Renewable energy targets in the EU: the case of fuels for transport

Laura Lonza
Scientific Officer, European Commission's Joint Research Centre,
Institute for Environment and Sustainability,
(corresponding author)[1]

Tel: +39 0332 783902
Fax: +39 0332 785236
Email: laura.lonza@jrc.ec.europa.eu

Address
European Commission, Joint Research Centre, Institute for Environment and Sustainability,
TP 441, Building 44, Office 1/118, I – 21027 Ispra – Va
http://ies.jrc.ec.europa.eu/jec

Heiko Maas
Research Engineer, Business Analytics, Environmental Science Department
Ford Research & Advanced Engineering Europe, http://www.eucar.be

Alan Reid
Technical Co-ordinator, Refining Technology
CONCAWE, http://www.concawe.be

Abstract: Transport is a crucial economic sector both in terms of people and goods movement and of employment. Negative environmental impacts, not limited to, but certainly stigmatised by, emissions and almost full dependence on finite fossil fuel sources bring it under the lens of the EU regulator in the definition and adoption of the objectives and the instruments to move towards the "low-carbon society".

A scenario-based study is presented, jointly developed by JRC, EUCAR[2*] and CONCAWE[3**], targeting theoretical scenarios towards achieving the mandatory 10% renewable energy target in transport by 2020. Focus of the analysis is road transport although other transport modes are considered. Expected road vehicle (passenger and goods) fleet development in 29 European countries constitutes the basis on which penetration and distribution of alternative motor fuels – and availability thereof – are analysed, including energy efficiency pace of development, CO_2 emissions, identification of the most sensitive parameters as well as relevant regulatory measures as either hindrances or spurs towards alternative fuels in transport target achievement.

Starting from reasonable assumptions results are robust and provide both information and material for further investigation in several research areas at the crossroads of energy and transport.

Keywords: EU renewable energy policies, transport, alternative motor fuels transport demand.

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[1] **Disclaimer:** the views expressed in this article are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

[2] * EUCAR , European Council for Automotive R&D

[3] ** Research Association of the European Oil Refining Industry

1 Introduction

1.1 What is JEC

The JEC research collaboration started in the year 2000 bringing together the Joint Research Centre of the European Commission, EUCAR (the European Council for Automotive Research and Development) and CONCAWE (the Oil Companies' European organisation for environment, Health and Safety). The three organisations have collaborated in the field of sustainability of European vehicle and oil industry, providing facts relating to the energy use and efficiency and emissions from a broad range of road vehicle powertrain and fuel options. The JEC Well-to-wheels methodology has become a scientific reference in the European energy research landscape.

1.2 JEC Biofuels Programme and content of this article

The JEC Biofuels Programme is a three-year (2008-2010) technical exercise intended to assess possible biofuel implementation scenarios for achieving renewable energy targets in the European Union in the transport sector by 2020. This technical exercise was not intended to commit the JEC partners to deliver any particular scenario or conclusion included in the study and presented in this article.

In this article the authors assess the potential role of alternative fuels in the European transport sector with a specific focus on biofuels. Following a review of the EU regulatory framework in Section 2, Section 3 describes the fleet and fuel scenario assessment tool developed by JEC and includes details of the reference scenario. Section 4 discusses the role of a selection of technically feasible scenarios. Section 5 outlines biofuels supply projections and compares with demand described in Section 4 thus providing an indication of the achievability of EU regulatory targets before drawing conclusions in Section 6.

Objectives and scope of JEC Biofuels Programme

The objectives of the JEC Biofuels Programme are the following:

- To clarify the opportunities and barriers to achieve 10% renewable energy (on an energy basis) in the transport sector by 2020, by developing a realistic and consensual fuel demand reference and supply of biofuel types and availability;
- To focus on fuel blends with conventional and advanced biofuels while accounting for growth in alternative motor fuels till 2020 and considering both domestic production and imports;
- To ensure that the introduction of biofuel blends 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 energy and Greenhouse Gases implications.

The scope of the JEC Biofuels Programme can be summarised as:

- Focusing analysis on road transport energy demand while at the same time including non-dynamic analysis of other transport modes;
- Analysing possible implementation scenarios within the 2010-2020 time horizon focusing on fuel alternatives in terms of requirements to road vehicle fleet developments, and;
- Considering standardisation requirements, (fuelling) infrastructure requirements, fuel production and distribution requirements, user/customer acceptance, and availability of demanded amounts of fuels (supply).

Approach of the JEC Biofuels Programme

In line with the objectives and scope of the JEC Biofuels Programme, partner organisations have proceeded to develop a consensus demand and supply picture of biofuel types and demand to meet the 2020 10% renewable energy target in the transport sector adopted by the Renewable Energies Directive of 23 April 2009 (EC 2009a) . The approach has therefore been one of

- Reviewing and analysing projections and other data for the period 2008-2020, covering:
  - biodiesel, ethanol and others, including conventional and advanced products
  - domestic production and imports
  - most recent updates on well-to-wheels energy and greenhouse gases implications
- Analysing possible biofuel implementation scenarios within the 2010-2020 timeframe and subject to the existing regulatory framework.

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 Directive and the FQD Directive.

The Renewable Energies Directive of 23 April 2009 (RED Directive) poses two key requirements for the uptake of renewable energy and – more specifically – biofuels in the transport sector.

EU Member States are required to meet 10% renewable energy share in the transport sector by 2020. All transport

modes are included in this target and different renewable energy sources are factored in differently, namely the contribution of advanced biofuels[4] towards achieving the 10% target are accounted twice whereas electricity from renewable energy sources for road transport counts 2.5 times[5].

Biofuels sustainability is required for feedstock and biofuels production as well as minimum greenhouse gases (GHG) savings per energy unit.

Each Member State is requested to establish a national renewable energy action plan including information on sectoral targets. In addition, Member States are expected to set out measures to achieve those targets, assessing the contribution of both energy efficiency and energy saving measures.

The Fuel Quality Directive of 23 April 2009 (EC 2009b) sets environmental requirements for petrol and diesel fuel in order to reduce their air pollutant emissions. These requirements consist of technical specifications for fuel content and binding targets to reduce fuels' life cycle greenhouse gases emissions. The directive places the responsibility for reducing GHG emissions on fuel suppliers.

Fuel suppliers will have to gradually reduce fuel greenhouse gases emissions of 6% by 2020. Member States may choose to expand this reduction up to 10%. They may also choose to set the intermediate targets of 2% by 2014 and 4% by 2017.

Suppliers will also have to reach an additional indicative reduction target of 2% by 2020 by either supplying electric vehicles or using GHG reduction technologies (including carbon capture and storage technology). Another indicative target of 2% by 2020 is to be achieved by the purchase of credits through the Clean Development Mechanism under the Kyoto Protocol[6]. The last two targets are subject to review.

From 2011 fuel suppliers will be bound to report annually to Member States on the life cycle greenhouse gas emissions per unit of fuel supplied.

