and Total Population (Stock size) are linked/interdependent parameters They are free to be varied individually, but the interdependencies must be considered. Here the scrappage function is set up in a way that the chosen parameters still make sense. Hence, the number of scrapped cars is defined by the stock size and the sales. Furthermore, the age distribution in individual model years needs to be realistic (in our model, they need to reflect the TREMOVE considerations). In the model this is assured by distributing the total number of to-be-scrapped vehicles per year (time step) across the vintages (model years) in the stock according to their age, hence the older the vintage in a year, the higher is the number of scrapped cars. This methodology assures an S-shaped age-distribution of the model years as observed in TREMOVE (see below) 			
Diesel Share in PC sales by 2020	%	Assumption on share of diesel vehicles in car sales in year 2020. Development of car sales from 2010 is assumed to change linearly to value of share in 2020	Reference scenario: 50% “Low” scenario: 40% “High” scenario: 60% (variable parameter)
Real World Factor	./.	Factor considering a higher fuel consumption of vehicle in real road operation compared to NEDC cycle. An approx. 15% higher fuel consumption is assumed reflecting the application of an on-road factor in TREMOVE and to also capture uncertainty and to fit the modelled energy demand with the actual 2010 fuel sales figures, sources: Wood Mackenzie, IEA (which also includes uncertainty, e.g. to fuel tourism)	Reference scenario: 1,149 “Low” scenario: ./. “High” scenario: ./. (fixed parameter)

Alternative powertrains (PC)

Alternative powertrains considered for passenger cars in the model:

CNGV, LPGV, FFV, BEV, PHEV and FCEV

Model Parameter	Unit	Explanation/Annotation	Values
Start year	[year]	First year in which corresponding alternative powertrain type is considered in the model. CNGV, LPGV, FFV, BEV and PHEV have already been introduced to the market in most recent year covered by statistics. In case of FCEV it is the year when market introduction (year of first sales) is assumed.	FCEV: 2017 (fixed parameter)
Share of alternative vehicles in sales in 2020	[%]	The sales share of an alternative powertrain type will result in corresponding stock share in 2020 Example for CNGV: If a 3% sales mix is assumed in 2020, the F&F model will assume a linear	CNGV: 3% (lo: 1%, hi: 5%) LPGV: 3% (lo: 2%, hi: 4%) FFV 0.5% (lo: 0%, hi: 1 %) BEV: 1% (lo: 0.7%, hi: 3.3%)

		growth from 2013 to 2020, which is based on the most recent statistical sales share of 0.54% in 2013. The resulting stock share will grow to approx. 0.85% in 2020 as a consequence.	PHEV: 2% (lo: 1.3%, hi: 6.7 %) FCEV: 0.25% (lo: 0%, hi: 0.5 %) (variable parameter)
Share Replacing gasoline vehicles	[%]	The share of new sales of corresponding alternative powertrain type replacing gasoline vehicles. e.g.: CNGV 50% means that 50% of CNG vehicle new sales replace gasoline vehicle new sales FFV/CNGV/LPGV/FCEV: could in principle serve Diesel-like usage patterns, but limited infrastructure (filling stations) and limited range at market introduction BEV/PHEV: assume to be more like gasoline cars. Plus limited e-range	CNGV: 50 % LPGV: 25 % FFV: 50 % BEV: 90 % PHEV: 90 % FCEV: 50 % (fixed parameters)
Share Replacing diesel vehicles	[%]	The share of new sales of alternative powertrain type replacing diesel vehicles e.g.: 50 % in case of CNG vehicles means that 50% of CNG new vehicle sales replace diesel new vehicle sales	CNGV: 50 % LPGV: 75% FFV: 50 % BEV: 10 % PHEV: 10 % FCEV: 50 % (fixed parameter)
Share of distance travelled using alternative fuel	[%]	The share of km driven using the alternative fuel e.g. 90% in case of CNG vehicles means 90% of the distance travelled is driven by using CNG fuel and 10% by gasoline fuel. Note that it most relevant to reflect 2020 situation, i.e. market intro done (chicken / egg problem on vehicles / infrastructure readiness basically resolved). For most alternative powertrain vehicle types a share 90% was assumed since customers were thought to buy such type of vehicles only if they mostly can run it with the alternative fuel available on their most frequently used route. A share of 100% in case of the BEV is fixed since it only runs with electricity as "alternative fuel".	CNGV: 90 % LPGV: 90 % FFV: 90 % BEV: 100 % PHEV: 90 % FCEV: 100 % (fixed parameter)

Average Annual Mileage (PC)

Model Parameter	Unit	Explanation/Annotation	Values
Average Annual Mileage compared to gasoline vehicle …..		Factor describing the average annual mileage of vehicle type compared to gasoline vehicle. e.g.: a factor of 1.65 for a diesel vehicle means that the average annual mileage of a diesel vehicle is assumed to be 65 % higher than for a gasoline vehicle Base TREMOVE value of gasoline vehicle average annual mileage has been adopted according to Appendix B.	
	[-]	**…. Diesel vehicle** Factor of "1.65" taken from TREMOVE data base (higher annual mileage compared to gasoline vehicle)	Reference scenario: 1.65 (fixed parameter)
	[-]	**…. CNG vehicle** Factor resulting from gasoline and diesel car replacement factors for CNGV (gasoline vehicles: 50%, diesel vehicles: 50%) and average mileage factors of gasoline (1.0) and diesel cars (1.65): 1.0 x 50% + 1.65 x 50% = 1.33 (higher annual mileage compared to gasoline vehicle)	Reference scenario: 1.33 (fixed parameter)
	[-]	….. LPG vehicle Factor resulting from gasoline and diesel car replacement factors for LPGV (gasoline vehicles: 25%, diesel vehicles: 75%)	Reference scenario: 1.49 (fixed parameter)
	[-]	…. BEV	Reference scenario: 1.07 (fixed parameter)
	[-]	… PHEV	Reference scenario: 1.07 (fixed parameter)
	[-]	….. FFV	Reference scenario: 1.33 (fixed parameter)

Vehicle CO_2 efficiency and fuel consumption vs. reference Gasoline Vehicle (PC)

Model Parameter	Unit	Explanation/Annotation	Values
Sales average CO_2 efficiency by 2020	[g/km]	This represents the average of the specific emissions of CO_2 of all new passenger cars sold in 2020. Reference scenario: currently foreseen EU target value of 95 gCO_2/km according to Regulation R (EC) No. 443/2009 (see Section 2.4). This was done irrespective of the probability that corresponding vehicle technology is available and without consideration of the potential implications on economics. **This assumption must not be considered as any commitment of the automotive industry towards this target, but has to be understood to model the likely fuel consumption in 2020 based on current - even if pending - legislative targets.** As for the purpose of calculating the fuel demand in 2020 a differentiation between conventional vehicle technology and hybrid vehicle technology is not necessary, there is only one new sales fleet average number for the gasoline consuming vehicle fleet and no split into "gasoline vehicle fleet" and "gasoline hybrid vehicle fleet". Same is true for diesel fuel consuming vehicle fleet. Nevertheless, as the economic impact of reaching a certain 2020 new sales fleet average heavily depends on the applied technologies (improvement of conventional powertrains versus increased share of hybrid vehicle fleet), it is essential to consider the impact of implicit HEV new sales when assessing the implementation of different fuel scenarios. To enable a simple modelling approach, the CO_2-emission reduction trend is considered to change linearly from 2012 (most recent statistical year) to 2020 without consideration of interim EU targets.	(fixed parameter)
Diesel vehicle CO_2-efficiency (2020)	[-]	Factor expressing the diesel vehicle TTW[70] CO_2 efficiency compared to gasoline vehicle for 2020. A factor of 0.95 means that the average diesel vehicle fleet emits 95% of the CO_2 of the average gasoline vehicle fleet on energy basis. It takes into account the higher fuel efficiency of a diesel vehicle technology compared to a gasoline vehicle technology (about 15% to 20%). It also considers the effect of different shares of diesel vehicles in the different car segments. As the diesel vehicle share in the larger/heavier segments is higher than for the small cars segment, the advantage for the total new sales fleet average for the diesel fleet is lower than the individual technical vehicle potential. The data range for this parameter is covered by the reported new vehicle CO_2-emission monitoring[71].	Reference scenario: 0.95 (fixed parameter)
CNG vehicle CO_2-efficiency	[-]	Factor expressing the CNG vehicle TTW CO_2 efficiency compared to gasoline vehicle assumed for 2020. The factor reflects the lower carbon content of CNG (factor of 0.77) compared to gasoline fuel on energy basis. Additionally, an improvement of efficiency is assumed due to more intensive development of engine	Reference scenario: 0.75 (fixed parameter)

[70] TTW is Tank To Wheel and is part of WTW v4 (JEC, 2014)

[71] Please see http://ec.europa.eu/environment/air/transport/co2/co2_monitoring.htm

		combustion process for CNGV application.	
LPG vehicle CO_2-efficiency	[-]	Factor expressing the LPG vehicle TTW CO_2 efficiency compared to gasoline vehicle. The factor assumed for 2005+ vehicles reflects the lower carbon content of LPG (factor of 0.89) compared to gasoline fuel on energy basis. The combustion efficiency (MJ/km) was assumed to be identical to gasoline vehicle. For LPG vehicles prior to 2005 a lower CO_2 efficiency was fixed (25% less) since gasoline cars converted to LPG operation were assumed to generally be larger vehicles and significantly less efficient with respect to fuel consumption. This approach reflects the reported automotive LPG fuel consumption in relation to the LPGV fleet size in 2003-2006 time frame	Reference scenario: 2005+: 0.89 Prior to 2005: 1.25 (fixed parameter)

