Richard Jones, Thomas Rätzsch, Alexander Buchsbaum

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BIOFUELS IN THE EUROPEAN UNION

Abstract

In the European Union (EU), the policy framework for the development of a biofuels market is Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport. This Directive sets an indicative target of 2% biofuel consumption (by energy content) in 2005 rising by 0.75% per annum and currently culminates in a target of 5.75% in 2010. However, the EU has acknowledged that the 2% consumption target for 2005 has not been met. This presentation therefore reviews the Key drivers and policy initiatives at both the Commission and Member State level that are influencing the development of the biofuels market in the EU in the period to 2010. In addition, sustainability and fuel quality issues arising from the use of 1st biofuels are also addressed in order to define the drivers for the introduction of 2nd generation products.

Introduction

In Europe the key drivers for the promotion of alternative fuels may be summarised as follows:

- **Security of Energy Supply** (which has been brought into sharper focus by the increasing price of oil and the interruption of gas supplies from Russia to the Ukraine).
- **Rural Development** (especially in conjunction with the ongoing Common Agricultural Policy (CAP) reforms concerning the end of the sugar regime).
- **Climate Change** (According to the White Paper "European transport policy for 2010: time to decide", the European Commission indicates that CO_2 emissions from transport could rise by 50% between 1990 and 2010. The constantly expanding transport sector accounts for more than 30% of total energy consumption in the European Union. The White Paper calls for dependence on oil (currently 98%) in the transport sector to be reduced by using alternative fuels and to support Europe's commitment to the Kyoto Protocol).

The Commission's *Energy for the Future - Renewable Sources of Energy,* White Paper projections concerning the creation of a significant biofuel market formed the basis for the Communication on Alternative Fuels for Road Transportation and on a Set of Measures to Promote Biofuels 2001/0265. The Communication sets the challenging development scenario for alternative fuels outlined in Table 1 below. The Commission has estimated that the 5.75% by energy content target in 2010 is equivalent to some 18Mtoe of alternative fuels.

Table 1: EU Alternative Fuel Targets

Year	**2005.**	**2010.**	**2015.**	**2020.**
Biofuels, %	2	6*	(7)	(8)
Natural gas, %	-	2	5	10
Hydrogen, %	-	-	2	5
Total	2 %	8 %	14 %	23 %

*5.75% by energy content

These challenging targets are based on the introduction of a minimum proportion of biofuels (on an energy content basis) and other renewable fuels in each Member State in the short to medium term (i.e. 2005-2010). The biofuel targets for 2015 and beyond but have been the subject of recent review by a group established by the European Commission, the Biofuels Research Advisory Council (BIOFRAC) in its report entitled, Biofuels in the European Union - A Vision for 2030 and Beyond.

The first phase of Biofuels introduction has been supported the Directive On the Promotion of Biofuels for Transport Directive 2003/30/EC and Directive Amending Directive 92/81/EEC with Regard to the Possibility of Applying a Reduced Rate of Excise Duty on Certain Mineral Oils Containing Biofuels and on Biofuels 2001/0265 (COD).

The so called 'Biofuels Directive' (2003/30/EC) sets indicative rather than mandatory target values for biofuels. However, the Commission has actively pursued those Member States which have not adopted the indicative targets into National Legislation without apparent due cause. The Directive stipulates the following:

- Member States need to ensure that a minimum proportion of biofuels are placed on the domestic market between 2005 and 2020,
- A reference value for these targets is set at 2% calculated on the basis of energy content, of all gasoline and diesel fuels by December 31, 2005 and 5.75% calculated on the basis of energy content, of all gasoline and diesel fuels by December 31, 2010.
- At least the products listed below shall be considered Biofuels:
    - 'bioethanol': ethanol produced from biomass and/or the biodegradable fraction of waste, to be used as Biofuel;
    - 'biodiesel': a methyl-ester produced from vegetable or animal oil, of diesel quality, to be used as Biofuel;