Regulation on CO_2 from light duty vehicles is addressed by Regulation 443/2009 (EC 2009c) setting emission performance standards for new passenger cars as part of the Community's integrated approach to educe CO_2 emissions from light-duty vehicles. Car manufacturers have to gradually reduce CO_2 emissions in the new fleet of passenger cars reaching new fleet averages of 130g/km in 2015 and 95g/km[7] in 2020.

The regulation places the burden of complying with

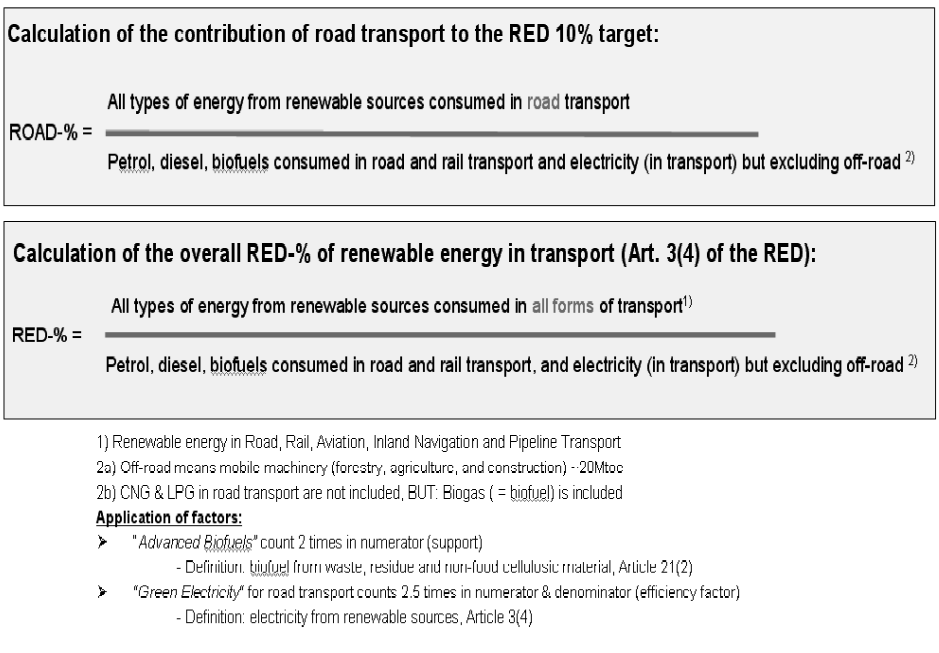

Figure 1. Renewable Energy Calculations in the RED Directive

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

[5] See Art. 3.4 of the RED

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

[7] The 95g/m target is a proposal at regulatory level and subject to review

the target on car manufacturers and recognises the role of alternative motor fuels (namely E85) and innovative technologies, by accounting for additional CO_2 reductions on overall emissions. Regarding E85 vehicles, the Regulation foresees that the CO_2 emission reduction may be applied providing at least 30% of filling stations provide E85 and that E85 meets sustainability criteria: there again yet another reason for car manufacturers and fuel producers and distributors to work together, e.g. by sharing a common knowledge basis.

Regulation on CO_2 from light commercial vehicles (vans) has been proposed by the European Commission in October 2009 (EC 2009e). The targeted EU fleet average for all new light commercial vehicles (vans) of 175 g/km is expected to be applied to its full extent as of 2016. The requirement will be phased-in as of 2014 when 75% of each manufacturer's newly registered vans will have to comply on average with the limit value curve set by the legislation then rising to 80% in 2015, and 100% from 2016 onwards.

2.1 Emission standards for passenger cars and heavy duty vehicles

Regulation 715/2007 (EC 2007) introduces new common requirements for emissions from motor vehicles and their specific replacement parts (Euro 5 and Euro 6 standards[8]) for passenger cars, vans and light duty 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.

Euro VI standard for Heavy Duty vehicles (categories N2, N3, M2 and M3) has been introduced by Regulation 595/2009 (EC 2009d) with new emission limits coming into force on 1 January 2013 (new type approvals) and 2014 (new registrations)[9].

European CEN fuel specifications are also relevant elements factored in the analysis presented in this article insofar as they determine specifications for fuel and biofuel blending.[10]

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

[9] Technical details will be specified in the implementing Regulation being developed by the European Commission in the course of year 2010.

[10] For ethanol, EN15376 for blending up to 5% in gasoline
For Fatty Acid Methyl Esters (FAME), EN 14214
Gasoline: 5% v/v (E5) ethanol and 2.7% oxygen (EN228)
Diesel 7% v/v (B7) FAME in road diesel fuel (EN590)
Generally, there are no standard limiting the addition of 2nd generation renewable diesel fuels, namely Hydrogenated Vegetable Oils (HVO) and animal fats and Biomass-to-Liquids (BtL).

2.2 Member States initiatives

Initiatives at Member State level provide a somewhat more diversified, heterogeneous situation. Examples range from E10 approved in France in 2009 while B7 had already been approved in the same country in 2008 and B30 for captive fleets. Similarly in Germany, B7 plus 3% renewable diesel was equally approved in 2008 whereas it was still not approved at European level and B100 was also approved for specially adapted vehicles. Examples from other countries range from B20 in Poland and B30 in the Czech Republic for captive fleets to E85 in Austria, France, Germany and Sweden.

Standardisation of high-quality fuels containing sustainable bio-components is essential not only to ensure trouble-free performance in the current and future European road vehicle fleet but impacts equally on the internal market.

3 Description of model and methodology

The JEC "Fleet and Fuels" (F&F) model is a spreadsheet-based simulation tool covering EU27+2 (Norway and Switzerland) vehicle fleet development and the resulting demand for fossil fuels and biofuels. The model has been developed to enable projections to the year 2020 based on a set of assumptions.

The F&F model is a scenario assessment tool based on a 2010 reference case and assuming realistic trends in the fleet, fuel and market developments over the coming decade. It further allows the evaluation of the Renewable Energy Directive and Fuel Quality Directive targets as well as the sensitivity of main parameters considered.