FFV vehicle CO_2-efficiency	[-]	Factor expressing the FFV vehicle TTW CO_2 efficiency on energy basis compared to gasoline vehicle. The factor reflects the lower carbon content of E85 (0.97) compared to gasoline fuel. The combustion efficiency (MJ/km) was assumed to be the same as for gasoline vehicle.	Reference scenario: 0.97 (fixed parameter)
PHEV CO_2-efficiency	[-]	Factor expressing the PHEV TTW CO_2 efficiency compared to gasoline vehicle assumed for 2020. The factor takes into account current regulations for electric vehicle with respect to NEDC certification. A value of 30% of the CO_2 emission of a conventional gasoline vehicle was estimated for PHEV (=factor 0,3)	Reference scenario: 0.3 (fixed parameter)
BEV & FCEV CO_2 efficiency	[-]	Factor expressing the BEV & FCEV TTW CO_2 efficiency compared to gasoline vehicle. According to current vehicle certification regulation CO_2 emission of a BEV is considered to be “0”	Reference scenario: 0 (fixed parameter)

CO_2 emission factors of gasoline use (or "in gasoline-consuming mode") in alternative powertrains / BEV electricity consumption

Model Parameter	Unit	Explanation/Annotation	Values
LPGV CO_2 efficiency in gasoline-consuming mode cp. To gasoline vehicle	[-]	Factor reflecting CO_2 efficiency of LPGV in gasoline-mode compared to conventional gasoline vehicle. Factor is assumed to be 1,0 meaning that CO_2 emission of LPGV is equal to conventional gasoline vehicle of corresponding vintage when operating it with gasoline fuel	Reference scenario: 1.0 (fixed parameter)
FFV CO_2 efficiency in gasoline-consuming mode cp. to gasoline vehicle	[-]	Factor reflecting CO_2 efficiency of FFV in gasoline-mode compared to conventional gasoline vehicle. Factor is assumed to be 1.0 meaning that CO_2 emission of FFV is equal to conventional gasoline vehicle of corresponding vintage when operating it with gasoline fuel	Reference scenario: 1.0 (fixed parameter)
PHEV CO_2 efficiency in gasoline-consuming mode cp. To gasoline vehicle	[-]	Factor reflecting CO_2 efficiency of PHEV in (charge sustaining) fuel consuming-mode compared to conventional gasoline vehicle A factor of 0.80 is assumed for years 2010+ meaning 20% less CO_2 emission for PHEV when operated in charge sustaining (fuel consuming) hybrid mode. Due to increasing efficiency of conventional ICE powertrains (reference), the factor is assumed to be 0.85 in 2020. Linear development assumed between 2010-2020	Reference scenario: 2010+: 0.80 2020: 0.85 (fixed parameter)
PHEV electric energy consumption	[MJ_e/km]	Electric energy consumption (“plug-to-wheel”) of PHEV in electric mode. Assumption made is based on	Reference scenario: 0.55 MJ_e/km (2010)

		current public available data and JEC WTW V4 data. Linear development assumed for 2010 – 2020.	0.45 MJ_e/km (2020) (fixed parameter)
BEV electric energy consumption	[MJ_e/km]	Electric energy consumption of BEV ("plug-to-wheel"). Assumption made is based on current public available data and JEC WTW V4 data. Linear development assumed for 2010 – 2020.	Reference scenario: 0.45 MJ_e/km (2010) 0.35 MJ_e/km (2020) (fixed parameter)
FCEV		Hydrogen consumption of FCEV. Assumption made is based on current public available and JEC WTW V4 data. Linear development assumed for 2010 – 2020.	Reference scenario: 0.75 MJ/km (2010) 0.55 MJ/km (2010) (fixed parameter)

Heavy Duty Vehicles (HD) Parameters

The model follows the TREMOVE classification of HD (gross vehicle weight[72]) classes:

- HD 3.5t-7.5t
- HD7.5t-16t
- HD16t-32t
- HD>32t
- Buses and Coaches: B&C

Heavy Duty Vehicles (HD) Fleet Parameters

Model Parameter	Unit	Explanation/Annotation	Values
HD Sales	Year on Year (YoY) % development	Sales development is taken from TREMOVE.	Base: HD3.5t-7.5t: 1.5% HD7.5t-16t: 1.3% HD16t-32t: 0.7% HD>32t: 1.0% B&C: 3.0% Low: -20% High: +20%
HD Stock size	YoY % development	Stock development is taken from TREMOVE.	Base: HD3.5t-7.5t: 1.8% HD7.5t-16t: 1.9% HD16t-32t: 1.3% HD>32t: 1.3% B&C: -2.33% Low: -20% High: +20%
HD tkm / (pkm for bus&coach) mileage development	billion vkm/a	Development taken from TREMOVE data base	Base: HD3.5t-7.5t: 2.0% HD7.5t-16t: 1.8% HD16t-32t: 1.7% HD>32t: 1.7% Special for bus&coach, pkm development: 2005-2020 Base: -1.6% Low: -20% High: +20%
Load factor	%YoY	Factor describing the development of the load factor	Base:

[72] "total maximum weight" see TREMOVE documentation http://www.tmleuven.be/methode/tremove/Final_Report_TREMOVE_9July2007c.pdf

		(factor that determines how much load is carried by a HD vehicle; tkm/vkm) Note: For B&C, load refers to pkm/vkm. All others to tkm/vkm	HD3.5t-7.5t: 0.14% HD7.5t-16t: 0.15% HD16t-32t: 0.11% HD>32t: 0.14% B&C: 0.04% For all cases Low: -20% High: +20%
FC development	%YoY	Factor describing the development of the Fuel consumption of new vehicles. Based on an ACEA announcement to improve FC by 20% in 2005-2020 timeline for new HD vehicles and on fuel consumed per tkm basis. 20% improvement 2005-2020 equals -1.48% YoY; a 10% improvement would result in approx. -1.0% YoY	Base: All: -1.48% Valid for central control / individual. Low: -1.0%

Alternative powertrains (HD)

Alternative powertrains considered for HD vehicles in the model:

CNGV, DMEV, E95V

Model Parameter	Unit	Explanation/Annotation	Values
Start year	[year]	First year in which corresponding alternative powertrain type is considered in the model.	DME: 2015 E95: 2012 BEV: 2015 CNG: 2012 LNG: 2015 EV: 2015, for B&C only FCEV 2020, 2015 for B&C (fixed parameter)
CNGV in 3.5-7.5t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 2% Min: 0% Max: 4%
CNGV in 7.5t-16t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 1.5% Min: 0% Max: 3%
DMEV in 16t-32t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 0.5% Min: 0% Max: 1.0%
E95V in 16t-32t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 0.5% Min: 0% Max: 1.0%
CNG in 16t-32t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 2.0% Min: 0% Max: 4.0%
LNG in 16t-32t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 1.0% Min: 0% Max: 2.0%
DME in >32t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 0.25% Min: 0% Max: 0.50%

LNG in >32t class	Sales% 2020	Sales share in 2020; builds up linearly from start year	Base: 1.0% Min: 0.8% Max: 2.0%
CNGV in B&C 2005	Fleet% 2005	CNG – busses are on the road already. According to NGVA information, this is approx. 1% by 2005	1% (fixed parameter):
CNGV in B&C	Sales% 2020	Sales share in 2020	Base: 5% Min: 0% Max: 10%
E95 in B&C	Sales% 2020	Sales share in 2020	Base: 2% Min: 1% Max: 4%
EV in B&C	Sales% 2020	Sales share in 2020	Base: 0.25% Min: 0% Max: 0.5%
FCEV in B&C	Sales% 2020	Sales share in 2020	Base: 0.5% Min: 0% Max: 1%

Vehicle Efficiency vs. Diesel Vehicle Efficiency (HD)

Model Parameter	Unit	Explanation/Annotation	Values
DME vehicle MJ/km efficiency	[-]	Factor expressing the new DME vehicle MJ/km efficiency compared to new diesel reference vehicle (same model years) in the respective HD class when in alternative fuel mode.	Reference scenario: 1 (fixed parameter)
E95 vehicle MJ/km efficiency	[-]	Factor expressing the E95 vehicle MJ/km efficiency compared to diesel reference vehicle in the respective HD class when in alternative fuel mode.	Reference scenario: 1 (fixed parameter)
CNG vehicle MJ/km efficiency	[-]	Factor expressing the CNG vehicle MJ/km efficiency compared to diesel reference vehicle in the respective HD class when in alternative fuel mode. The development between 2010 and 2020 reflects tendency to shift from spark ignited engines to advanced combustion systems.	Reference scenario: 2010: factor of 1.2 2020: factor of 1.1 Linear development of factor between 2005-2020 (fixed parameter)
LNG vehicle MJ/km efficiency	[-]	Factor expressing the LNG vehicle MJ/km efficiency compared to diesel reference vehicle in the respective HD class when in alternative fuel mode.	Reference scenario: 1.1 (fixed parameter)
FCEV vehicle MJ/km efficiency	[-]	Factor expressing the FCEV vehicle MJ/km efficiency compared to diesel reference vehicle in the respective HD class when in alternative fuel mode.	Reference scenario: 0.6 (fixed parameter)
EV vehicle MJ/km efficiency	[-]	Factor expressing the EV vehicle MJ/km efficiency compared to diesel reference vehicle in the respective HD class when in alternative fuel mode.	Reference scenario: 0.4 (fixed parameter)