  - 'biogas': a fuel gas produced from biomass and/or from the biodegradable fraction of waste, that can be purified to natural gas quality, to be used as Biofuel, or woodgas;
  - 'biomethanol': methanol produced from biomass, to be used as Biofuel;
  - 'biodimethylether': dimethylether produced from biomass, to be used as Biofuel;
  - 'bio-ETBE (ethyl-tertio-butyl-ether)': ETBE produced on the basis of bioethanol. The percentage by volume of bio-ETBE that is calculated as Biofuel is 47 %;
  - 'bio-MTBE (methyl-tertio-butyl-ether)': a fuel produced on the basis of biomethanol. The percentage by volume of bio- MTBE that is calculated, as Biofuel is 36 %;
  - 'synthetic Biofuels': synthetic hydrocarbons or mixtures of synthetic hydrocarbons, which have been produced from biomass;
  - 'biohydrogen': hydrogen produced from biomass, and/or from the biodegradable fraction of waste, to be used as Biofuel;
  - 'pure vegetable oil': oil produced from oil plants through pressing, extraction or comparable procedures, crude or refined but chemically unmodified, when compatible with the type of engines involved and the corresponding emission requirements.
- As specified in the Biofuel Directive, each Member State is requested to submit to the Commission an annual report (before 1 July) that should include the following points:
  - Measures to promote biofuels or other alternative fuels used for transport.
  - National resources allocated to the production of biomass for energy uses other than transport.
  - Total sales of transport fuel and the share of biofuels, pure or blended, and other renewable fuels placed on the market for the preceding year.
  - In their first report following the entry into force of the European Biofuel Directive, the level of their national indicative targets for the first phase (2005). In the report covering the year 2006, Member States shall indicate their national indicative targets for the second phase (2010).

The inherent challenge in meeting the indicative targets of the Biofuels Directive are illustrated in Figure 1, in that in 2003 only 11 of the 25 member states utilised biofuels in transport prior to the Directive and all at a level less than the initial target. Perhaps as a consequence the EU will not meet the indicative target of 2% biofuels consumption in 2005 as shown by Figure 2 which summarises the targets adopted by the member states which results in an average for the EU25 of 1.4%, however it is also unlikely that this will be achieved in practice.

At the time of writing, EU Member States are in the process of reporting their biofuels consumption for 2005. Official figures released so far indicate that Sweden

(2.3%), the UK (0.24%) and the Czech Republic (0.046%) did not meet their indicated targets. Similarly, as yet unofficial data for France (below 1.2 %) and Spain (0.44%) indicate that these national targets were not met. In contrast, Germany (3.4%) has apparently considerably exceeded its biofuel target according to data from Germany's Agency of Renewable Resources (FNR).

