TITLE: Metrology for Liquefied Natural Gas (LNG)

Abstract

An improved infrastructure for liquefied natural gas (LNG) is one of the priorities of the EC integrated energy policy, motivated by the need to ensure a more diversified and secure energy supply [1,2,3] and fair and open trade in natural gas [4].

LNG trading is currently based on a complex scheme of sampling, direct measurements of quantities (LNG tank level, composition, temperature) and calculations of derived quantities (LNG volume, density, gross calorific value) to determine the amount of energy exchanged [5]. The implementation, accuracy and traceability of these static and dynamic measurement methods are a major metrological challenge with many unsolved issues.

Joint Research Projects (JRPs) submitted for this topic should aim to address the evaluation of current LNG transfer measurement methods and the development of new and improved measurement techniques and metrological standards for LNG transfer.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008[1], section on "*Grand Challenges"* related to *Energy* on pages 8 and 23.

Keywords

Liquefied natural gas (LNG), security of energy supply, sustainable energy supply, LNG flow measurement, LNG thermo-physical properties, certified reference materials, compressibility, LNG thermal expansion, LNG density, LNG equation of state, LNG chemical composition, LNG calorific value, thermodynamic modelling of LNG flow, LNG static and dynamic measurements, primary standard for cryogenic mass flow.

Background to Metrological Challenges

The drive to reduce emissions has resulted in increased importation of natural gas as a main source of clean energy in Europe. A significant proportion of this imported gas will be in cryogenic form (LNG, temperature ≈ -160°C) as part of diversity of supply and Europe is therefore increasing its LNG capacity: 13 LNG terminals in operation, 7 LNG terminals under construction, 27 LNG terminals planned [6]. The trade of LNG is currently based on a complex scheme of measurement methods and calculations for determining the LNG amount and composition. The performance figures of such measurement methods and calculations (traceability, uncertainty, installation effects, operating conditions) are questionable on a scientific and metrological basis. The lack of indisputable measurement standards is slowing down the implementation of LNG flow and composition measurement techniques for custody transfer. In addition, there are currently no international standards governing the

measurement methods but only guidelines such as the one covered by the GIIGNL handbook [5].

In international trading of LNG (LNG custody transfer), the quantity invoiced is the LNG energy that is transferred. The LNG energy transferred is given by the product of three quantities: the **LNG volume**, the **LNG density** and the **LNG gross caloric value**.

The **LNG volume** measurement is currently based on tank level metering, with a total claimed accuracy of about 0.5% (or worse) under ideal measurement conditions and for large volumes. There is general consensus that flow metering will provide for much higher accuracy. Coriolis and ultrasonic flow meters are available and are being developed for LNG but traceable calibration and validation facilities at representative conditions (e.g. at ≈-160°C) are not available. The demand for LNG flow measurements will however increase in the future due to:

1. The preference for custody transfer to be based on more accurate measurements by all stakeholders in the LNG chain, now that a LNG spot market is emerging.
2. The trend towards floating offshore production and re-gasification of LNG. Sloshing of LNG due to the constant movement of offshore tanks hinders tank level measurements.
3. Recent developments with a common LNG production facility where operators share storage capacity and flow meters are used for the allocation of ownership.
4. The need for accurate book keeping (mass balance) of both the incoming and re-gasified LNG for operational and governmental regulation (emission) purposes.

The extreme coldness of LNG has a clear effect on the performance of measuring equipment and on fluid behaviour. Knowledge about these effects is poorly developed and must be expanded by experimentation and modelling. This knowledge is indispensable in order to estimate the uncertainty of calibration and in-field measurement results.

A challenge is to develop primary standards able to provide traceable calibrations with low uncertainties for inline flow metering technologies.

The **LNG gross caloric value** of the traded LNG is calculated from its composition and large variations in LNG composition can occur. The **LNG density** is calculated from the composition and temperature of the LNG. Both the composition and the density of the LNG are critical parameters for determining the value of the cargo and to check whether applicable Gas Qualification Standards are met. If highly accurate reference values (or equations) exist and the composition is measured, the physical properties can be calculated from the composition. A number of measurement methods exist but all methods have their advantages and drawbacks and it is essential to assess the obtainable accuracy and applicability of these methods for LNG. In addition analyzing equipment should be calibrated using a reference sample of LNG. At present no fluid reference material for LNG is available and the development of such a standard is needed.

Thus the main challenges are:

- Traceable calibration system for inline flow meters at large LNG flow rates
- Effects of cryogenic media on flow meter performance
- Properties of LNG and methods of sampling and analyses
- Metrological infrastructure for LNG

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 core objective is to develop a science based metrological framework for LNG.

Specific objectives are to:

- Develop measurement methods and measurements capabilities for traceable LNG flow measurements with reduced uncertainties.
- Develop measurement procedures and reference materials with reduced uncertainties for LNG composition, physical properties such as density and calorific value for a variety of LNG-qualities/compositions.
- Develop sampling technologies for LNG measurements
- Improve the understanding of LNG-specific effects in energy metering systems
- Enable European guidelines and standards development for LNG

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 of the European Commission:

“Second Gas Directive” 2003/55/EC [4]

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

In response to the need for standardised measurement techniques you should detail how your JRP results are going to:

- Feed into the development of documentary standards and guidelines through CEN, other standards developing bodies or other appropriate bodies
- Transfer knowledge to the industry, regulators and policy makers.

Additional information

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

[1] Press release 5215/09, Council of European Union, Council Meeting on “Transport, Telecommunications and Energy”, EU, Brussels, 12 January 2009.

[2] Council Conclusion on “Second Strategic Energy Review – An EU energy security and solidarity action plan”, Transport, Telecommunications and Energy Council Meeting, EU, Brussels, 19 February 2009

[3] New Energy Focus, “Cleaner energy in the European Union”, http://www.newenergyfocus.com/go/legislation/europe/, 8/06/08.

[4] 2003/55/EC of the European Parliament and of the Council of 26 June 2003 (the “Second Gas Directive”) concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC. The European Commission introduced measures requiring member states to provide open access to gas infrastructure (including LNG terminals) on fair, transparent and non-discriminatory terms. The Second Gas Directive anticipates a system of regulated third-party access to LNG receiving terminals. http://www.energy.eu/directives/l_17620030715en00570078.pdf, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:176:0057:0078:EN:PDF

[5] G.I.I.G.N.L. (International Group of Liquefied Natural Gas Importers), *LNG Custody Transfer Handbook* (2001), G.I.I.G.N.L. (Groupe International des Importateurs de Gaz Naturel Liquefie), Paris, France

[6] Study on Interoperability of LNG Facilities and Interchangeability of Gas and Advice on the Opportunity to Set-up an Action Plan for the Promotion of LNG Chain Investments, Final report, May 2008.

[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