The model does not lead to a single globally optimised solution but does allow a side-by-side comparison of various scenarios of fleet and fuel development. Very importantly, the model does not assess the cost implications associated with the various scenarios. Due to the assumptions and simplifications introduced in the JEC Biofuels Programme – and subsequently in the F&F model as its main analytical tool – the model can not 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, fuels and biofuels to assess renewable energy implementation

Table 1. Transport demand projections (Mtoe), including JEC F&F Reference Scenario

EU27+2 Transport Energy Demand: [Mtoe]	2008 EuroStat	2020 JEC F&F Reference Scenario	2020 DG TREN
1. Road mode	**303**	**281**	**350**
1.1 Diesel	188	186	
1.1.1 Light Duty		69	
1.1.2 Heavy Duty incl. Vans		117	
1.2 Gasoline	100	66	
1.3 Biofuels	10	21.5	
1.4 Other: CNG, LPG, electricity	5	7.8	
2. Other modes	**84**	**109**	**89**
2.1 Rail (Diesel & Electricity)	9.5	10	10
2.2 Aviation	54	73	73
2.3 Inland navigation	6.5	6	6
3. Off-road (Diesel)	14	20	
Total	**387**	**390**	**439**

scenarios looking at:

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

Key parameters relevant to fuel demand included in the F&F model cover the following areas:

- Passenger car, van, bus&coach, heavy duty truck fleet segments;
- Vehicle efficiency and projected efficiency improvement over time;
- Percentage of diesel in new car sales;
- Fleet introduction of alternative vehicles;
- Vehicle model year (vintage) assumed to be compatible with specific fuel blending grades for biofuels;

3.1 Reference data sources

The reference source used to provide historical input on per vintage vehicle fleet module is TREMOVE, Version 2.7b[11], yet revised via both referenced studies (iTREN2030 2010, EC 2008) and ACEA sales data. Comparisons of energy demand projections towards 2020 were not straightforward due to differences in underlying assumptions. Despite inevitable uncertainties, considerable efforts were made while developing the F&F model to ensure the highest degree of transparency regarding assumptions and data used.

TREMOVE has been used to model information on fleet composition, and activity (vehicle-km and tonne-km), per vintage and year. JEC Well-to-wheel data[12] have been used to model fuel efficiency of passenger cars and fuel specifications.

The 2008-2009 economic recession has been factored in the F&F model using input from the iTREN2030 analysis.

Vehicle classes and fuel options

The F&F model considers the following vehicle classes and related fuel type options:

Seven light duty passenger car types (and related fuel type options)

- Gasoline, Diesel and Flexi-Fuel Vehicles (FFV)
- Compressed Natural Gas (CNG), Liquefied Propane Gas (LPG)
- Plug-in Hybrid electric vehicle (PHEV), Battery Electric Vehicle (BEV)

Three van classes (and related fuel type options)

- Gasoline (Gasoline, CNG, LPG, xEV[13])
- Small Diesel <2.5 tonnes Gross Vehicle Weight (GVW) (Diesel, CNG, LPG, xEV)[14]
- Large Diesel >2.5 tonnes GVW (Diesel, CNG, LPG, xEV)

Five heavy-duty vehicle classes (and related 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, E95, DME)
- > 32 tonnes GVW (Diesel)
- Buses and coaches (Diesel, CNG, E95)

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

[12] http://ies.jrc.ec.europa.eu/jec-research-collaboration/activities-jec/jec-well-to-wheels-analyses-wtw.html

[13] xEV stands for PHEV or BEV.

[14] 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.

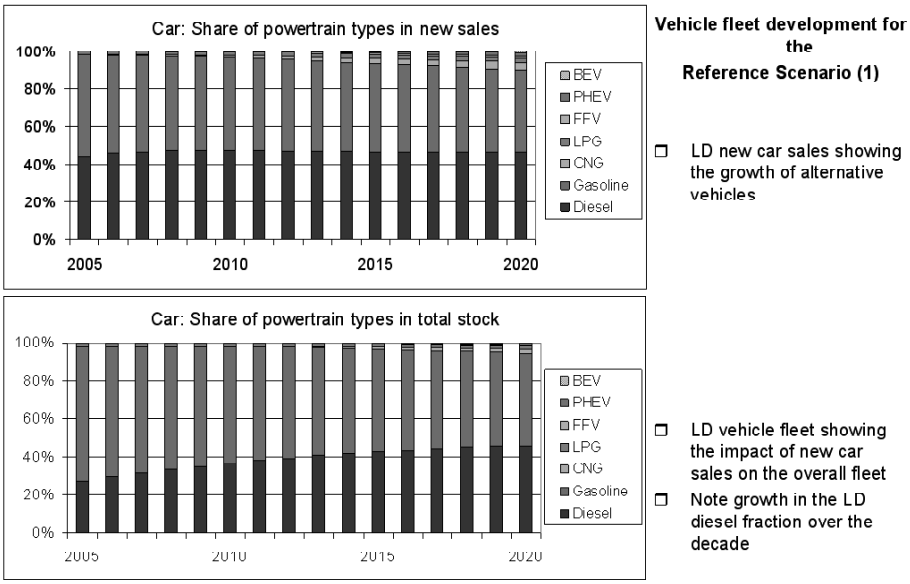

Figure 2. Example of F&F Model Output: Vehicle Fleet Development

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:

- Sales and stock annual growth rate per vehicle class and fuel type
- Vehicle activity, that is the annual mileage (km driven for passenger cars, vans and bus&coach) and annual tonne-km for heavy duty vehicles
- Vehicle fuel efficiency and prospective 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 fuel vehicles (e.g. E85 take-up rate for FFV).

With regard to fuel implementation in the F&F model, it is worth highlighting an assumption, which determines the functioning of the model by assuming biofuel blending by volume at the maximum allowed specification. To clarify with an example, this assumption means in practice that there will be no fuel quality and quantity variation throughout Europe for all biofuel blending.

The only concession made to this assumption is a minus 0.1% by volume of blending tolerance for each blending grade.

The F&F model allows up to 3 different gasoline grades ("protection grade", main grade, and E85) and up to 2 different diesel grades ("protection grade", and main grade). Additionally, for the main diesel grade, market uptake by Heavy Duty (HD) fleet, Light-Commercial Vehicles. Light-Duty vehicles and vehicle vintage compatibility can be independently set.

The F&F model allows setting vehicle vintage (model year) compatibility with fuel grade. It is worth noting though that HVO or BtL are included in the diesel pool assuming backward compatibility. Advanced ethanol (lignocellulose-based) is replacing/added to gasoline and therefore equally not subject to the blending grades of conventional ethanol. Other oxygenates (e.g. ETBE) are not modelled separately but would be allowed up to the maximum oxygen specification allowed.

The F&F model includes energy demand by non-road transport modes using historic data series [15] and projections in reference sources by European Commission (iTREN2030 2010 and EC 2008), as sketched in Figure 4. Data have been verified by actively seeking the expert advice of key European stakeholders of non-road transport modes.

When considering RED targets extra-credits provided for in that legislative act are implemented in the F&F model for advanced biofuels and renewable electricity.