Figure 1: Market Share of Biofuels, 2003 (EU 25); Source: EU 2004

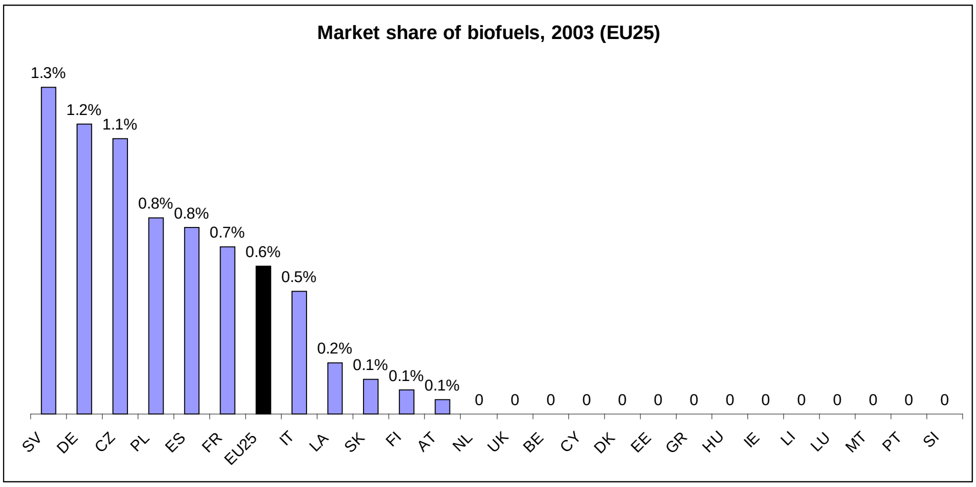
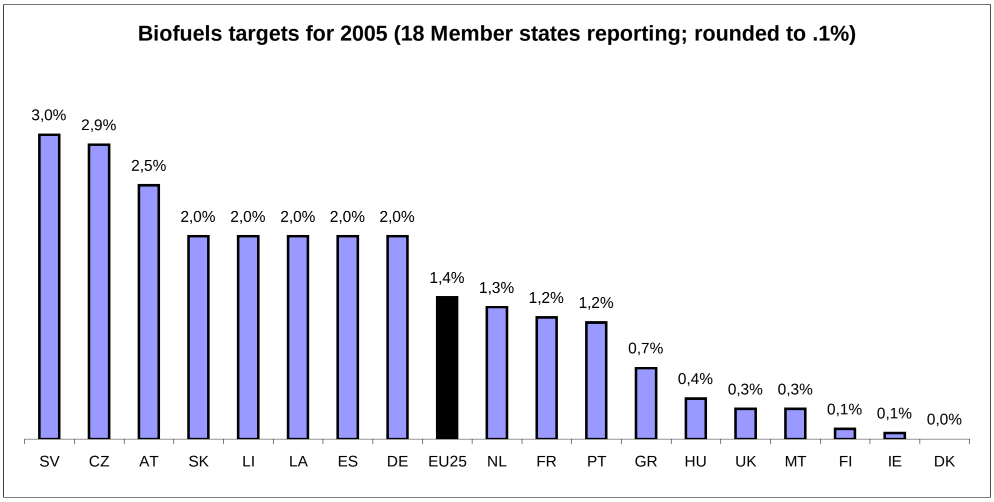
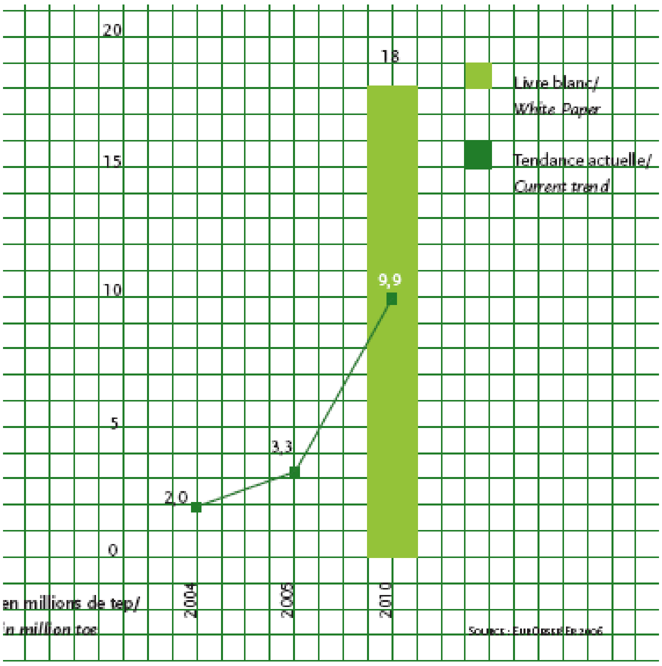


Figure 2: Biofuels targets for 2005



Source: EU 2004

Figure 3: Comparison of present trend with White Paper Objectives (in Mtoe)



Source: EurObserv'ER, 2006

The EU sponsored EurObserv'ER extrapolates current trends to forecast 9.9Mtoe biofuel consumption in 2010 which equates to slightly greater than 50% of the indicative target set by the Biofuels Directive (Figure 3). However, rapid policy enactment could still result in a significant increase in the quantity of biofuels actually employed by 2010.

It should however be noted that the biofuels market development aims of the Biofuels Directive are not aligned with the European directives on the quality of gasoline and diesel fuels and the accompanying technical specifications laid out under the current CEN (Center for European Normalisation) standards EN 228 (gasoline) and EN590 (diesel) standards.

This EU legislative and standardization framework allows ethanol blends up to 5% by volume (or oxygenates up to 2.7% by weight oxygen) and biodiesel at 5% by volume, respectively. However, in order to meet the Biofuels Directive targets (not taking into account the potential contribution from 'higher blends' e.g. E85 and B100), these direct blending limits would need to be increased to 8.5% and 6.3%, respectively. Alternatively, if ETBE is blended at 15% by volume into gasoline, it is a possible to add a further 1% v/v of ethanol before reaching the oxygen limit. This composition results in 6,99% bioenergy content in gasoline.