Light commercial vehicle Parameters

LCV Fleet Parameters

The model follows the TREMOVE classification of LCV classes:

- Gasoline LCV (GV)
- Diesel LCV <2.5t (DV<2.5t)[73]
- Diesel LCV >2.5t (DV>2.5t)

Model Parameter	Unit	Explanation/Annotation	Values
LCV sales	YoY % development	Sales development is taken from TREMOVE.	Base: GV: 2.7% DV<2.5t: 2.5% DV>2.5t: -0.9% Low: -20% High: +20%
LCV stock	YoY % development	Stock development is taken from TREMOVE.	Base: GV: 4.9% DV<2.5t: 0.88% DV>2.5t: -1.3% Low: -20% High: +20%
LCV vkm	YoY % development	vkm development is taken from TREMOVE.	Base: GV: 4.8% DV<2.5t: 0.9% DV>2.5t: -1.5% Low: -20% High: +20%
LCV sales average CO_2 emissions by 2020	[g/km]	This represents the average of the specific emissions of CO_2 of all new LCVs sold in 2020: 147 g/km by 2020. This assumption must not be considered as any commitment of the automotive industry towards this target, but has to be understood to model the likely fuel consumption in 2020 based on current - even if pending - legislative targets. To enable a simple modelling approach, the CO_2-emission reduction trend is considered to change linearly from latest statistical year to 2020 without consideration of interim EU targets.	(fixed parameter)
Start year	[year]	First year in which corresponding alternative powertrain type is considered in the model. CNGV, LPGV, FFV, PHEV and BEV LCVs have already been introduced to the market in most recent year covered by statistics. In case of the listed powertrain options the year of first sales is given.	FCEV: 2017 (fixed parameter)
Share of alternatives vehicles in <u>sales</u> in 2020	[%]	The sales share of an alternative powertrain type will result in corresponding stock share in 2020	CNGV: 3% (lo: 1%, hi: 5%) LPGV: 1% (lo: 0%, hi: 2%) FFV 0.5% (lo: 0%, hi: 1 %) BEV: 1% (lo: 0%, hi: 2%) PHEV: 1% (lo: 0%, hi: 2%) FCEV: 0.25% (lo: 0%, hi: 0.5 %) (variable parameter)

[73] "total maximum weight" see TREMOVE documentation http://www.tmleuven.be/methode/tremove/Final_Report_TREMOVE_9July2007c.pdf

Appendix B. Diesel split Light and Heavy Duty assessment

The "Fleet and Fuels" model, developed by the JEC consortium, is used in the JEC Biofuels Study. It simulates the road fuel demand for a given time period based on fleet composition development and alternative vehicle and fuel penetration assumptions. The vehicle fleet baseline is taken from the TREMOVE 3.3.2 Alt scenario[74]. A validation of the 2010 vehicle fleet data has been conducted with the use of following data sources:

- TREMOVE 3.3.2 Alt → STEERS →F&F models
- Wood Mackenzie 2010 EU fuel market statistics
- Statistical data from several sources like EUROSTAT, ACEA, EEA etc.

The vehicle stock, total fuel consumption and activity are reviewed to define the most suitable baseline of 2010.

F&F model covers the EU area EU27+NO+CH and contain the following vehicle categories:

Passenger cars

- Gasoline, diesel and LPG several types

Vans (also referred to as Light Duty Vehicles)

- Gasoline
- Diesel <2.5t
- Diesel>2.5t

Heavy duty

- Diesel 3.5-7.5t
- Diesel 7.5-16t
- Diesel 16-32t
- Diesel >32t
- Diesel busses and coaches

It is widely recognized that having statistical data on fleet parameters and resulting fuel demand is very difficult, especially the split in diesel demand between PC and commercial vehicles. The European Commission initiates several projects that try to gather and validate fleet data. Projects like FLEETS in the past and currently project TRACCS are examples. Therefore a validation step of the TREMOVE data has been conducted. It should be noted that the objective of the JEC Biofuels study is to stay as close as possible to the TREMOVE 3.3.2 Alt data and only deviate when recent statistical data is available or deviations based on recent statistical data inevitable.

[74] http://www.tremove.org/documentation/index.htm

TREMOVE 3.3.2 Alt

This version of TREMOVE has as baseline 2005 and the fleet data was updated with results from the FLEETS project. From 2005 onwards the TREMOVE data is projected based on iTREN modeling results. Furthermore, the Alt scenario aimed to reflect the economic crisis impact of 2008-2010. Any discrepancy between TREMOVE year 2010 results and statistics can be explained because of differences in assumptions and covering the effects of the economic crisis compared to statistics.

Wood Mackenzie 2010 statistics

Every year, Wood Mackenzie publishes statistical data on energy use in different sectors like road transport per country. The fuel consumption statistics for diesel and gasoline have been used to correct TREMOVE data as a first step.

Data validation

As stated before, TREMOVE data for the year 2010 are projected and a result of their fleet model. Therefore, a validation step of the TREMOVE data is needed to see if it is still in line with reality. Several sources have been used to verify the TREMOVE data. The main objective is to get the best split between Passenger Cars (PC), Vans and Heavy Duty (HD) vehicles fuel demand, especially for the diesel consumption. Data on PC gasoline demand could be calculated based on statistics and has been used to determine the split of diesel consumption between the 3 categories (PC, Van and HD). Determining this split is not straightforward and needs some iterative steps. The different steps are explained below.

The following 4 steps have been taken:

- STEP 1 match TREMOVE fuel consumption with Wood Mackenzie 2010 statistics
- STEP 2 determine diesel consumption in PC
- STEP 3 determine diesel consumption in Vans
- STEP 4 remaining diesel consumption is for HD

STEP 1 Match TREMOVE fuel consumption with Wood Mackenzie 2010 statistics

The TREMOVE 3.3.2 Alt results have been calibrated to match Wood Mackenzie year 2010 fuel consumption for EU27+NO+CH. This was done by an external consultant Aeris Europe. The activity parameter (vkm/vehicle/year) in TREMOVE has been used for calibration. This “tuning” parameter was also used by EMISIA when they validated the TREMOVE results after updating the model with FLEETS results.

The modified TREMOVE data has been checked on the following parameters: vehicle stock, activity and fuel consumption. Relevant statistical data has been found and used to validate or improve the TREMOVE year 2010 data.

The fuel consumption is calculated based on three parameters and statistics data is not available for all parameters. The formula is:

[Fuel Consumption] = [Vehicle stock] * [Fuel Consumption Factor] * [Activity]

[kton/year] = [mln vehicles] * [g_{fuel}/km] * [km/vehicle/year]

An iterative approach was needed to determine the split in diesel consumption as data has not been available for all three parameters. The following results of modified TREMOVE 2010 have been reviewed:

2010	Stock	FC	Activity	Fuel Consumption	Activity/veh
	mln	kton	mln vkm	l/100km	vkm/veh/year
PC gasoline	150.55	91,056	1,441,838	8.48	9,577
PC diesel	79.92	114,357	2,015,445	6.82	25,219
Van gasoline	6.32	2,480	25,759	12.93	4,078
Van diesel	21.28	22,200	286,162	9.32	13,448
HD diesel	7.66	64,431	348,795	22.20	45,560

The red cells indicate the main deviations that were found when comparing with statistics. Furthermore, the diesel split between PC and Commercial vehicles (HD+VAN) is 57% and 43%, where F&F model 2011 had a split of 32% and 68%. So this split does not match with previous findings and consultation with other stakeholders confirmed that this split is likely not representative.

The Van gasoline was not changed because no statistical data were found for validation. The original TREMOVE data have been used in the Fleet and Fuels model.

STEP 2 Determine diesel consumption in PC

This step compares modified TREMOVE PC gasoline consumption and activity versus ACEA and EC transport statistics. The following statistics were used to calculate the activity for PC diesel:

Parameter	Value	Source	Reference
EU car fleet composition	Gasoline = 61.5% Diesel = 35.5% Others = 3.2%	ACEA	http://www.acea.be/images/uploads/files/ACEA_POCKET_GUIDE_2012_UPDATED.pdf
EU fleet development PC	240 mln vehicles	ACEA	http://www.acea.be/images/uploads/files/ACEA_POCKET_GUIDE_2012_UPDATED.pdf
EU transport Passenger car pkm	4738 bln pkm	EC	http://ec.europa.eu/transport/facts-fundings/statistics/doc/2012/pocketbook2012.pdf
Occupancy	1.665 passengers/car	TREMOVE	
Gasoline fuel consumption 2010	90249 kt	EUROSTAT	http://appsso.eurostat.ec.europa.eu/nui/show.do?query=BOOKMARK_DS-053528_QID_-12928126_UID_-3F171EB0&layout=TIME,C,X,0;GEO,L,Y,0;UNIT,L,Z,0;PRODUCT,L,Z,1;INDIC_NRG,L,Z,2;INDICATORS,C,Z,3;&zSelection=DS-053528INDIC_NRG,B_101920;DS-053528UNIT,1000T;DS-053528INDICATORS,OBS_FLAG;DS-053528PRODUCT,3265;&rankName1=PRODUCT_1_2_-1_2&rankName2=INDIC-NRG_1_2_-1_2&rankName3=INDICATORS_1_2_-1_2&rankName4=UNIT_1_2_-1_2&rankName5=TIME_1_0_0_0&rankName6=GEO_1_2_0_1&sortC=ASC_-1_FIRST&rStp=&cStp=&rDCh=&cDCh=&rDM=true&cDM=true&footnes=false&empty=false&wai=false&time_mode=NONE&time_most_recent=false&lang=EN&cfo=%23%23%23%2C%23%23%23.%23%23%23

Table 1: Statistical sources used

Step 2a Total fleet: The total PC diesel and gasoline fleet has been calculated based on the EU car fleet composition and new vehicle sales development data of ACEA. The results differ only slightly from TREMOVE and it has been decided to keep the fleet stock data in the Fleet & Fuels model to be aligned with TREMOVE and only change the vehicle activity.

