Renewable fuels: looking ahead to 2020

Modelling realistic biofuel implementation scenarios to 2020

Increasing renewable energy and reducing GHG emissions from transport

It is widely recognised that mobility and transport are fundamental to satisfy socio-economic needs and curbing mobility is not an option. Demand for mobility and transport services is expected to continue growing in Europe until 2050, while at the same time a reduction in greenhouse gas (GHG) emissions from the sector of 60% compared to 1990 level is targeted.

As part of an ongoing strategy to address GHG emissions and energy use from transport, the European Union in 2009 enacted a package of regulations and directives intended to reduce GHG emissions from the transport sector. These included required improvements in the CO_2 emissions performance of passenger vehicles and light-duty vans, as well as the increasing use of renewable and alternative energies in transport fuels before the end of this decade. At the same time, there will be increased attention on even tighter limits for regulated pollutants. Legislation for new refuelling infrastructures for alternative fuels are expected to encourage greater diversification in both vehicles and fuels.

Two of these Directives are changing the composition of road fuels over the coming decade and beyond. The 2009 Renewable Energy Directive[1] (RED) mandates a 10% share of renewable energy in transport by 2020.

Advanced biofuel products are being developed that will be manufactured from biomass, like straw and wood. However, the biofuels that will be available in large volume by 2020 will either be ethanol fermented from sugars and starch, or esterified or hydrogenated vegetable oils and animal fats. Ethanol can be blended today at up to 10% volume in petrol (E10) while esterified oils, called fatty acid methyl esters (FAME), can be blended at up to 7% volume in diesel fuels (B7)[2]. Smaller volumes of speciality biofuel blends, like E85 or B100, are also available in some countries for specially adapted vehicles. The European Committee for Standardization (CEN) is constantly working to revise the EU-wide fuel standards and ensure that they remain 'fit for purpose' for use in European vehicles.

At the same time as the 2009 RED was enacted, the Fuel Quality Directive[3] (FQD) mandated that fuel suppliers must also reduce the GHG intensity of transport fuels by 6% in 2020 compared to a 2010 baseline. Although efficiency improvements in the fuel manufacturing process can contribute to meeting this target, the growing and increasingly disparate gasoline and diesel demand means that the majority of this GHG performance improvement must be achieved through biofuel blending.

Although the 2020 RED and FQD targets have been clearly stated, the path to achieve these targets has not, and has largely been left to Member States and the transportation sector to work out. Each Member State documented in 2010 how they intend to meet their specific obligations through National Renewable Energy Action Plans (NREAPs). These plans varied significantly from one country to the next depending upon the specific weights of each country's transport components, the energy policy priorities, and the availability of alternative energy options.

The 2011 JEC Biofuels Programme

Understanding technically achievable options for meeting both the RED and FQD mandates is a complicated task. With different priorities and pace of implementation in each Member State, the potential for increasingly uncoordinated changes in fuel blends and vehicle types is considerable, which could make it even more difficult to achieve the 2020 targets.

Before the 2009 EU legislative package was enacted, the three partners in the JEC Consortium—the Joint Research Center (JRC) of the European Commission, the European Council for Automotive R&D (EUCAR)

1 Renewable Energy Directive (2009/28/EC)

2 Biofuel contents are expressed as the percentage of bio-component in fossil fuel on a volumetric basis. For example, B7 stands for 7% v/v FAME in diesel fuel while E5 stands for 5% v/v ethanol in gasoline.

3 FQD = Fuel Quality Directive (2009/30/EC)

and Concawe (see page 8)—decided to look closely at this problem. This resulted in the first 'JEC Biofuels Study', published in 2011, which examined possible biofuel and alternative fuel uptake implementation scenarios for mass market fuels that could potentially achieve the 10% RED target for transport fuels by 2020. Using the scenario results and the FQD's GHG intensity default values for different renewable products, the 2020 GHG emissions reductions were also calculated associated with different biofuel blending options and volumes.

Nine scenarios were evaluated using reasonable assumptions for the development of the on-road vehicle fleet over the coming decade and the likely penetration of new vehicle technologies, such as plug-in hybrids, electric vehicles, CNG- and LPG-powered vehicles, etc. A reasonable contribution to the RED mandate was also assumed from non-road transport, including inland waterways, rail, aviation and off-road modes.

The 2011 Biofuels Study concluded that the reference scenario based on currently approved biofuel blends (B7, E5, E10) for broad market road fuels would almost meet the RED 10% renewable energy target. However, none of the considered scenarios achieved the minimum 6% GHG reduction target mandated in FQD Article 7a with the assumptions taken for the FQD calculations.

The 2013 JEC Biofuels Study update

In only a few years, much has changed. New legislative proposals have been introduced to revise the 2009 Directives. These included a new proposal by the European Commission in October 2012 (EC, 2012b), which was amended by the European Parliament in September 2013 (EP, 2013), and revised again by the Environment Council in December 2013 (CEU, 2013). Each of these legislative concepts for RED and FQD implementation have significant differences from the original legislation and from each other, and would therefore have an impact on the feasibility of achieving the 2020 targets in different ways. The main features of these three legislative proposals are compared in Table 1.