To provide flexibility in meeting the biofuels target an increase has been requested by the biofuels industry for a legislative allowance of 10% direct blends. In addition, an increase of the volatility limit (RVP) from 60kpa to 70kpa and further increase in the oxygen content for ethanol from 2.7% to 3.7% has similarly been requested whilst biodiesel producers have requested an increase in the density specification to 850kg/m^3 at 15℃. However, it should be remembered that the original parameters were adopted in order to meet the air quality and automotive emission targets established under the EU Ambient Air Quality Framework Directive and the Automotive Emissions Directive. The Directives were based on Auto Oil I and II data analysis, modelling and final industry and government negotiations. Whilst the review of the Fuels Quality Directive is still on going following input from relevant industry groups it would appear unlikely that all of these requested changes will be granted to prevent there being a negative impact on air quality.

In 2003 a biodiesel standard for Fatty Acid Methyl Esters (FAME) EN 14214 was adopted. This standard covers biodiesel quality as B100 and as a blending component for use in conventional fuels. A bioethanol standard is in the process of being finalised.

In the period till 2010 the biofuel options for the EU are realistically limited to biodiesel, bioethanol and bio-ETBE due to commercial availability and infrastructure development. It should also be noted that in terms of basic product demand Europe is currently long in gasoline and short in diesel. The technical issues facing the adoption of these biofuels may be summarised as follows:

Biodiesel

The term Biodiesel is currently normally associated with the mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Fatty Acid Methyl Ester (FAME) is often used as a generic term for the trans-esters of these naturally occurring triglycerides which find application as either a replacement for, or a blending component for use with, fossil derived diesel. In addition the production of the ethyl ester equivalent (FAEE) is also currently under investigation in the EU and is already commercial in Brazil. It should be noted however that the term Biodiesel in its generic sense should include any diesel fuel or blending component produced from biomass. Hydrotreated oils, NExBTL and BTL therefore fall under this category.

FAME Product Specifications

A number of national Standards for Fatty Acid Methyl Esters or Vegetable Oil Methyl Esters (VOME) were generated by individual member nations as a result of operability concerns raised by OEMs and their equipment suppliers. The European Standard (EN14214) subsequently superseded these and applies both to the use of

FAME as a dedicated diesel engine fuel (B100) and as a blending component for inclusion in EN590 diesel.

CEN acknowledge that the specification is conservative and that with appropriate additional data some of the specifications limits may be relaxed. Consequently the EU has recently initiated a series of test programs to evaluate potential modifications to the standard. One such program is seeking to establish whether the current Iodine Number test can be replaced with a performance based test to allow greater quantities of mono-unsaturated oils to be utilised. A further program is investigating FAEE.

Currently Biodiesel in Europe is largely produced from rapeseed oil with some contribution from sunflower, palm and soybean oils though these latter feedstocks may currently only be used in a blend due to the degree of unsaturation found in these materials. In addition used cooking oils and tallow are also utilised.

The EN14214 standard required the development of certain new test methods and to reach acceptable levels for these parameters (particularly stability) it was found that the inclusion of suitable fuel additives was beneficial. Key criteria include;

Oxidation Stability

The Rancimat Test (ISO 6886) has been adopted in EN14214 to determine oxidation stability and requires a minimum induction period of 6 hours. However, the FIE manufacturers report that many FAME fuels cannot better an induction period of four hours.

Storage Stability

ASTM D 4625 is considered to mimic storage of diesel fuel at ambient temperature. However, in the case of FAME, the observed changes of FAME quality parameters during real storage in the Biostab programme were considerably different to the ones recorded during accelerated storage at 43℃. As a result it was concluded that ASTM D 4625 does not correctly mimic the storage of FAME at ambient temperature.

It is understood that a modified ASTM D 4625 (43℃ for 16 weeks using glass fibre filters with tests for acid number & viscosity every 4 weeks) is under development in the US. The EU Biostab programme developed a procedure similar to IP48/IP306, which employs the Rancimat apparatus has demonstrated the ability to differentiate between high & low stability samples.