Step 2b Total activity: The European Commission Transport statistics report the passenger-kms driven in Europe for each year. When combining this with an average occupancy of 1.665 passengers per car (from TREMOVE), the total vehicle kilometers per year in the passenger car sector can be calculated. To simplify the calculation it has been assumed that all passenger car kilometers are driven by diesel and gasoline powertrains, neglecting all alternative vehicles as they are a small percent of total fleet.

Step 2c Total activity gasoline cars: With the average fuel consumption per km given by TREMOVE and the total gasoline consumption in Europe from EUROSTAT (Total gasoline minus VAN gasoline consumption from TREMOVE), the total activity of gasoline passenger cars can be calculated.

Step 2d: Total activity diesel cars: The total activity for diesel cars can be calculated by subtracting activity of gasoline car from the total activity of passenger cars in Europe.

With above data and calculations a reasonable split in activity between diesel and gasoline passenger cars can be made:

Table 2: Statistical data on PC 2010

STATISTICAL data on Passenger Cars (PC) 2010		
Stocks PC gasoline	mln vehicles	148
Stocks PC diesel	mln vehicles	85
Total fuel petrol	‘000 ton	87,856
Total activity PC petrol	bln km/year	**1391**
Total PC activity	bln pkm/year	4738
Average occupancy	passengers/km	1.6653
Total PC activity	bln km/year	**2845**
		vkm/veh/year
Total PC petrol	vkm/veh/year	9425
Total PC diesel	vkm/veh/year	17066

Table 2 shows that the activity for gasoline cars is in line with modified TREMOVE 2010 data. However the activity for diesel cars (17,066 compared to 25,219 km/year per vehicle) deviates significantly from TREMOVE. The 17,066 km per vehicle per year is more in line with the Fleet and Fuels model (version 2011) assumption which was around 16,000 km per vehicle per year.

The above results are then used to determine the diesel PC fuel demand by using the ratio of diesel/gasoline activity, the TREMOVE fuel consumption and TREMOVE stock data. This results in the PC diesel part of the total diesel fuel consumption.

STEP 3 Determine diesel consumption in Vans

The remaining categories to validate are commercial vehicles which include Vans and Heavy Duty Vehicles.

For Vans, stock data were available in EUROSTAT which showed that the TREMOVE 3.3.2 alt. van stock data deviated by approx. 15% from statistics (21.3mln TREMOVE versus 24.3mln EUROSTAT). It was decided to use the TREMOVE stock data.

No statistical data on van activity are available but an impact assessment study by EC on Light Duty vehicle stated that the activity per diesel van vehicle is comparable to that of diesel cars and therefore around 17.033 vkm per year has been assumed, see reference below:

“Proposal for a regulation of the European Parliament and of the Council amending
Regulation (EU) No 510/2011 to define the modalities for reaching the 2020 target to reduce CO2 emissions from new light commercial vehicles”
(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2012:0213(51):FIN:EN:PDF)

For the Vans part the stocks from TREMOVE, the fuel consumption data from TREMOVE and the same activity as PC were used to determine the diesel fuel consumption.
Hence, remaining step is to start with the EU diesel consumption in transport based on Wood Mackenzie 2010 data and subtract PC diesel and Van diesel demand to get the HD vehicle diesel demand.

STEP 4 Determine diesel consumption in Heavy Duty Vehicles

The Heavy Duty segment consists of Heavy duty vehicles starting from 3.5t and busses and coaches. The stock statistics are more or less in line with TREMOVE (7.6 million in TREMOVE versus 7.3 EUROSTAT). In EUROSTAT the road tractors and special vehicles were selected to define the Heavy Duty truck stock. Also for the Heavy duty part the Fleet and Fuels stock 2010 kept in line with TREMOVE data.

With the fuel consumption data used from TREMOVE, the resulting average vkm in HD class needs to be 66,292 vkm per vehicle per year to consume the remaining diesel volume.

Conclusion

The overall diesel split result is then:

		Fuel consumption [kton]	vkm [mln]	Stock [mln]	Fuel Factor [l/100km]	km/a/veh
Select PC scenario :	TREMOVE PC 17340km	78,611	1,385,466	79.9	6.82	17,340
Select Van scenario :	TREMOVE VAN 17340km	28,626	368,992	21.3	9.32	17,340
Result HD scenario :	TREMOVE HD 66292km	93,750	507,511	7.7	22.2	66,292

Figure 1: Result on revised diesel split PC, Van and HD

With the approach described above the 'Fleet & Fuel' model will be in line with TREMOVE 3.3.2 Alt on vehicle stocks and fuel consumption data (which is in fact NEDC and real world factor, which is in line with TREMOVE) but has been only been changed with respect to activity to match statistics.

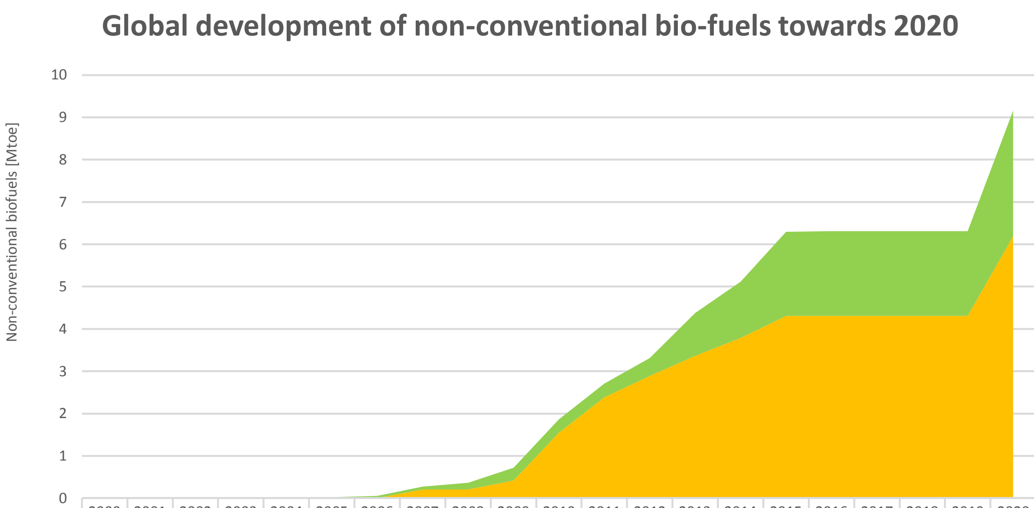
Above calculated split results in a passenger versus commercial vehicle ratio of:

Diesel consumption 2010	TREMOVE	Corrected TREMOVE = F&F model v2013
Passenger Vehicles	57%	39%
Commercial Vehicles	43%	61%

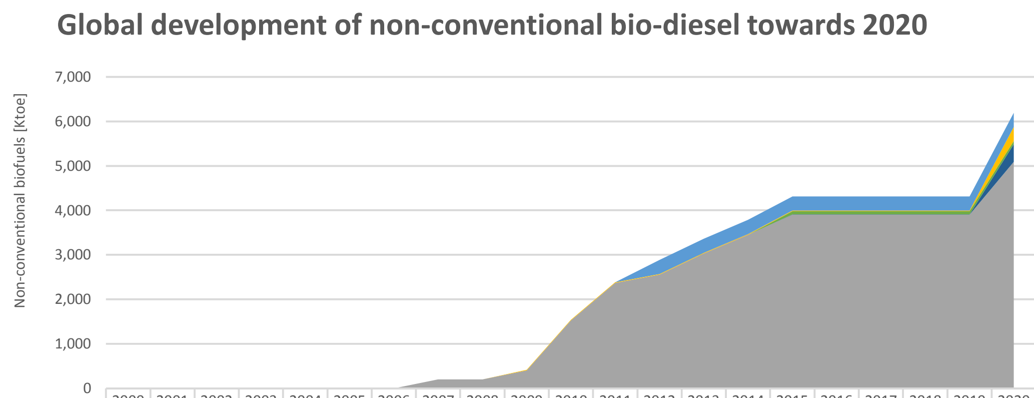
Concluding comments in this context:

- TREMOVE fuel consumption data have been used because it uses COPERT 4 v9 factors that strive to reflect real world driving. (The Fleet & Fuels model uses the NEDC emission factors and a real world factor to align NEDC and real world driving behavior)
- The difference in total Heavy Duty Vehicle stock between Fleet & Fuels model 2011 HDV stock of 12mln and now 7.6 mln was caused by a revision of TREMOVE classes Light Duty versus Heavy Duty vehicles (TREMOVE v2.7 and TREMOVE 3.3.2 Alt). After consulting with TM Leuven, it was recognized that one of the reasons for changing TREMOVE v2.7 HDV assumptions is that there is no de-registration procedure across the EU nor an incentive to de-register HDV and therefore the Heavy Duty was overestimated in previous TREMOVE versions. See TREMOVE documentation for further details.