The FQD and RED Directives invited the European Commission to review and advise on GHG emissions associated with biofuel production and, if appropriate, propose ways to minimise GHG emissions while respecting investments already made in European biofuels production. A key factor in this review was the effect of so-called indirect land use change (ILUC) emissions.

In its October 2012 proposal the European Commission issued a new proposal to minimise ILUC emissions by incentivising advanced biofuels. This was to be done mainly by capping the contribution of biofuels produced from food crops, raising the GHG savings thresholds for

Table 1 Main characteristics of legislative concepts for the RED and FQD amendment

European Commission (EC) ILUC proposal, October 2012	European Parliament (EP) vote, September 2013	Council compromise proposal, December 2013
5% cap on 2011 estimated share of first generation biofuels (energy crops not included)	6% cap on final consumption in 2020 of first generation biofuels and DLUC/ILUC energy crops	7% cap on final consumption in 2020 of first generation 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.

new installations, and incentivising the market penetration of more advanced biofuels. Importantly, ILUC emissions values were introduced for the first time for different crop groups, like cereals, sugars and oil crops, as a reporting obligation.

Because of these important developments, the JEC Consortium decided to update the 2011 Study by completely revising the vehicle fleet development, resulting fuel/energy demand, and biofuel blending assumptions. The 2013 Study (published in 2014) also widened the 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 RED and FQD amendment process.

The JEC Biofuels Study can be summarised as:

- analysing road transport energy demand and including an analysis of other transport modes;
- analysing possible fuel demand scenarios within the 2010–20 time period while focusing on potential market barriers to the uptake of alternative fuels;
- analysing the supply outlook of conventional and advanced biofuels and their projected availability on the European market; and
- consideration of other aspects, such as requirements for phasing in fuel standards, infrastructure requirements, fuel production and distribution, and customer acceptance of higher biofuel grades.

The 'Fleet and Fuels' model

To evaluate different biofuel implementation scenarios, the JEC team first developed a robust spreadsheet-based modelling tool called the 'Fleet and Fuels' model. This model is based on historical vehicle fleet data for the EU27+2 countries (including Norway and Switzerland) and was benchmarked against actual fuel consumption data from the 1990s and 2000s. The model allows independent inputs for seven types of passenger vehicles, including flexi-fuel, plug-in hybrid electric, battery electric and fuel cell, three classes of commercial vans, and five classes of heavy-duty vehicles and buses. Each vehicle type was described by reasonable parameters estimating the annual growth rate, typical annual mileage, vehicle fuel efficiency and years of useful life. Fuel alternatives were also considered for each vehicle type.

Outputs from the model included total vehicle fleet composition plus the projected demand for different fossil fuels, renewable fuels and alternatives. Because the RED counts renewable and alternative energy used in all transport modes, estimating the RED contributions that could be expected from railroads, inland navigation, aviation and other off-road uses was also important. Credible estimates from public sources for non-road transport demand were evaluated so that the RED percentage could be calculated for each scenario using the legislated formula.

The 'Reference Scenario'

With a model of this type, there is no limit to the number of biofuel implementation scenarios that can be tested. A Reference Scenario was assumed that represents a reasonable scenario based on already endorsed market fuel standards. Two gasoline grades are assumed, an E5 'protection grade' for older vehicles and an E10 'main grade' for most vehicles marketed since 2000. The experience from E10 introduction in Finland, France and Germany, has been used to include a realistic market uptake of E10 throughout Europe. One diesel grade was assumed, a B7 grade that can be used in all passenger and heavy-duty diesel vehicles. A small contribution for E85 from flexi-fuel vehicles was included as well as reasonable assumptions for the development of alternatively-powered vehicles including plug-in hybrid and battery electric, and vehicles operating on gaseous fuels, including hydrogen.

All of the vehicle, fuel and biofuel data were re-evaluated and updated in the 2013 Study. The model was then used to estimate the biofuel demand volumes and their overall contribution to the RED mandate. Figure 1 shows that this Reference Scenario would require about 15 Mtoe/a of FAME for diesel blending and about 5 Mtoe/a of ethanol for petrol blending. The contribution to the RED target from road use only is about 7.9% with an additional approx. 0.8% contribution from non-road transport modes. Thus, the Reference Scenario is projected to fall short of the 10% RED target using quite optimistic assumptions about the pace of advanced biofuel implementation and the willingness of customers to select fuel grades containing higher biofuel contents. Significant questions must also be addressed related to implementation costs, implications for refining and the fuel supply and distribution system, and the availability and certification of sustainable biofuels.

Beyond the Reference Scenario

In addition to the Reference Scenario, three other biofuel implementation scenarios were evaluated that assume different total fuel demand composition using an assumption of fuel grades that are not on the market today. 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 a B10 diesel blend for captive fleets representing a small fraction of the total heavy duty diesel demand.