Thermal Stability

The original ASTM D 6468 conditions (150℃, 180 or 90 minutes) were investigated in the Biostab programme but the resulting variations in the measured quality parameters (acid value, Rancimat, ester content) were too low to be measured correctly. After further investigation it was established that it was possible to utilise the Rancimat apparatus with a procedure specially modified for thermal stability evaluation. This modified procedure was deemed suitable for use in terms of test repeatability.

It is understood that modifications to ASTM D2274 (95℃ for 16 hours using glass fibre filters and testing for acid number and viscosity increase) are being investigated in the US.

Cold Flow

The intrinsic cold flow properties of a given B100 depend upon the degree of unsaturation associated with the oil seed crop from which it derives. Blends of FAME produced from differing sources show an approximately linear effect on cold flow properties. B100 does not respond to traditional CFPP products and requires re-optimised cold flow enhancement products.

However, EN14214 states that ‘FAME meeting the requirements of the EN14214 specification and with a CFPP in accordance with the limits specified in Table 2 (which describes climate-related requirements and test methods) may be used as a blending component in blends of FAME with mineral oil based automotive fuels for diesel engines providing the resulting blends meet the requirements of the national standards for automotive fuels for diesel engines’. This combined with studies & field experience which demonstrates the efficacy of traditional CFPP additive systems in B5 blends effectively removes the need for bespoke FAME cold flow additives in the EU at this time. However blends higher than B5 may require re-optimised treatment regimes for both the FAME and fossil derived components.

Materials Compatibility

Concerns have been raised over the compatibility of B100 & higher BX blends with certain materials commonly employed for seals, o-rings & fuel lines within a diesel engine. As a consequence additional studies have been performed on this topic such as that by the CRC (Impact of Biodiesel on Fuel System Component Durability).

Sustainability

In addition to the above technical issues it should be noted that the majority of the plant oils now used to produce biodiesel (e.g. rapeseed, soybean, palm oil) also have application in the food industry leading to competition between food and fuel use with a concomitant increase in price. This has caused certain observers to question the ethics of this situation. In addition, the clearing of rainforest to create new or larger palm plantations is also of concern both for the direct impact on CO_2 emissions but also for potentially reducing biodiversity.

To counter these issues the use of non-edible plant oils derived from plants grown on semi-arid waste land (e.g. Jatropha Curcas) is being pursued. In addition, the processing of biomass waste via gasification and subsequent Fisher Tropsch reaction is also being actively investigated both as a result of the favorable characteristics of the final product and the ability to process biomass waste rather than food crops.

Concerns such as these have led legislators in Countries such as the Netherlands, Sweden and the UK to lobby for the adoption of sustainability criteria within Biofuels legislation at both EU and Member State level.

Bioethanol

CEN have recently released a draft bioethanol specification (prEN 15376) for material used as a blending component in EN228. However, ethanol can also be used as an 85% blend (E85) in Flexible Fuel Vehicles (FFV's) or in specially modified compression ignition engines with a combustion improver.

Ethanol is currently produced from a range of sugar or starch containing crops which again creates a potential sustainability issue. The synthesis of ethanol from lignocellulosic base stocks such as straw and forestry waste is therefore of interest as a 2^{nd} generation technology. In addition, the CO_2 life cycle is reported to be improved.

A number of factors dictate the maximum concentration of ethanol, which can be employed in a given application. The maximum level is determined by materials compatibility (certain metals & elastomers being adversely affected as described later) and whether the engines have also been modified to allow for lower energy content, stoichiometry etc., in order not to impair driveability.

Similarly as regards the minimum concentration it should be noted that ethanol is hygroscopic and that phase separation will occur if water ingress is excessive and this is exacerbated by lower ethanol concentrations, resulting in the predominant use of anhydrous ethanol in fuel applications. In addition, a reduction in the volatility of the hydrocarbon base-stock may be necessary if the existing gasoline specification is to be met.