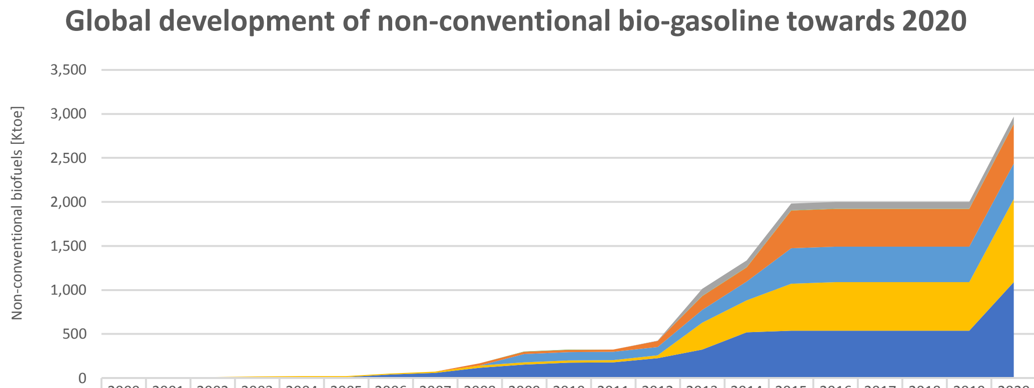
Appendix C. Non-Conventional Supply Outlook breakdown



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Non-conv. Bio-gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.3	0.4	1.0	1.3	2.0	2.0	2.0	2.0	2.0	3.0
Non-conv. Bio-diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	1.5	2.4	2.9	3.4	3.8	4.3	4.3	4.3	4.3	4.3	6.2



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biodiesel other	0	0	0	0	0	0	0	0	0	0	0	0	316	316	316	316	316	316	316	316	316
DME Waste Wood	0	0	0	0	0	0	0	0	0	1	1	2	2	2	2	2	2	2	2	2	2
Biodiesel Waste Veg./AF	0	0	0	0	0	0	0	0	0	14	14	14	14	14	14	14	14	14	14	14	311
Biodiesel FT Farmed Wood	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	71	71	71	71	71
Biodiesel Waste Wood FT	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	397
HVO/Co-processing	0	0	0	0	0	0	0	200	200	400	1,524	2,366	2,555	3,028	3,449	3,904	3,904	3,904	3,904	3,904	5,092

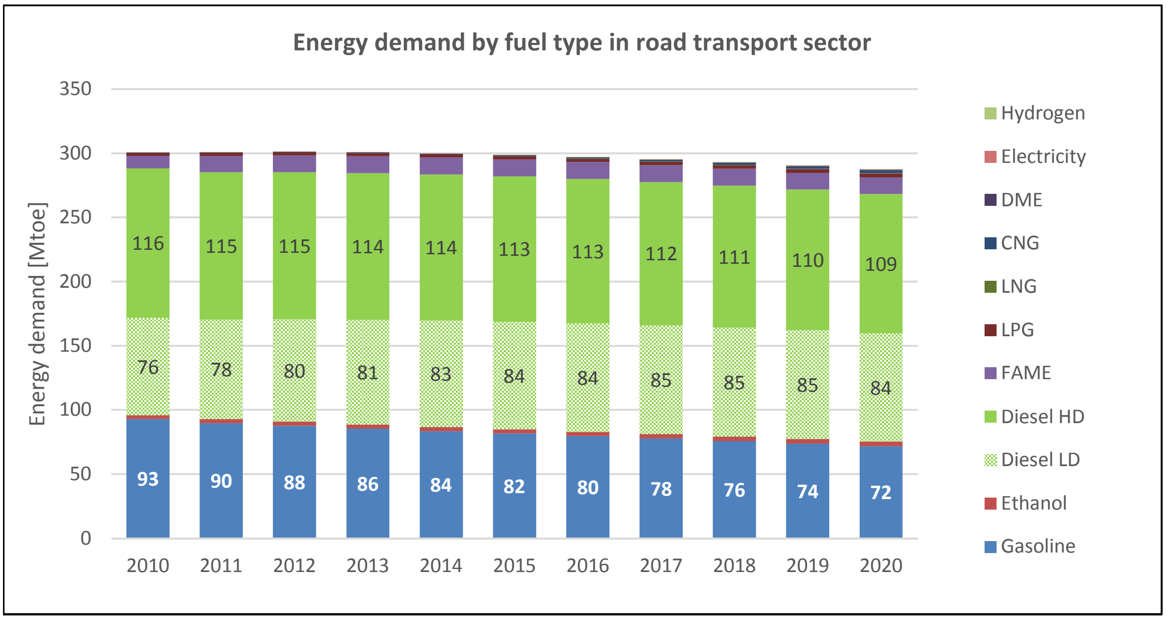


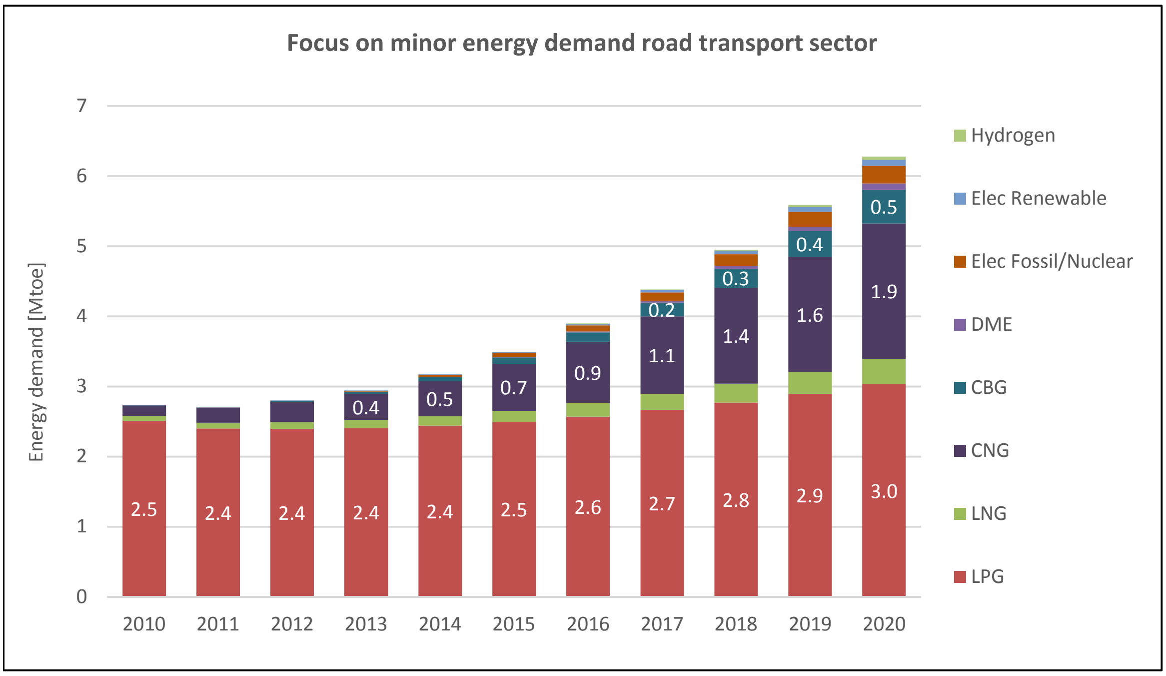
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ethanol others	0	0	0	0	0	0	0	0	0	0	0	0	0	78	78	78	78	78	78	78	78
Ethanol Framed wood	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	4
Biobutanol	0	0	0	0	0	0	0	0	24	24	24	24	67	159	159	428	428	428	428	428	452
Methanol Waste wood	0	0	0	0	0	0	0	0	0	95	95	95	95	143	214	403	403	403	403	403	403
Ethanol Waste wood	0	0	0	9	9	11	11	14	25	25	25	25	34	305	362	532	551	551	551	551	941
Ethanol Wheat straw type	10	10	10	11	12	13	42	58	118	154	175	178	223	324	520	538	538	538	538	538	1,090

