TITLE: Metrology for Biofuels

Abstract

The European Union's Renewable Energy Directive 2009/28/EC represents a new driving force for developing of a metrological infrastructure for conventional and advanced biofuels.

Joint Research Projects (JRPs) submitted for this topic should develop a metrological infrastructure to determine physical and chemical characteristics, and the geographical and biological origin of biofuels.

Joint Research Projects (JRPs) submitted for this topic should prioritise those parameters that are of relevance to the automotive industry, giving secondary consideration to the aviation industry. The JRP should include establishing metrological techniques and reference data to support modelling the atomisation, ignition and combustion processes in the development phase of engines or gas turbines. The high quality data from the JRP should aim to enable more efficient use of biofuels through the development of higher energy products, which can lead to reduced emissions. The JRP may also focus on the metrological requirements need to establishing fairer trade of biofuels throughout the energy value chain from generation, through energy transport, to use, including metrological support for fiscal regulations.

Conformity with the Work programme

This Call for JRPs conforms to the EMRP 2008, section on "*Grand Challenges"* related to *Energy* on pages 8 and 23.

Keywords

Biofuels, biofuel blends, metrology, reference methods, viscosity, calorific value, water content, pH, electroconductivity, density, surface tension, chemical composition, contaminants, on-site measurements, life cycle assessment, sustainability, biological origin, geographical origin.

Background to the Metrological Challenges

The pressing need for the EU region to address the dual challenges of climate change and sustainable energy supply has driven the adoption of the Renewable Energy Directive 2009/28/EC of the European Parliament. Through this Directive, Member States of the European Union have made a joint commitment to sourcing 20% of the region's energy from renewable sources. The Directive recognises that this increased consumption of biofuels will need to be balanced by sustainability criteria such as accurate knowledge of levels of emissions and environmental impact of its production, and assessment on the impact on food security.

Efficient use of biofuels and blends with biofuels in the transport sector can be greatly enhanced by developing metrological techniques. Internationally compatible measurement standards are vital components in aiding the industries that produce the vehicles able to run on these fuels and promoting the trade in sustainable produced biofuels.

Most of the standards and measurement methods used today for the characterisation of biofuels are drawn from specifications and test methods originally developed for fossil fuels and industrial or commercial alcohol. For bio-ethanol and FAME (Fatty Acid Methyl Esters) (bio-diesel) vehicle fuels, standardisation organizations (CEN, ASTM, ABTN) have already developed specifications and test methods. However the "White Paper on Internationally Compatible Biofuels Standards" published on 31 December 2007 by the Tripartite Task Force (BR, EU, USA) identified a series of parameters and biofuels specifications that need to be harmonized between regions regarding their relevance. There is a clear need to work on the relevance of methods and parameters currently used by field laboratories, for example pH of bio-ethanol.

In response and European Commission supported 7th Framework project, BIOREMA, was initiated in 2008 by the metrology community. It addresses the need for reference materials for conventional biofuels that have well characterised reference values. Such reference materials are essential for the further development and validation of measurement methods. The Joint Research Projects submitted are expected to have a focus complementary to BIOREMA.

New international standardisation activities have also started. ISO/TC 28/SC 7 "Liquid biofuels" [4] had their first meeting in January 2009. This subcommittee will initially only deal with test methods for FAME and bio-ethanol, and a small number of parameters.

For the "next generation" biofuels, such as Biomass to Liquid (BtL), Gas to Liquid (GtL), or cellulosic ethanol, and for biogas (such as biomethane), neither European standards nor metrological activities have been developed yet. National documents and documents which are supported by a limited number of stakeholders do, however, exist. For instance, a CEN document has been developed (CWA) [6] describing the specifications and test methods for a diesel fuel on the basis of synthesis gas (from natural gas, coal or biomass) or of hydro-treated vegetable or animal oils. This document is supported by a (limited) number of car manufacturers and biofuel producers. Furthermore, national quality demands for biogas exist in France, Switzerland, Sweden and Germany. Specifications for most of the parameters currently differ between these countries, which therefore impacts on trade.

From the perspective of transport vehicle manufacturers, the growing promotion of the trade in biofuels and biofuel blends leads to an increased level of interest in modelling atomisation, ignition and combustion processes, for example during the development phase of engines or gas turbines. These simulations require detailed knowledge of the biofuels thermochemical and thermophysical properties. It is therefore necessary to determine accurately the properties of biofuels and biofuel blends as a function of temperature. The physical properties (density, thermal conductivity, thermal expansion, specific heat, viscosity, density, surface tension, sorption energy on different materials…) of biofuels mainly depend on the feedstock sources used for their production. These properties can also vary depending on the water content in biofuel and on the biofuel blend ratio (biofuels used alone or blended with fossil fuels) and also the chemical composition of the biofuel.

Confidence in the reliability of analytical data requires understanding of the traceability chain, which links the results measured in the biofuel samples to the International System of Units (SI).

Water within biofuels results in serious quality problems. The water content of biofuels is usually measured by Karl Fischer titration method, as described in EN ISO 12937, EN 15489, ASTM E1064 and ASTM E203 standards. Although very accurate, this method is not suited to on-site measurements. A valuable output of this project would be to develop an alternative approach for on-site and even in-line measurements.