Direct blending - 'Low Blends'

OEM Concerns

General Motors observed increased fuel pump wear in a section of the US vehicle fleet operating on E10 and, as a consequence, performed field studies investigating the quality of the ethanol being utilized in the gasoline pool. As a result, GM proposed changes to the specification for fuel grade ethanol as follows:

- Development of an acid detection method – The "pHe method"
- The ethanol manufacturers should control pHe
- Incorporation of a pHe specification into ASTM D4806 and D5798

GM developed a method to determine pHe (which was later adopted as ASTM D6423).

The study demonstrated that a significant fraction of the US ethanol pool had low pHe and that during long term storage of ethanol, the pHe decreased due to acid formation. Low pHe strongly correlates with increased corrosivity as demonstrated by poor performance in the NACE (TM-01-72) rust test.

pHE Control

Additive manufacturers have demonstrated that for all ethanol with a base pHe greater than 2.5 it is possible to increase the pHe to meet with the ASTM specification (of 6.5 to 9.0) via the use of a suitable additive.

Corrosion Inhibition

Low pHe can be correlated with poor performance in the NACE rust test, however with additive treatment a denatured ethanol NACE rating can be increased from 'E' to 'A'.

Volatility

Blends of ethanol and gasoline display a disproportionate increase in vapor pressure together with a reduction in front-end distillation temperature. The effect is of particular concern at low blend volumes where the negative RVP effect is maximised without having exploited the potential blending octane contribution from the component. However, additional volumes of ethanol yield only small increases in vapor pressure and as the volume of ethanol blended approaches 10 vol%, the RVP first levels off and then start to decline. Increases in gasoline RVP result in increases of evaporative hydrocarbon and hazardous air pollutant emissions. Higher gasoline vapor pressure can also cause driveability problems in vehicles. As a consequence, the base gasoline must be blended to allow for the volatility increase that ethanol addition will produce in the finished blend, this normally results in the removal of high volatility blending components such as butane.

Material Compatibility

The corrosive nature of gasohol rises with increasing ethanol content, therefore, whilst materials such as aluminium, brass, zinc and lead including terne (lead/tin alloy and lead solder) are compatible with low percentage ethanol blends, they have been found to dissolve in the presence of higher ethanol concentrations. Even if component failure does not directly result, the materials introduced into the fuel can impair vehicle operability by blocking fuel filters. Stainless steel, black iron and bronze are materials, which may be used to prevent such occurrences. Additive treatment can also be an effective way of protecting vulnerable metals in traditional vehicles exposed to moderate ethanol concentrations.

Also of concern is the potential effect on non-metallic materials that are commonly employed as seals, gaskets, o-rings & fuel lines. The swelling or embrittlement of such components could potentially result in a fuel leak giving rise to a fire hazard. Natural rubber, polyurethane, polyvinyl chloride (PVC), polyamides, methyl-methacrylate plastics, and certain thermo and thermoset plastics are all of concern in this regard. However, Viton, Teflon, thermoset reinforced fiberglass, neoprene rubber and polypropylene offer acceptable alternatives.

Water content

As mentioned previously this parameter is of greater importance in low ethanol content petrol blends. Ethanol is hygroscopic, and as such will pick up water from ambient air and the distribution system. As a result, the water content of fuel ethanol must be limited when it is to be blended with gasoline in order to minimise the potential for phase separation. The risk of phase separation reduces the higher the temperature, ethanol content and base-fuel aromaticity. At low temperatures, even small quantities of water can cause phase separation, which has the potential to seriously affect vehicle operability.

ETBE

Ethanol may be converted to Ethyl Tertiary Butyl Ether via reaction with isobutylene. The properties of ETBE more closely match that of gasoline than ethanol (and there is net RVP decrease on blending), therefore the use of ETBE has traditionally been preferred to direct blending in countries such as France and Spain. It should also be considered that within the limits of current fuel specifications, ETBE allows the incorporation of a larger quantity of bioethanol in gasoline both in preference to and in combination with ethanol than by incorporating ethanol in isolation. Concerns over the short term availability of both manufacturing plants and isobutylene has recently resulted in both France and Spain promoting the direct blending of ethanol in addition to the use of ETBE. However, the Industry appears confident that the conversion of MTBE plants to ETBE and the installation of new capacity will allow ETBE to make a significant contribution to the growth of biofuels in Europe.