Appendix D. Biofuel pathways information

Biofuels pathways used	Applied in all 4 cases		EU2009		EC2012		EP2013		CEU2013	
	GHG intensity in 2020	iLUC factor	Cap applied?	Counting factor	Cap applied?	Counting factor	Cap applied?	Counting factor	Cap applied?	Counting factor
Pathways gasoline pool	[gCO_2eq/MJ]	[gCO_2eq/MJ]		[1,2 or4]		[1,2 or4]		[1,2 or4]		[1,2 or4]
Ethanol from Wheat	44.2	12	No	1	5%	1	6%	1	7%	1
Ethanol from Maize	43.0	12	No	1	5%	1	6%	1	7%	1
Ethanol from Barley	43.0	12	No	1	5%	1	6%	1	7%	1
Ethanol from Rye	43.0	12	No	1	5%	1	6%	1	7%	1
Ethanol from Triticale	43.0	12	No	1	5%	1	6%	1	7%	1
Ethanol from Sugar beet	40.0	13	No	1	5%	1	6%	1	7%	1
Ethanol from Sugar cane	24.0	13	No	1	5%	1	6%	1	7%	1
Ethanol from other conventionals	43.0	12	No	1	5%	1	6%	1	7%	1
Ethanol from Wine	15.0	0	No	2	No	4	No	1	No	2
Ethanol from Farmed wood	25.0	0	No	2	No	2	No	1	No	2
Ethanol from Waste wood	22.0	0	No	2	No	2	No	1	No	2
Ethanol from Wheat straw	13.0	0	No	2	No	4	No	1	No	2
Ethanol from advanced	35.3	0	No	2	No	2	No	1	No	2
Butanol from advanced	35.3	0	No	2	No	2	No	1	No	2
Butanol from conventionals	35.3	0	No	1	5%	1	6%	1	7%	1
Methanol from waste wood	5.0	0	No	2	No	2	No	1	No	2
Pathways diesel pool										
FAME from Rapeseed	52.0	55	No	1	5%	1	6%	1	7%	1
FAME from Soybean	58.0	55	No	1	5%	1	6%	1	7%	1
FAME from Palm Oil	52.5	55	No	1	5%	1	6%	1	7%	1
FAME from Sunflower seed	41.0	55	No	1	5%	1	6%	1	7%	1
FAME from conventionals	47.3	55	No	1	5%	1	6%	1	7%	1
Diesel from Farmed wood FT	6.0	0	No	2	No	2	No	1	No	2
Diesel from Waste oil	14.0	0	No	2	No	2	No	2	No	2
Diesel from Waste wood FT	4.0	0	No	2	No	2	No	1	No	2
Diesel from advanced	35.3	0	No	2	No	2	No	1	No	2
HVO/co-processing from Waste oil	20.5	0	No	2	No	2	No	2	No	2
HVO/co-processing from Rapeseed oil	42.8	55	No	1	5%	1	6%	1	7%	1
HVO/co-processing from Palm Oil	44.2	55	No	1	5%	1	6%	1	7%	1
Pathway DME pool										
DME from Waste wood	5.0	0	No	2	No	2	No	1	No	2

Appendix E. Alternative fuel energy demand growth





Appendix F. European Electricity mix in 2020

GHG emissions from the EU27 electric energy mix – Year 2020

The Green House Gas (GHG) emissions due to the EU27 electric energy mix in year 2020 can be estimated on the base of the present (year 2009) specific GHG emissions of the EU27 power plants, by considering the evolution of the electric mix composition hypothesized for year 2020.

The initial hypotheses adopted for this calculation are the following:

- Electric power plants have been grouped into three homogeneous categories, or technology classes: Fossil fuel, Nuclear and Renewable Energy Sources (RES)
- The "Fossil fuel" category involves thermal power plants using, in input, the following fuels (IEA classification): Coal/peat products, Natural Gas, Crude Oil, LNG, refinery feedstocks, Oil products.
- The "nuclear" classification considers the current state of the art nuclear technology
- The "RES" group of technology refer to the following IEA categories: Biomass (wood), Liquid biofuel, Biogas, Waste (Industrial waste and municipal waste), Hydropower, Wind power, solar power, geothermal energy.
- The technological evolution of the EU27 power plant park has been considered constant from year 2010 to 2020. Consequently, the efficiency and specific emissions of each technology group along the 2010-2020 timeframe is considered constant.
- The 2010 specific GHG emissions of each class of technologies have been considered the same presented in the WTW v.4 report for the 2009 EU27 electric mix.
- Some approximation has been adopted while splitting the EU electric mix into Fossil fuel *plus* Nuclear *plus* RES, because of a slightly different classification between IEA and EUROSTAT data.

Calculation of 2009-2010 specific GHG emissions

Calculations here below refer to EU 2009 statistical data, considering the efficiency of the existing park of power plants. Data are consistent with data presented in the WTW-4 report.

1) Emissions from the whole mix (Fossil + Nuke + RES)

Total Gross electric energy produced in output in EU27: **3170 TWh**

GHG Emissions		
	gCO_2eq/kWh	gCO_2eq/MJe
Gross electric energy production	**457**	127
Net electric energy production (minus internal power plant losses)	**476**	132
Electric energy supplied (minus pumping)	**482**	134
Electric energy consumed at High Voltage	**490**	136
Electric energy consumed at Medium Voltage	**508**	141
Electric energy consumed at Low Voltage	**540**	150

2) Fossil fuels only

Total Gross electric energy produced in 2009 in EU27 from Fossil fuels: **1762 TWh**

GHG Emissions		
	gCO_2eq/kWh	gCO_2eq/MJe
Gross electric energy production	**867**	241
Net electric energy production (minus internal power plant losses)	**902**	251
Electric energy supplied (minus pumping)	**915**	254

Electric energy consumed at High Voltage	**929**	258
Electric energy consumed at Medium Voltage	**964**	268
Electric energy consumed at Low Voltage	**<u>1025</u>**	285

3) Emissions from Nuclear energy only

Total Gross electric energy produced in 2009 in EU27 from nuclear source: **880 TWh**

GHG Emissions		
	gCO_2eq/kWh	gCO_2eq/MJe
Gross electric energy production	**16**	4
Net electric energy production (minus internal power plant losses)	**17**	5
Electric energy supplied (minus pumping)	**17**	5
Electric energy consumed at High Voltage	**17**	5
Electric energy consumed at Medium Voltage	**18**	5
Electric energy consumed at Low Voltage	**<u>19</u>**	5

4) Emissions from Renewable Energy Sources (RES) only

Total Gross electric energy produced in 2009 in EU27 from RES: **526 TWh**

GHG Emissions		
	gCO_2eq/kWh	gCO_2eq/MJe
Gross electric energy production	**35**	10
Net electric energy production (minus internal power plant losses)	**37**	10
Electric energy supplied (minus pumping)	**37**	10
Electric energy consumed at High Voltage	**38**	11
Electric energy consumed at Medium Voltage	**39**	11
Electric energy consumed at Low Voltage	**<u>42</u>**	12

<u>GHG emissions from the 2020 estimated electric energy mix for EU27</u>

We consider as 2020 EU electric mix the same electric mix share forecasted in the baseline scenario of the report: "EU energy trends to 2030" (EC 2009). This estimation is reported in the table below

Power generation technology class	Year 2010 share	**Year 2020 share**
Fossil	51%	**49.5%**
Nuclear	28%	**24.5%**
RES	19%	**26.0%**

Considering the share estimated for year 2020 and the specific emissions reported in the tables above the 2020 EU electric energy mix can be assessed as follows:

GHG Emissions - year 2020 – EU27		
	gCO_2eq/kWh	**gCO_2eq/MJe**
Gross electric energy production	**442**	123
Net electric energy production (minus internal power plant losses)	**460**	128
Electric energy supplied (minus pumping)	**467**	130
Electric energy consumed at High Voltage	**474**	132
Electric energy consumed at Medium Voltage	**492**	137
Electric energy consumed at Low Voltage	**523**	145

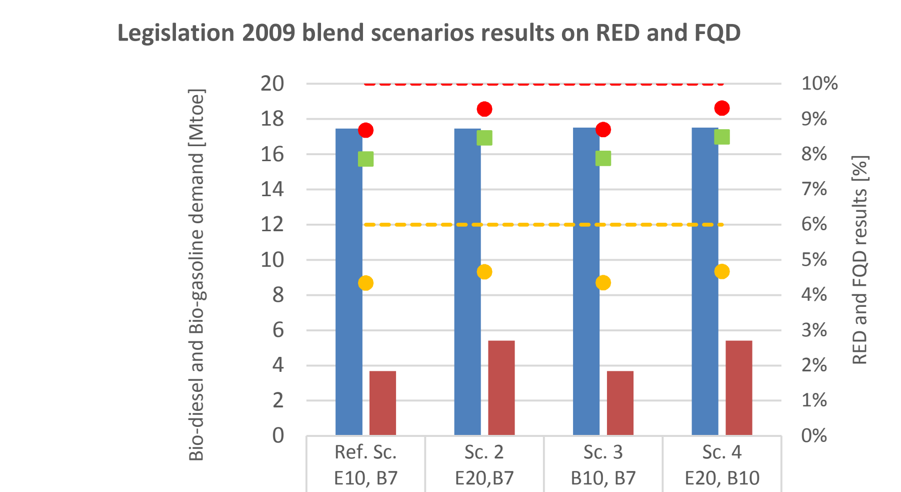
REFERENCES:

WTT v4, (Edwards R. et al), 2013 "Well-to-Tank Report Version 4.0", Well-to Wheels analysis of future automotive fuels and powertrains in the European context", CONCAWE, EUCAR, JRC. Several Reports available on the JRC/IES website at: http://ies.jrc.ec.europa.eu/about-jec

IEA (International Energy Agency), 2011, Energy statistics of OECD countries, Paris, The International Energy Agency.