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

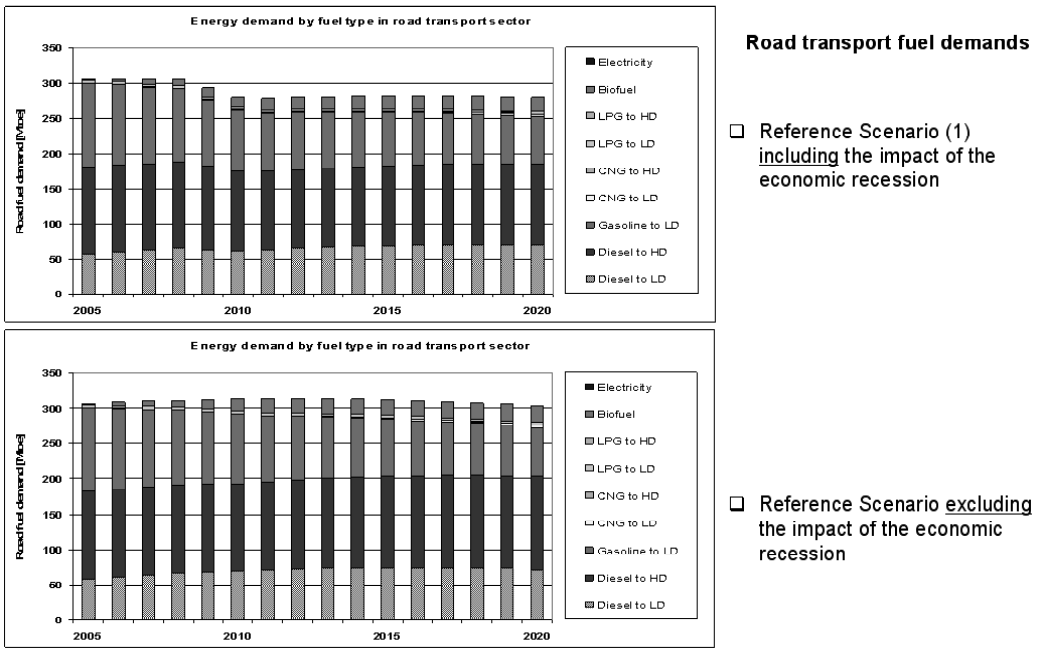

Figure 3. Example of F&F Model Output: Road Transport Fuel Demand

Aviation

- Projections range from 56[2] - 73[1] Mtoe consumption by 2020
- Jet fuel specification likely to allow only HVO or BTL in this decade
- HVO/BTL or ETS certificates are options to offset GHG emissions
- Aviation fuel consumption excluded from FQD but included in RED

Rail

- ~10 Mtoe consumption by 2020 [1] [2]
- Fuel by 2020: ~70% electricity, ~30% Diesel (DG TREN[1])
- Rail Diesel: likely shifts to road diesel quality fuel by 2020
- Diesel will likely contain FAME, HVO, BTL, the same as road diesel (i.e. B7 = reference blend)

Inland navigation

- ~6 Mtoe consumption by 2020 [1] [2]
- Likely shifts to road diesel quality fuel by 2020
- Diesel will likely contain FAME, HVO, BTL, the same as road diesel (i.e. B7 = reference blend)

Other off-road diesel

- ~20 Mtoe consumption by 2020 (JEC estimate)
- Diesel will likely contain FAME, HVO, BTL, the same as road diesel (i.e. B7 = reference blend)
- Other off-road fuel consumption excluded from RED but included in FQD

1) DG TREN: "European Energy and transport trends to 2030, Update 2007"
2) ITREN 2030, 2009

Figure 4. Non-road transport modes: Outlook

3.2 Non-road transport modes

The F&F model is mainly devoted to the analysis of road transport energy and fleet demand. Nonetheless it is not realistic to consider and analyse road transport in isolation. This is true for three reasons at least:

- non-road transport modes are accounted for towards meeting the targets of the RED and FQD EU Directives;
- non-road transport mode demand for alternative transport fuels, including (but not limited to) biofuels may represent a competing demand limiting the uptake opportunity of such fuel options in the road transport sector;
- other modes' demand may provide opportunities for investment in new biofuel plants and/or funding for advanced research and development activities (this seems to be realistic with a longer term perspective).

Rail contribution towards meeting the RED target has been split into its electricity and diesel components assuming 35% average renewable electricity in the grid by 2020 (EREC 2008, JRC 2009), accounting for slightly less than 1% of the RED target from this mode. Inland navigation assuming the uptake of B7 by the sector accounts for less than 0.1% towards the RED target while aviation is assumed to make no contribution by 2020.

4 Scenario analysis

With the support of the F&F model, a reference scenario has been defined, which represents the energy demand development commonly agreed by the European automotive industry, the fuel producers active in Europe and fully in line with the EU energy and transport regulatory and policy framework. Considering diverging starting points and expectations, the identification and characterisation of a commonly agreed reference scenario can already be considered a success.

Following this fundamental step, eight further scenarios have been developed and analysed, which are feasible to approach the RED 10% target in 2020.

4.1 Reference case scenario 2020

Fleet parameters in the reference scenario have been assumed to be the following:

- Sales and stock in 2020 for all vehicle classes as in TREMOVE except for sales of Heavy Duty vehicle

classes expected to be lower due to economic recession;
- Economic recession impacts fleet activity (vkm and tkm), using input from the iTREN2030 project;
- Efficiency improvements are specific per vehicle class;
- Alternative fuel vehicles enter the market assuming a start year for market introduction and a target sales share by 2020.

Fleet parameters in the 2020 reference scenario (as sketched in Table 2) therefore result in:
- Passenger cars
  - New car average CO_2 target is 95g/km[16];
  - Diesel/gasoline sales share at 50%/50%;
  - Sales reach 20 million vehicles per year.
  - Total fleet is 270 million vehicles
  - Alternative fuel vehicles enter the market;
  - Although the financial crisis impacts miles travelled, total fleet mileage still increases.

- Vans
  - New van average CO_2 target is 175 g/km[17];
  - Sales reach 1.5 million vehicles per year. Total fleet is 28 million vehicles;
  - Alternative fuel vehicles enter the market;
  - Although the financial crisis impacts miles travelled, total fleet mileage still increases.

- Heavy Duty vehicles
  - New truck average year-on-year energy efficiency improvement is 1.5% (the model defines different efficiency gains per heavy duty vehicle class);
  - Sales reach 0.8 million vehicles per year. Total fleet is 15 million vehicles;
  - Alternative fuel vehicles enter the market in specific heavy duty classes (and therefore Member States markets);
  - Although the financial crisis impacts heavily on both activity (tkm) and sales, dynamic growth is still expected.

The resulting biofuel parameters used in the reference scenario are as follows:

- Conventional biofuels: blending grades
  - Ramping up to E5 by 2011 with no vehicle compatibility restriction (protection grade);
  - New E10 (main) grade from 2011 with vehicle compatibility with E10 from 2005+ model year;
  - Ramping up to B7 by 2010 with no vehicle compatibility restriction (protection grade);
  - Assumption of 1 Mtoe FAME/HVO coming from waste oils, which are accounted double towards meeting the 10% RED target. Quality of produced FAME or HVO is expected not to be impacted.

- Non-conventional biofuels
  - Ramping up of HVO, BtL and advanced ethanol according to assumptions outlined in Table 3.