Dedicated and Flexible Fuel Vehicles (FFV’s)

Dedicated ethanol vehicles have previously been utilized in markets such as Brazil, however consumer concerns over the security of fuel supply and fuel availability (ie retail coverage) in markets led several major automobile manufacturers to develop Flexible Fuel Vehicles (FFVs) which can run on either gasoline or ethanol/E85 fuel or any blend of the two. Whilst this results in a compromise in the maximum efficiency available on ethanol/E85 due to having to adopt a compression ratio, which is compatible with the gasoline grade, the vehicles employ sensors, which allow other parameters such as injection and ignition timing to be optimised for the fuel blend created in the vehicle tank. These changes maximise the efficiency of the vehicle as regards both fuel economy and emissions. The vehicles fuel/engine system are naturally constructed from materials proven to be compatible with Ethanol. FFV’s are achieving increasing market penetration in Sweden and the EU sponsored BioEthanol for Sustainable Transport (BEST) program is looking to demonstrate the technology in additional member states. Currently there is no EU specification for E85, however CEN issued a Workshop Agreement (CWA 15293) in May 2005 and the Swedish Government are apparently close to finalising a national specification. In addition, France is also currently conducting a trial with a view to establishing a national standard.

Ethanol in Diesel Engines

Ethanol may be used directly in specially modified compression ignition engines if blended with an ignition improver. Sweden has utilized such technology for several years and the BEST program is seeking to expand its use. In addition, ethanol may be blended into diesel with the aid of a co-solvent or via the formation of an emulsion. Concerns exist regarding the flash point and volatility of such blends.

Conclusions

To-date Member State support for biofuels has typically taken the form of partial or total duty exemptions for biodiesel and ethanol (either direct and/or in the form of ETBE), however the cost of providing such exemptions and the variable results achieved via such incentive systems has led many countries to introduce blending obligations. The European Commission has noted this trend and has indicated the benefits of such legislation will be reviewed in the on-going up-date of the Biofuels directive. Currently however biofuels are not projected to meet the 2010 indicative target of 5.75% by energy content.

Modifications to the blending limits of biofuels allowed under the Fuel Quality Directive and accompanying CEN specifications are currently also under review in order to allow greater flexibility in meeting the targets of the Biofuels directive. However concerns exist regarding both the overall impact of such changes on air quality and the compatibility of the existing vehicle fleet. The use of high blends such as E85 in specially adapted vehicles is also being pursued to overcome such potential limitations.

Total well to wheels greenhouse gas emissions, sustainability and vehicle operability are key drivers for the introduction of the so called 2nd generation biofuels. Legislation is being developed both at the Commission level and in certain Member States with the aim of requiring minimum sustainability criteria to be met whilst favoring the products with the lowest net greenhouse gas emissions. Certain of these technologies (e.g. BTL, Lignocellulosic ethanol) are still undergoing technology optimization and have yet to be produced on a commercial scale. Research supported by the IEEA and FP6/FP7, together with the setting up of BIOFRAC aims to overcome these barriers to adoption.

Literatura / References:

1. GEERT HILBERTUS JONKER, *Hydrogenation of edible oils and fats*, Proefschrift Rijksuniversiteit Groningen, 1999
2. 417. Verordnung zur Änderung der Kraftstoffverordnung 1999
3. WWFC, Issue December 2002
4. Fatty Acid Methyl Ester Fuels - Joint FIE Manufacturers Statement, issued June 2004
5. Report of the CEN/BT/WG 149 „The need for European Standards for liquid and gaseous alternative fuels“
6. BUCHSBAUM A., HUTTER K., DANZINGER F., LICHTSCHEIDL J., *The Challenge of the Biofuels Directive for a European Refinery*, 2004
7. Bioethanol and ETBE developments in Europe, Walter R. Mirabella, Lyondell Chemical Europe Inc.
   Hart's 11th World Refining & Fuels Conference, Brussels, Belgium, 1st June 2006
8. CRC Project No. AVFL-2a, Impact of Biodiesel on Fuel System Component Durability, 2005
9. Joint EUCAR/JRC/CONCAWE Well-to-Wheels study, 2006

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Autori / Authors:

Richard Jones, Thomas Rätzsch, Alexander Buchsbaum
OMV Refining & Marketing GmbH

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