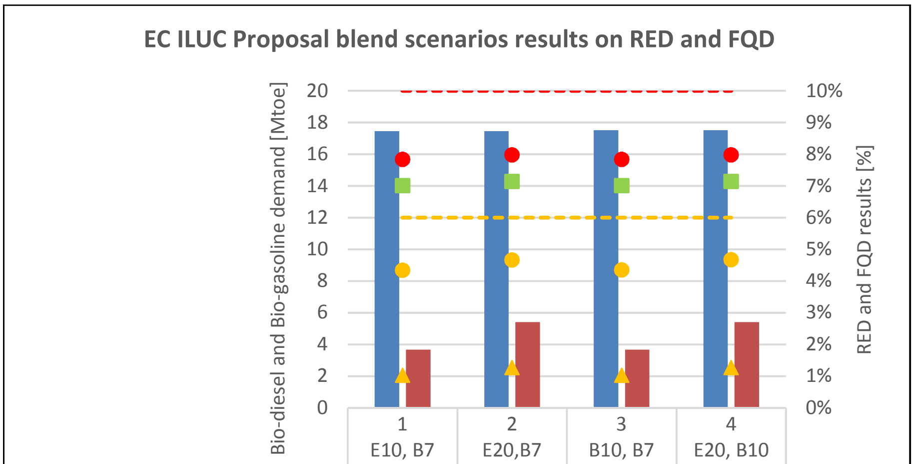
EC, 2009, “EU energy trends to 2030” Update 2009, DG Energy, European Commission

Appendix G. Legislative proposal results on fuel blend scenarios



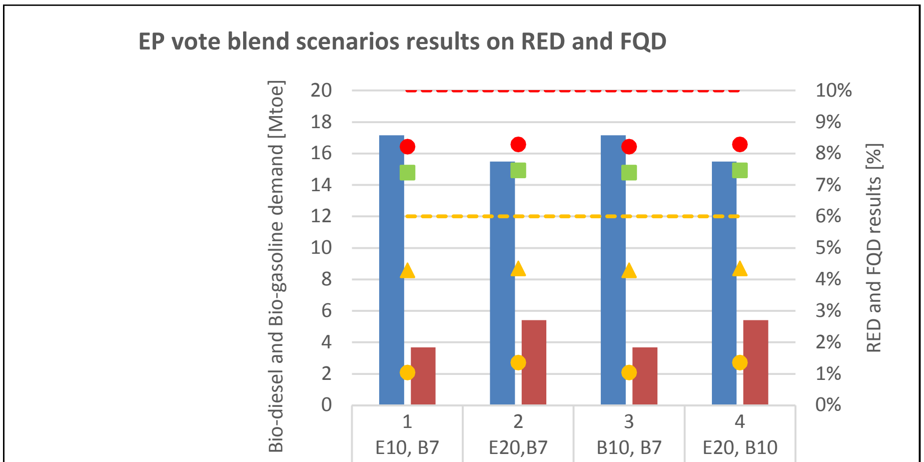
	Ref. Sc. E10, B7	Sc. 2 E20,B7	Sc. 3 B10, B7	Sc. 4 E20, B10
Bio-diesel [Mtoe]	17.46	17.46	17.52	17.52
Bio-gasoline [Mtoe]	3.68	5.42	3.68	5.42
RED: Road	7.9%	8.5%	7.9%	8.5%
RED: all sectors	8.7%	9.3%	8.7%	9.3%
FQD: all sectors	4.3%	4.7%	4.3%	4.7%
RED target	10%	10%	10%	10%
FQD target	6%	6%	6%	6%

Figure 7-1. European legislation 2009 results



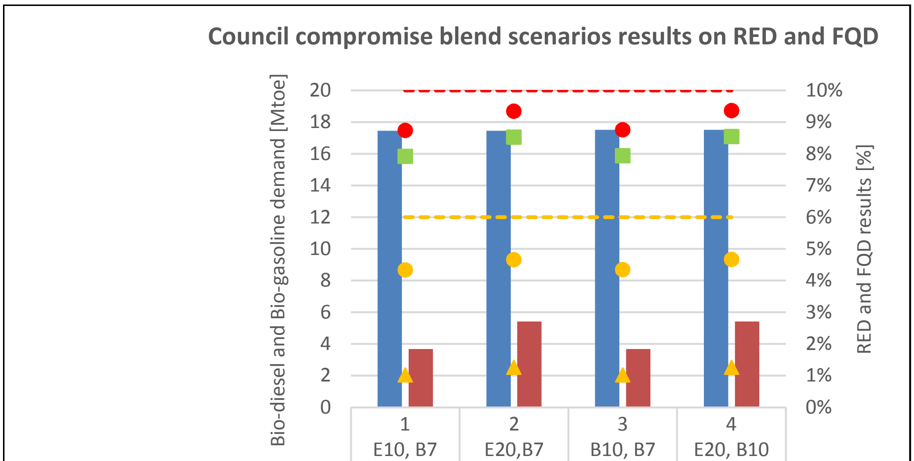
	1 E10, B7	2 E20,B7	3 B10, B7	4 E20, B10
Bio-diesel [Mtoe]	17.46	17.46	17.52	17.52
Bio-gasoline [Mtoe]	3.68	5.42	3.68	5.42
RED: Road	7.0%	7.1%	7.0%	7.1%
RED: all sectors	7.8%	8.0%	7.8%	8.0%
FQD: all sectors	4.3%	4.7%	4.3%	4.7%
FQD incl. iLUC reporting	1.0%	1.3%	1.0%	1.3%
RED target	10%	10%	10%	10%
FQD target	6%	6%	6%	6%

Figure 7-2. European Commission ILUC proposal results



	1 E10, B7	2 E20,B7	3 B10, B7	4 E20, B10
Bio-diesel [Mtoe]	17.16	15.49	17.16	15.49
Bio-gasoline [Mtoe]	3.7	5.4	3.7	5.4
RED: Road	7.4%	7.5%	7.4%	7.5%
RED: all sectors	8.2%	8.3%	8.2%	8.3%
FQD: all sectors	1.0%	1.4%	1.0%	1.4%
FQD excl. iLUC reporting	4.3%	4.4%	4.3%	4.4%
RED target	10%	10%	10%	10%
FQD target	6%	6%	6%	6%

Figure 7-3. European Parliament vote results



	1 E10, B7	2 E20,B7	3 B10, B7	4 E20, B10
Bio-diesel [Mtoe]	17.46	17.46	17.52	17.52
Bio-gasoline [Mtoe]	3.68	5.42	3.68	5.42
RED: Road	7.9%	8.5%	7.9%	8.6%
RED: all sectors	8.7%	9.4%	8.8%	9.4%
FQD: all sectors	4.3%	4.7%	4.3%	4.7%
FQD excl. iLUC reporting	1.0%	1.3%	1.0%	1.3%
RED target	10%	10%	10%	10%
FQD target	6%	6%	6%	6%

Figure 7-4. European Council compromise results

Appendix H. Adjustable parameter sensitivity run results

Reference scenario		RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.679%	
Reference scenario		FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.338%	
PC sensitivities			20	20	20	20	20	20	20	20	20	20	20	Delta 20
PC_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.88%	7.23%	7.33%	7.51%	7.66%	7.81%	8.60%	-0.078%
PC_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.66%	3.78%	3.90%	4.31%	-0.032%
PC_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.25%	7.37%	7.56%	7.73%	7.92%	8.75%	0.073%
PC_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.54%	3.68%	3.81%	3.94%	4.37%	0.031%
PC_TOTALFLEET	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.62%	6.90%	7.27%	7.39%	7.60%	7.78%	7.97%	8.82%	0.143%
PC_TOTALFLEET	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.54%	3.68%	3.82%	3.96%	4.39%	0.051%
PC_TOTALFLEET	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.60%	6.87%	7.21%	7.31%	7.48%	7.62%	7.78%	8.56%	-0.115%
PC_TOTALFLEET	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.66%	3.78%	3.90%	4.30%	-0.038%
PC_TOTALMILEAGE	MIN	RED: all sectors	4.83%	6.35%	6.52%	6.62%	6.90%	7.26%	7.37%	7.56%	7.73%	7.90%	8.73%	0.054%
PC_TOTALMILEAGE	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.54%	3.67%	3.80%	3.93%	4.35%	0.011%
PC_TOTALMILEAGE	MAX	RED: all sectors	4.83%	6.35%	6.50%	6.60%	6.87%	7.22%	7.32%	7.51%	7.66%	7.83%	8.63%	-0.053%
PC_TOTALMILEAGE	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.33%	-0.011%
PC_DIESELREG	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.88%	7.24%	7.34%	7.52%	7.68%	7.84%	8.65%	-0.026%
PC_DIESELREG	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.54%	3.68%	3.80%	3.94%	4.35%	0.015%
PC_DIESELREG	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.25%	7.36%	7.55%	7.71%	7.89%	8.71%	0.026%
PC_DIESELREG	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.66%	3.79%	3.91%	4.32%	-0.015%
PC_CNGV_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.88%	7.24%	7.34%	7.51%	7.66%	7.81%	8.60%	-0.078%
PC_CNGV_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.43%	3.52%	3.65%	3.76%	3.88%	4.28%	-0.062%
PC_CNGV_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.25%	7.36%	7.55%	7.73%	7.92%	8.76%	0.078%
PC_CNGV_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.54%	3.69%	3.83%	3.97%	4.40%	0.062%
PC_LPGV_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.86%	8.68%	-0.003%
PC_LPGV_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.43%	3.53%	3.66%	3.78%	3.91%	4.32%	-0.020%
PC_LPGV_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.54%	7.70%	7.87%	8.68%	0.003%
PC_LPGV_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.54%	3.68%	3.81%	3.94%	4.36%	0.020%
PC_xEV_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.88%	7.24%	7.34%	7.52%	7.68%	7.84%	8.65%	-0.031%
PC_xEV_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.66%	3.78%	3.91%	4.32%	-0.017%
PC_xEV_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.90%	7.27%	7.39%	7.59%	7.78%	7.98%	8.82%	0.145%
PC_xEV_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.25%	3.45%	3.55%	3.70%	3.84%	3.99%	4.42%	0.077%
PC_FCEV_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	0.000%
PC_FCEV_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.000%
PC_FCEV_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	0.000%
PC_FCEV_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.000%