Results in terms of energy demand in the 2020 reference scenario when compared to start year 2010 can be summarised as follows:
- Fossil energy demand changes
  - Gasoline demand decreases by 24%
  - Diesel demand increases by 6%
  - Diesel demand increases 13% for light duty and 3% for heavy duty vehicles
  - Diesel/ gasoline ration increases from 2.0 to 2.8
- Large biofuel volumes are needed, with increasing demand for CNG and CBG;
- The RED 10% target is not met, but reaches 9.7% including 1.0% contribution from non-road transport modes;
- FQD target of -6% GHG emissions is not met, with 4.4% savings from all relevant transport modes included.

Results in terms of alternative fuel demand for the transport sector are:
- FAME dominates the biofuel market: the steep demand increase in 2010 is driven by B7 blending specification
- The steep demand increase for ethanol in 2010 is driven by E5 blending specification while increase beyond 2010 is due to E10 blending specification
- HVO and BtL demand follow availability assumptions (backward compatible vehicles imply no grade dependency)
- CNG and CBG demand is driven by the introduction of CNG vehicles in Light Duty fleet segment but also Heavy Duty segment.

[16] Value is used for calculation purposes; so far the figure is a proposal at regulatory level and still subject to review

[17] Value is used for calculation purposes; so far relevant legislation is at negotiation stage.

Table 2. Alternative Fleet Parameters in the Reference Scenario

Alternative Fuel Passenger Cars	**In 2020 New Sales**		**In 2020 Vehicle Fleet**	
Flex-Fuel Vehicles (FFV)	1%		0.5%	
Compressed Natural Gas Vehicles (CNGV)	4% 0.8 Million		2% ~5 Million	
Liquefied Propane Gas Vehicles (LPGV)	2% 0.4 Million		2% ~5 Million	
Electric Vehicles Battery Electric (BEV) & Plug-in Hybrid (PHEV)	3% 0.6 Million		1% 2.7 Million	
Alternative Fuel Vans	**In 2020 New Sales**		**In 2020 Vehicle Fleet**	
Compressed Natural Gas Vehicles (CNGV)	4%		1.7%	
Liquefied Propane Gas Vehicles (LPGV)	1%		0.4%	
Flex Fuel Vehicles (FFV)	1%		0.3%	
Electric Vehicles Battery Electric (BEV) & Plug-in Hybrid (PHEV)	2% 24 Thousand		0.4% 90 Thousand	
	In 2020 New Sales			
Alternative Fuel Heavy Duty Vehicles	3.5t to 7.5t	7.5t to 16t	16t to 32t	Bus-Coach
Compressed Natural Gas Vehicles (CNGV)	2%	1%	1%	5%
Di-Methyl Ether Vehicles (DMEV)	==	==	0.5%	==
95% Ethanol (E95) Vehicles	==	==	1%	2%

In absolute terms, FAME demand in all transport sectors in 2020 will be approximately 15 Mtoe per year, increasing from 1.5 Mtoe per year in 2005 and 7.9 Mtoe in 2008. Ethanol demand is expected to be in the range of 5Mtoe per year, increasing from 0.7 Mtoe in 2005 and 1.8 Mtoe in 2008.

4.2 Biofuels scenarios using the Fleet and Fuels model

The eight further scenarios analysed with the F&F model imply a specific development of the vehicle fleet with given years of introduction of fuel grades and given model years of vehicle compatibility, resulting in a given energy demand and fuel diversification per fleet vintage.

The rationale for defining the scenarios is based on the following criteria:

- Respect the constraints identified in the definition of the reference scenario;
- Reflect differences in current situations and – therefore – likely future priorities, which are present across EU Member States;
- Maintain the number of scenarios to a reasonable number allowing a detailed analysis, including their pros and cons as well as a sound sensitivity analysis.

Table 3. Advanced biofuels as fuel parameters in the reference scenario

	Biomass-to-Liquid (BTL)	**Hydrogenated Vegetable Oil (HVO)**	**Advanced Ethanol**
Start year	2012	2009	2012
Production simulation	Linear ramp-up to 2020	+1.6 Mtoe to 2012 +1.4 Mtoe and linear ramp from 2012 to 2020	Linear ramp-up to 2020
Availability in 2020	0.25 Mtoe	3 Mtoe	0.64 Mtoe

Table 4. Energy demand in the reference case and EU Directives targets

Road fuel (Mtoe)	**2005**	**2010**	**2020**
Fossil Gasoline to car	118	87	66
Fossil Diesel to car	58	61	69
Fossil Diesel to HD	123	114	117
Sum fossil Diesel	181	175	186
Diesel to Gasoline ratio (road only)	1,5	2,0	2,8
CNG	0,42	0,85	3,26
CBG			0,82
LPG	4,17	3,32	3,24
FAME	1,50	11,90	12,80
HVO	0,00	1,00	3,00
BTL	0,00	0,00	0,25
DME	0,00	0,00	0,09
Total Ethanol	0,72	2,47	5,32
EtOH conv.	0,72	2,47	4,68
EtOH Adv.	0,00	0,00	0,64
"Fossil" Electricity	0,00	0,00	0,28
Renewable Electricity			0,15
Sum road fuel demand	**306**	**281**	**281**
RED Contributions			
Non-road			1,0%
Road			8,6%
Sum RED-%			**9,7%**
FQD GHG saving			**-4,4%**

Scenario 1 is the reference case described in detail in Section 4.1.

Scenarios 2-9 can be characterised as follows:

- Scenarios 2-4: "high biofuel grades for all vehicle classes";
- Scenarios 5-6: "high biodiesel grades for heavy duty vehicles only";
- Scenarios 7-9: "additional Flex-Fuel vehicles (FFV)"