Reference absolute method is the unique technique allowing accurate measurements of energetic characteristics of biofuels. Temperature influences viscosity of the fuel and its yield in the engine combustion. Normative documents on bioethanol recommend a viscosity value of 3.5-5 mm^2/s in Europe (EN ISO 3104) and 1.9-6 mm^2/s in USA (ASTM D445). With a fluctuating value of kinematics' viscosity, temperature and pressure effects on biofuels may also be evaluated within this project

Biofuels may also contain various impurities including water that lead to corrosion or the build up of damaging deposits. The development of measurement methods to quantify the chemical composition and contaminants of biofuels will be valuable in informing the understanding of the physical characteristics and performing risk assessments for the potential damage to engines and storage tanks.

During 2008, public and political acceptance of an international trade in biofuels has become concerned with sustainability issues. This concern is key features in the Renewable Energy Directive 2009/28/EC. Accurate methods to identify the geographic and biological origin of biofuels are required to enable trading standards organisations to certify the source of the biofuel. In addition, methods are needed enabling the statement of an uncertainty for the assessment of environmental impact in particular, the balance of greenhouse gas emissions versus carbon uptake by the crops. Through this contribution, the European Metrology community can play a crucial part in informing consumer groups, regulators and those involved in the trade and supply of biofuels.

Scientific and Technological Objectives

Proposers should aim to address all of the stated objectives below. However where this is not feasible (i.e. due to budgetary or scientific / technical constraints) this should be clearly stated in the JRP protocol. The objectives are based around the PRT submissions. As experts in the field, JRP proposers should establish the current state of the art, which may lead to amendments to the objectives - these should be justified in the JRP proposal.

The aim of your JRP should be to provide validated and reliable measurements/methods with traceability wherever it is practicable to do so for physical and chemical parameters of biofuels (gas, liquid or solid) with relevance to the development of engines or gas turbines and facilitate a sustainable contribution of biofuels to the European energy supply with the focus being the automotive and aviation industry.

1) Develop and validate measurement methods with full uncertainty budgets for the physical parameters of biofuels;

2) Develop and validate measurement methods with full uncertainty budgets for chemical parameters of biofuels;

3) Develop Reference Materials: determine which reference materials are needed and develop methods to produce these (certified) reference material standards for 2nd generation biofuels;

4) Develop and validate "Quality Indicators" for biofuels;

5) Measure water content of biofuels;

6) Determine of the effect of biofuel blend on the physical and chemical properties of the Biofuels

7) Develop and validate metrological methods and systems to determine the origin of Biofuels;

8) Life cycle assessment: Develop and validate metrological techniques to improve ”life cycle inventories” used to quantify the impact of production and used of biofuels on the environment.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

In your JRP submission please detail the impact that your proposed JRP will have on the following Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources

You should also detail other Impacts of your proposed JRP as detailed in the document “Guidance for writing a JRP”

You should detail how your JRP results are going to:

- feed into the development of urgent standards through CEN and other appropriate standards bodies
- transfer knowledge to the automotive and aviation sector.
- support fiscal metering regulations

Time-scale

The project should be completed in a reasonable time scale (3 years) for the automotive and aviation in the European region to respond to the Renewable energy directives.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] European Metrology Research Programme. Outline 2008 Edition - November 2008, http://www.euramet.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/docs/EMRP-outline2008.pdf&t=1248796946&hash=9da9ceb781370f04c322ac48068deca5

[2] Directive 2009/28/EC of the European Parliament and the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

[3] "BIOREMA project: Reference Materials for Biofuel Specifications", A. Baldan et al, 2nd International Conference on Biofuels Standards, 19-20 March 2009, Brussels, Belgium. http://ec.europa.eu/energy/renewables/events/doc/2009_03_19/session2/biorema.pdf

[4] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0088:0113:EN:PDF

[5] White Paper on International compatible Biofuel Standards, Tripartite Task Force: Brazil, European Union and United States of America, 31 December 2007. http://ec.europa.eu/energy/renewables/biofuels/doc/standard/white_paper_icbs_final.pdf

[6] "ISO, CEN, and ASTM cooperative work in support of biofuel test methods", P. Tittarelli, 2nd International Conference on Biofuels Standards, 19-20 March 2009, Brussels, Belgium.
http://ec.europa.eu/energy/renewables/events/doc/2009_03_19/session4/tittarelli.pdf

[7] EPA proposal for Renewable Fuel Standard 2 program. Published May 26, 2009 on http://www.epa.gov/oms/renewablefuels/

[8] EN 14103:2003, "Fat and oil derivatives – Fatty Acid Methyl Esters (FAME) – Determination of ester and linolenic acid methyl ester contents".

[9] EN 14105: 2003, "Fat and oil derivatives – Fatty Acid Methyl Esters (FAME) – Determination of free and total glycerol and mono-, di-, triglyceride content".

[10] First European meeting on the metrology of biofuels supporting production, use and regulations - "BioFuels Met 2008" (6-7 November 2008, Strasbourg, France) http://www.ptb.de/de/org/3/33/BioFuels_Mappe_2.pdf