VAN sensitivities			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
VAN_TOTALMILEAGE_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.54%	7.70%	7.87%	8.68%	0.004%
VAN_TOTALMILEAGE_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.001%
VAN_TOTALMILEAGE_ALLCLASSES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.86%	8.68%	-0.004%
VAN_TOTALMILEAGE_ALLCLASSES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.000%
VAN_CNGV_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.86%	8.67%	-0.008%
VAN_CNGV_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.33%	-0.006%
VAN_CNGV_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.54%	7.70%	7.87%	8.69%	0.008%
VAN_CNGV_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.80%	3.93%	4.34%	0.006%
VAN_FCEV_SALES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	0.000%
VAN_FCEV_SALES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.000%
VAN_FCEV_SALES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	0.000%
VAN_FCEV_SALES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.000%

HD sensitivities			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
HD_EFFICIENCY_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.88%	7.24%	7.34%	7.53%	7.69%	7.86%	8.66%	-0.015%
HD_EFFICIENCY_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.43%	3.53%	3.66%	3.79%	3.92%	4.33%	-0.009%
HD_LOADFACTOR_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.86%	8.68%	-0.001%
HD_LOADFACTOR_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	-0.001%
HD_LOADFACTOR_ALLCLASSES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	0.001%
HD_LOADFACTOR_ALLCLASSES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.93%	4.34%	0.001%
HD_TRANSPORTDEMAND_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.25%	7.35%	7.54%	7.70%	7.88%	8.70%	0.020%
HD_TRANSPORTDEMAND_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.25%	3.44%	3.54%	3.68%	3.80%	3.93%	4.35%	0.012%
HD_TRANSPORTDEMAND_ALLCLASSES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.88%	7.24%	7.34%	7.53%	7.68%	7.85%	8.66%	-0.020%
HD_TRANSPORTDEMAND_ALLCLASSES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.43%	3.53%	3.66%	3.79%	3.92%	4.33%	-0.012%
HD_CNGV_SALES_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.60%	6.88%	7.23%	7.33%	7.50%	7.65%	7.80%	8.59%	-0.086%
HD_CNGV_SALES_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.23%	3.42%	3.51%	3.64%	3.75%	3.87%	4.27%	-0.070%
HD_CNGV_SALES_ALLCLASSES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.25%	7.37%	7.56%	7.74%	7.93%	8.77%	0.086%
HD_CNGV_SALES_ALLCLASSES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.09%	3.25%	3.45%	3.56%	3.70%	3.84%	3.98%	4.41%	0.070%
HD_LNG_SALES_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	-0.001%
HD_LNG_SALES_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	-0.001%
HD_LNG_SALES_ALLCLASSES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.87%	8.68%	0.002%
HD_LNG_SALES_ALLCLASSES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.93%	4.34%	0.001%
HD_E95_SALES_ALLCLASSES	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.60%	6.88%	7.23%	7.34%	7.52%	7.67%	7.83%	8.64%	-0.038%
HD_E95_SALES_ALLCLASSES	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.43%	3.52%	3.66%	3.78%	3.91%	4.32%	-0.021%
HD_E95_SALES_ALLCLASSES	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.26%	7.37%	7.56%	7.73%	7.91%	8.73%	0.055%
HD_E95_SALES_ALLCLASSES	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.25%	3.45%	3.54%	3.68%	3.81%	3.95%	4.37%	0.030%
HD_DME_SALES_16-32TON	MIN	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.53%	7.69%	7.85%	8.66%	-0.017%
HD_DME_SALES_16-32TON	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.33%	-0.009%
HD_DME_SALES_16-32TON	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.54%	7.70%	7.88%	8.70%	0.017%
HD_DME_SALES_16-32TON	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.80%	3.93%	4.35%	0.009%

Supply Outlook			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Supply Outlook	MAX	RED: all sectors	5.18%	6.70%	6.87%	7.13%	7.43%	7.79%	7.91%	8.10%	8.27%	8.45%	9.52%	0.840%
Supply Outlook	MAX	FQD: all sectors	2.40%	3.06%	3.16%	3.31%	3.47%	3.67%	3.77%	3.91%	4.03%	4.17%	4.68%	0.342%
Ramp-up E10			**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Ramp-up E10	MIN17%	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.47%	7.60%	7.76%	8.55%	-0.128%
Ramp-up E10	MIN17%	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.64%	3.75%	3.87%	4.27%	-0.068%
Ramp-up E10	MAX100%	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.96%	7.40%	7.58%	7.78%	8.00%	8.24%	9.12%	0.437%
Ramp-up E10	MAX100%	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.28%	3.52%	3.65%	3.80%	3.96%	4.12%	4.57%	0.232%
Electricity mix 2020			**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Electricity mix 2020 (Fossil, Nuclear, RES)	MIN	RED: all sectors	4.83%	6.35%	6.50%	6.59%	6.86%	7.20%	7.29%	7.46%	7.61%	7.76%	8.55%	-0.127%
Electricity mix 2020 (Fossil, Nuclear, RES)	MIN	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	-0.002%
Electricity mix 2020 (Fossil, Nuclear, RES)	MAX	RED: all sectors	4.83%	6.35%	6.52%	6.63%	6.92%	7.29%	7.40%	7.60%	7.78%	7.97%	8.81%	0.127%
Electricity mix 2020 (Fossil, Nuclear, RES)	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.80%	3.93%	4.34%	0.002%
E10 Model Year compatability			**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
E10 Model compatability Year	MIN	RED: all sectors	4.83%	6.33%	6.49%	6.59%	6.86%	7.22%	7.32%	7.49%	7.65%	7.82%	8.63%	-0.053%
E10 Model compatability Year	MIN	FQD: all sectors	2.24%	2.90%	3.00%	3.07%	3.23%	3.43%	3.52%	3.65%	3.77%	3.90%	4.31%	-0.028%
E10 Model compatability Year	MAX	RED: all sectors	4.83%	6.36%	6.52%	6.62%	6.90%	7.26%	7.36%	7.56%	7.72%	7.89%	8.71%	0.031%
E10 Model compatability Year	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.09%	3.25%	3.45%	3.54%	3.68%	3.81%	3.94%	4.35%	0.016%
Flight path			**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Flight path	MAX	RED: all sectors	4.83%	6.35%	6.51%	6.61%	6.89%	7.24%	7.35%	7.60%	7.76%	7.93%	8.75%	0.067%
Flight path	MAX	FQD: all sectors	2.24%	2.91%	3.01%	3.08%	3.24%	3.44%	3.53%	3.67%	3.79%	3.92%	4.34%	0.000%

Appendix I. Glossary

ANFAC	Asociación Española de Fabricantes de Automóviles y camiones
BEV	Battery Electric Vehicle
BTL	Biomass-to-Liquids
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CEN	European Committee for Standardisation
CNG/CNGV	Compressed Natural Gas/CNG Vehicle
DLUC	Direct Land Use Change
DME/DMEV	Dimethyl ether/DME vehicles
E95/E95V	E95 fuel, 95%vol Ethanol, remainder mainly ignition enhancer/E95 Vehicle
E-REV	(Battery) Electric vehicle with Range Extender
ETBE	Ethyl Tertiary Butyl Ether
EU	European Union
EU27+2	EU 27 Member States plus Norway and Switzerland
F&F Model	Fleet and Fuels Model
FAME	Fatty Acid Methyl Ester
FCEV	Fuel Cell Electric Vehicle
FFV	Flexible Fuel Vehicle (Vehicle able to run with ethanol blends up to E85)
FQD	Fuel Quality Directive
GHG	Greenhouse Gas(es)
HD/HDV	Heavy Duty/Heavy Duty Vehicle
HVO	Hydrogenated Vegetable Oil
ILUC	Indirect Land Use Change
JEC	European Commission’s Joint Research Centre (JRC), EUCAR and CONCAWE
LCV	Light Commercial Vehicle
LD/LDV	Light Duty/Light Duty Vehicle
LPG/LPGV	Liquefied Petroleum Gas/LPG Vehicle
Mtoe	Million tonnes oil equivalent
MY	Model Year
PHEV	Plug-In Hybrid Vehicle
pkm	Passenger kilometres (used for buses and coaches instead of annual mileage) transport of one passenger over a distance of one kilometre

RED	Renewable Energy Directive
RES	Renewable Energy Sources
tkm	Tonne kilometres (used for HD instead of annual mileages) transport of one tonne over a distance of one kilometre
TREMOVE	Policy assessment model to study the effects of different transport and environment policies on the transport sector for all European countries more information: www.tremove.com
TTW	Tank-to-Wheels
vkm	vehicle kilometres
WTT	Well-to-Tank
WTW	Well-to-Wheels

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