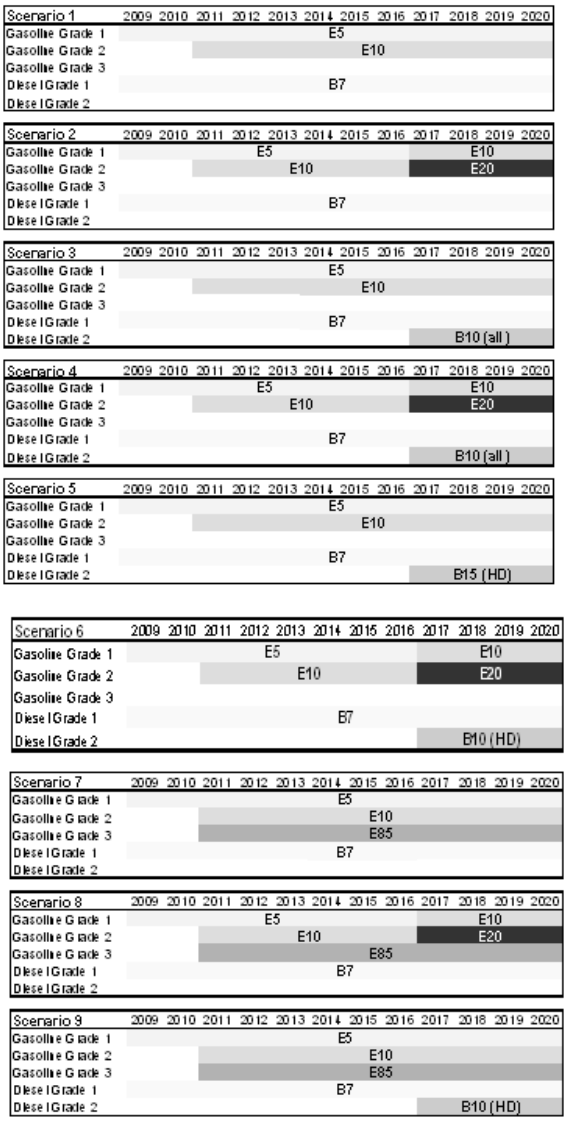

Figure 6. Visual representation of analysed scenarios

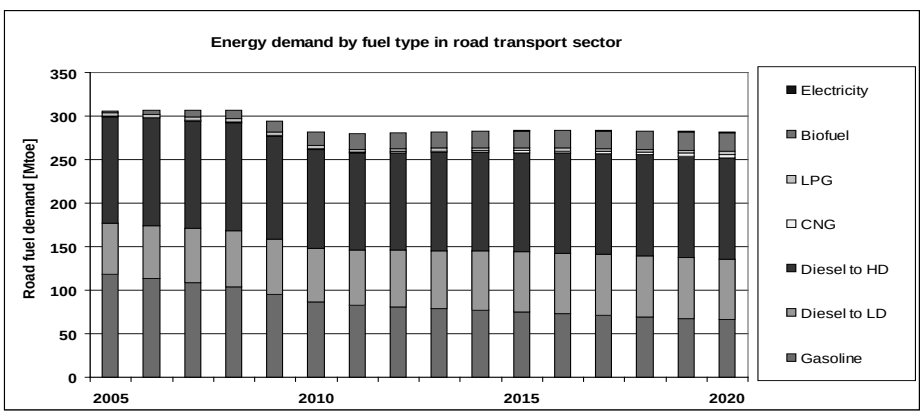

Figure 5. Energy demand by fuel type in road transport sector in the reference scenario

The FFV scenarios feature a sales share of 4.5% resulting in a 2.5% FFV stock (6.5 million) vehicles in 2020.

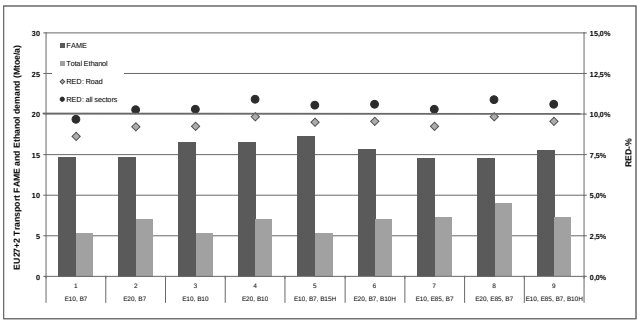

Figure 7. Summary of scenario results

4.3 Sensitivity analysis

The F&F model has several adjustable parameters that influence projections to the year 2020. They can be grouped in three categories and the main outcomes of the sensitivity analysis are presented.

– Passenger Cars

Sales assumptions for alternative fuel vehicles, namely Flex-Fuel Vehicles (FFV) impact the capacity to reach the RED % target.

Table 5. Sensitivity analysis for passenger cars

Passenger Cars Parameter		reference	min	max
Sales	M cars/a in 2020	20,20	16,2	24,2
Total fleet	M cars in 2020	270	216	324
Total Mileage	% yoy growth (2011+)	2,25%	1,8%	2,7%
CO2 sales avg 2020	g/km	95	95	120
Diesel reg. 2020	% of G+D	50%	30%	70%
CNGV	sales sales start year	4,0% 2006	2,0%	6,0%
LPGV	sales	0,40%	0,0%	2,6%
FFV	sales sales start year	1,00% 2005	0,0%	4,0%
Electric vehicle	sales sales start year	3,00% 2011	1,5%	10,0%

– Vans and Heavy Duty

Sensitivity assumptions for both vans and heavy duty vehicles do not make a significant difference in terms of reaching the RED % target.

Vans Parameters	reference	min	max
CO2 sales avg 2020 g/km	175	160	175
vkm YoY growth 2011-2020	1,00%	0,8%	1,2%
CNGV sales share 2020	4,0%	2,0%	6,0%
FFV sales share 2020	1,0%	0,0%	4,0%
HD Parameters			
Efficiency 2011+ ALL HD classes YOY improvement 2011 - 2020	-1,45%	-1,00%	-1,45%
Load factor ALL HD classes w/o bus&coach Load YOY growth 2005-2020	0,080%	0,06%	0,10%
Transport demand ALL HD classes w/o bus&coach tkm YoY growth 2011-2020	2,250%	1,8%	2,70%
HDV Vehicles 3.5-7.5 Tonnes CNGV sales share 2020	2,0%	0,00%	4,00%
HDV Vehicles 7.5-16 Tonnes CNGV sales share 2020	1,0%	0,00%	2,00%
HDV Vehicles 16-32 Tonnes DME sales share 2020	0,50%	0,00%	1,00%
E95 sales share 2020	1,00%	0,00%	2,00%
CNGV sales share 2020	1,00%	0,00%	2,00%
HDV Vehicles bus&coach E95 sales share 2020	2,00%	1,00%	4,00%
CNGV sales share 2020	5,0%	0,00%	10,00%

Table 6. Sensitivity analysis for vans and heavy duty vehicles

– Fuels

The pace of development of advanced biofuels (BtL and advanced ethanol) and HVO significantly impacts the capacity to reach the RED % target.

Table 7. Sensitivity analysis for fuels in all scenarios.

Biofuels availability 2020		reference	min	max
HVO	[Mtoe/a]	3,0	1,5	4,5
BTL	[Mtoe/a]	0,25	0,0	0,5
Adv. Ethanol	[Mtoe/a]	0,64	0,00	1,28

Table 8. Additional parameters' sensitivities.

Additional		Reference	min	max
HVO availability in 2020	[Mtoe/a]	3,0	1,5	4,5
FFV	sales% 2020	1,0%	0%	4,0%
E20 MY 2015+	first model year	2017		2015
B10 MY2015+	first model year	2017		2015
B10 MY2015+ (cars) & all (HD)	first model year	2017		2015/all
B15 HD MY2015+	first model year	2017		2015
B15 HD all	first model year	2017		all
Biogas in CNG	Share e/e [%]	20%	0%	40%
Renewable electricity in road trans.	Share e/e [%]	35%		100%
B30 for Inland Navigation	FAME blend	B7		B30
Renewable electricity in rail trans.	Share e/e [%]	35%		100%

Sensitivity was tested on scenario-specific additional parameters, chosen based on expert advice.

As a conclusion of the sensitivity analysis and of Section 4, the following statements are highlighted as mostly relevant:

– Timely implementation and uptake of higher biofuel

levels significantly impacts RED % target. For instance, the 50% reduction in uptake of E10 grade in the reference scenario would decrease the RED% from 9.7% to 9.3%.
- Implementing higher biodiesel levels in non-road sectors significantly impacts RED % target;
- Renewable electricity in rail transport mode can contribute significantly to RED % target.