Scenario 2 assumed that an E20 blend could be introduced into 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 would be E10 compatible. The same market uptake assumption is used as for the introduction of E10 in the Reference Scenario.

Scenario 3 assumed that the B10 diesel grade for captive fleets is introduced representing 2.5% of the total heavy duty diesel demand. Scenario 4 is a combination of Scenarios 2 and 3. All other assumptions were kept the same in order to fairly compare the various regulatory proposals. The results are compared in Figure 1.

Figure 1 Fuel blend scenario results for 2020 from the 2013 JEC Biofuels Study

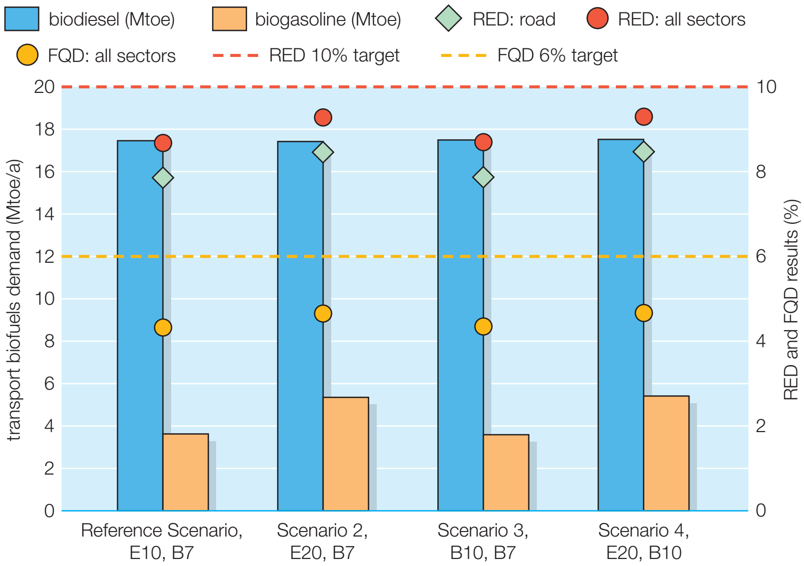

Figure 1 shows the demand in Mtoe/a[4] for ethanol and FAME in 2020 for the reference scenario and three additional biofuel implementation scenarios, together with the projected contributions for renewable energy percentage from on-road use and from all transport uses.

Conclusions from the 2013 Biofuels Study

The new results show lower attainment levels than the JEC Biofuels Study 2011 (Table 2). The old reference scenario indicated a level 9.7% renewable energy content (against the RED target of 10%) compared with 8.7% in

Table 2 Comparison of RED and FQD results from v2011 and v2014

For Reference Scenario:		RED	FQD (without IUC)	FQD (with ILUC)
Target:		**10%**	**6%**	**n/a**
2011 JEC Biofuels Study	2009 RED and FQD	9.7%	4.4%	n/a
2013 JEC Biofuels Study	2009 RED and FQD	8.7%	4.3%	n/a
	2012 EC proposal	7.8%	4.3%	1.0%
	2013 EP first reading	8.2%	n/a	1.0%
	2013 Council text	8.7%	4.3%	1.0%

4 Mtoe /a = Million tonnes oil equivalent/year

the 2013 revision. Including default values for ILUC effects results in a less than 1% reduction in GHG intensity (against the FQD reduction target of 6%) due to a different biofuel blending. Several findings from the updated Study are especially noteworthy:

- the pace of development and the supply volumes of advanced biofuels assumed in the base case are not projected to be sufficient to fill the RED gap by 2020;
- multiple counting factors on different feedstock types are not enough to close the gap towards reaching the RED target;
- market introduction, customer preferences and acceptance to use available vehicle and fuel alternatives play an important role in approaching the RED and FQD targets;
- lower-than-expected vehicle sale trends point towards a slower renewal of the vehicle fleet resulting in an overall lower efficiency of the fleet stock and a limited uptake of alternative-fuelled vehicles, including electric and other alternatives, resulting in a bigger gap towards achieving the RED and FQD target; and
- the projected strong increase in the demand for diesel relative to gasoline for European vehicles will reduce the likelihood of attaining the FQD GHG intensity reduction target, because of the lower renewable energy content and higher GHG intensity of diesel compared to gasoline.

Additional considerations

This Study did not assess the viability, costs, logistics, or impact on the supply chain and vehicle industry of the different demand scenarios, and additional work would be needed to determine the technical and commercial readiness of any one scenario. Realising any one of these ‘technically feasible’ scenarios will depend on a combination of factors: the associated costs, and the timelines and coordination of decisions across the EU.

Given the turbulent state of policy considerations and the market factors that impact the JEC Biofuels Study analysis, the JEC partner organisations intend to continue to closely watch developments in this area, given the relatively short time before the 2020 EU renewable energy and GHG targets must be attained.

References

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