5 Biofuel Supply Outlook

Inevitably, the question that accompanies the projected biofuel demand per type of fuels based on the assumptions and analysis of the F&F is whether these quantities of biofuels will be available not only and possibly more interestingly for the objectives of the study – whether they will be available for European use through 2020 and, if so: from domestic production and from imports? From sustainable sources meeting GHG reduction targets?

The biofuel supply part of the analysis is considerably less detailed than the modelling and analytical work performed for the demand side and its primary focus has been on availability and not on costs and investments although they are indirectly factored in the main reference source[18] (WMac 2009) used for this section of the study.

5.1 How this complements the demand analysis modelled with Fleet and Fuels

Using scenarios presented in Section 4, biofuels demand, including sensitivity testing on selected parameters, is summarised in Table 9.

Today's European production capacity[19] installed in Europe (GBC 2010) is in the range of 3.4 Mtoe bioethanol functioning at 43% of its potential and therefore producing approximately 1.5 Mtoe bioethanol per year and an additional 13 plants currently under construction to produce 0.9 Mtoe when operational. European biodiesel production capacity installed in 2009 reaches 18.4 Mtoe per year, with 6.9 Mtoe actually produced in 2008 at a utilisation rate of 37% of installed capacity.

Furthermore, HVO production needs to be taken into account with an expected production capacity in Europe slightly below 2 Mtoe per year as of 2015 and in the range of 3Mtoe per year worldwide. These assumptions are therefore in line with those used for the 2020 reference case. Yet, it is important to remember that the demand for HVO from other world regions may change over the next decade.

The supply of both FAME and HVO is limited by the total availability of natural and waste oils. Imports are therefore essential to fully utilised higher biodiesel blends to the volume levels suggested by the demand scenarios. The same statement is valid for ethanol where both imports and the development of advanced ethanol are key to meeting projected demand volumes.

5.2 Key messages comparing biofuel supply and projected demand

Although there are many uncertainties, the results of our demand and supply analysis allows reaching these preliminary conclusions:

Table 9. Biofuel demand from modelled scenarios

	Biofuel Type	Demand Outlook (Scenarios)	Demand Outlook (Scenarios & parameter variation)
Conventional Biofuels	Bio-ethanol from fermentation	Up to 8.5 Mtoe	Up to 12 Mtoe
	FAME (and FAEE)	Up to 17.5 Mtoe	Up to 19 Mtoe
Advanced Biofuels	Bio-ethanol from lignocellulose	0.6 Mtoe	1.3 Mtoe
	Hydrogenated Natural Oils (HVO)	3.0 Mtoe	4.5 Mtoe
	Biomass to Liquids (BTL)	0.25 Mtoe	0.5 Mtoe
Other Renewables	Biogas	Up to 0.7 Mtoe	Up to 1.0 Mtoe
	Electric from renewables	Up to 0.5 Mtoe	Up to 1.0 Mtoe

[18] Data from European Biodiesel Board (http://www.ebb-eu.org) and European Bioethanol Fuels Association (http://www.ebio.org) have been considered for the analysis.

[19] JEC analysis for conventional and advanced biofuels, based on data provided in referenced source.

- Ethanol is likely to be available in volumes needed to cover EU demand given lower gasoline volumes and availability of imported ethanol;
- FAME may possibly be available in needed volumes with open questions regarding domestic development, global demand, and competition for natural and waste oils for HVO production;
- Advanced ethanol: despite growing global supply uncertainties remain about European production through 2020;
- HVO may be possibly competing with demand from global aviation sector and, and competition for natural and waste oils for FAME production;
- BTL scaling up to world-class plant size seems difficult within the given time horizon due to technical issues.

Other related issues that could affect supply include:

- Sustainability and certification criteria not yet fully defined;
- Impact of Indirect Land Use Change (ILUC) on GHG targets is far from being a settled issue;
- Impact of taxation and tariffs on imports/exports.

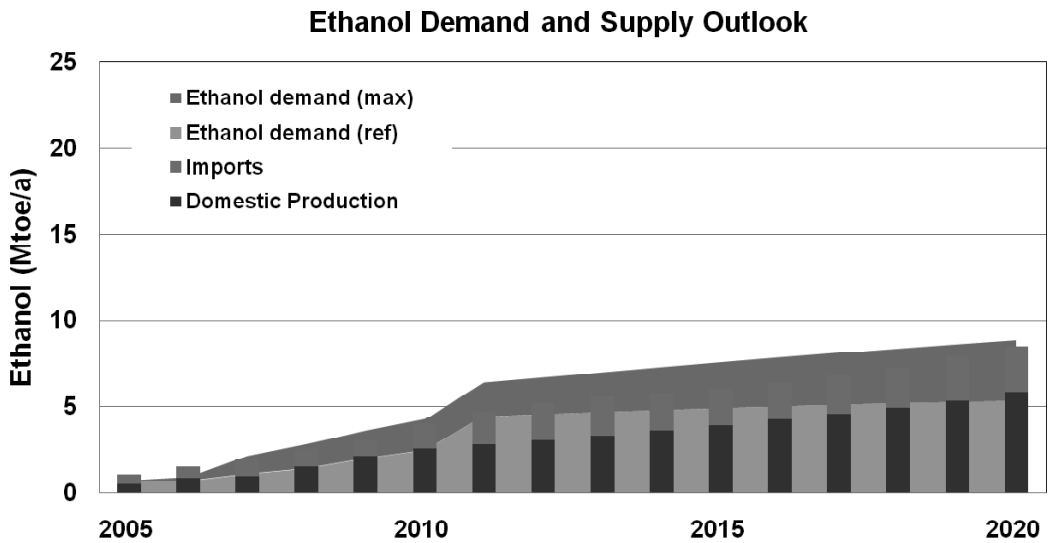

Figure 8. Demand and supply: FAME and HVO

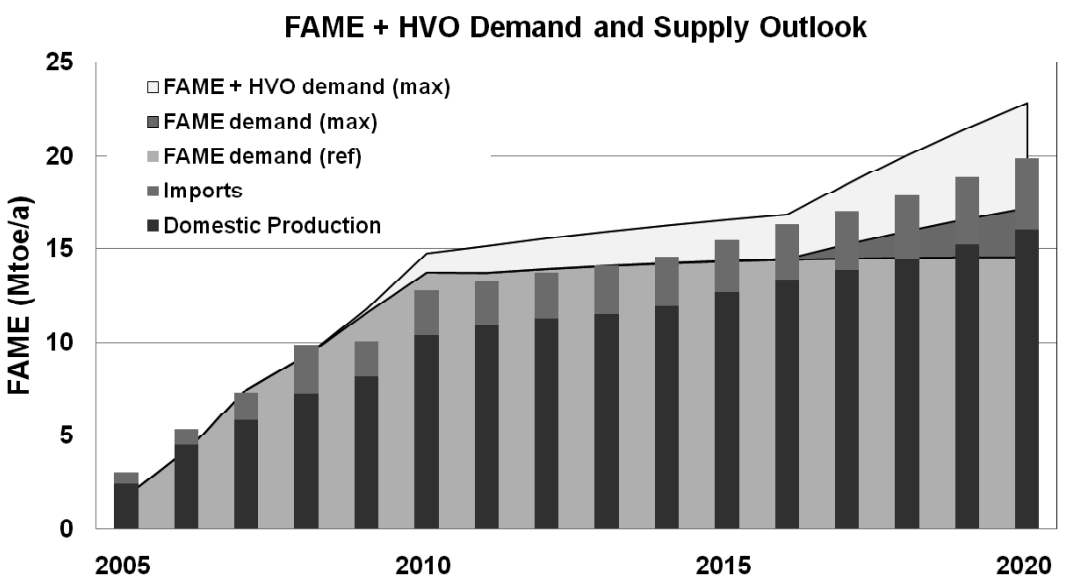

Figure 9. Demand and supply: Ethanol

6 Conclusions

The coming decade for European road transport can be characterised by focusing on three components and on the basis of such characterisation, the outcomes of the JEC Biofuels Programme via its F&F model as main analytical tool can be valued.

The first component is that of vehicles. Vehicles in the coming decade are expected to be characterised by more advanced engines and after-treatment systems, while at the same time we will see an increasing diversification in engines and fleet. Fuel consumption of light-duty vehicles is expected to fall with heavy duty diesel demand slightly increasing. Increasing pressure from the regulator on limiting CO_2 emissions is expected to lead to higher associated costs. Customer preferences may potentially be in conflict with transport and energy policies.

Certainly, today's vehicles are already E10 (from model year 2005 onwards) and B7 compatible. On the other hand, compatibility with higher biofuel blends is still to be proven and this will take time, testing and investment.

The second component is that of fuels. Fuel production at refineries will continue the current trend characterised by an increasing diesel/gasoline demand ratio. This means that higher CO_2 emissions can be expected due to diesel demand and product specifications. Similarly to the "vehicles" component, an increasing pressure from the regulator on limiting CO_2 emissions is expected and likely to push up associated costs.

It is uncertain whether existing logistics infrastructure may be compatible with higher blending grades. A coordinated development of CEN specifications is needed for higher grades to match the needs and/or payback investments needed to have that infrastructure adapted. The scenario analysis shows that potential higher blends need to be fully utilised in order to approach regulatory EU targets set in the RED and the FQD Directives, even more so when considering that in the chosen scenarios the FQD Article 7a GHG emissions' reduction target was not achieved.

The third component is that of biofuels and other renewable energy sources for transport. In the first place, the 10% (energy basis) mandatory target by 2020 is a given assumption. Conventional biofuels are widely available but are accompanied by sustainability concerns in the face of increasing demand. This concern is strengthened when noticing the slower than expected pace of development of some advanced biofuels. It is also worth noticing and keeping in mind the different pace of development and the different priorities across EU Member States, potentially leading to a proliferation of fuel varieties and specifications. As a counter side to that, the standardisation process (CEN specifications) is somehow struggling to keep pace with the regulatory targets, which are relatively more swiftly adopted.

Significant questions therefore remain regarding sustainability, pace of development, and imports. Given these uncertainties, ethanol and FAME are in the range needed to achieve the RED 10% target, yet the most important factors – and open questions – are the pace of development of non-conventional biofuels on the one hand, and the uptake of HVO/BTL by the aviation sector.

To conclude, other key messages to be learned from the study are schematically exposed as follows:

- The attractiveness of different scenarios will vary by Member State;
- Contribution of non-road transport modes to achieving the RED 10% target is important;
- Potential exists for higher biodiesel blends to be used in non-road targets to meet targets but will require time, testing and investment;
- Higher biodiesel blends could also be used in non-road transport modes to meet targets;
- Costs and investments could be significant and were not evaluated in this study;
- Maintaining consumer and citizen confidence in European fuel and biofuel strategy is critical to achieve objectives.

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Цели по Возобновляемой Энергетике в ЕС: Случай Топлива для Транспорта

Laura Lonza
Научный сотрудник, Совместный Научно-Исследовательский Центр Европейской Комиссии,
Институт Окружающей Среды и Устойчивости,
(соответствующий автор)1

Тел: +39 0332 783902
Факс: +39 0332 785236
E-mail: laura.lonza@jrc.ec.europa.eu

Адрес
Европейская Комиссия, Совместный Научно-Исследовательский Центр, Институт Окружающей Среды и Устойчивости,
TP 441, Здание 44, Офис 1/118, я – 21027 Испра – Va
http://ies.jrc.ec.europa.eu/jec

Хейко Маас
Инженер-исследователь, Бизнес-Аналитика, Департамент Наук Окружающей Среды
Форд Исследование & Передовая Инженерия Европы, http://www.eucar.be

Алан Рид
Технический Координатор, Технология Рафинирования
CONCAWE, http://www.concawe.be

Резюме: Транспорт – ключевой сектор экономики с точки зрения движения людей и товаров, а также с точки зрения занятости. Отрицательные воздействия на окружающую среду, не ограниченные, но конечно стигматизационные эмиссиями и почти полная зависимость от конечных источников ископаемого топлива, приносят это под линзой регулятора ЕС в определении и принятии целей и инструментов, чтобы двигаться в напровлении "низко-углеродистому обществу". Представляется исследование на основе сценария, совместно разработанно с JRC, EUCAR* и CONCAWE **, нацеленно на теоретические сценарии к достижению принудительной 10%-ой цели возобновляемой энергетики в транспорте к 2020. Центр анализа - дорожный транспорт, хотя другие способы транспортировки рассматриваются. Ожидаемое развитие дорожных транспортных средств (пассажиров и товара) в 29 европейских странах составляет основание, на котором проникновение и распределение альтернативного моторного топлива – и его наличие – анализируются, включая темпа развития энергетической эффективности, эмиссий CO_2, идентификации самых чувствительных параметров а также соответствующих регулирующих мер как помехи или стимулы к альтернативным видам топлива в транспортном целевом достижении. Начиная с разумных предположениях результаты являются крепкими и предоставляют информацию и материалы для дальнейшего расследования в нескольких областях исследования на перекрестке энергетики и транспорта.

Ключевые слова: Политика возобновляемой энергетики ЕС, транспорт, спрос альтернативного моторного топлива на транспорт.

[1] Отречение: представления, выраженные в этой статье, являются исключительно авторов, и не могут ни при каких обстоятельствах рассматриваться в качестве заявления официальной позиции Европейской Комиссии.
* EUCAR, Европейский Совет по Автомобильным Исследованиям и Разработкам R&D.
** Ассоциация Исследования Европейской Нефтеперерабатывающей Промышленности.