TOPIC DESCRIPTION: Metrology for Energy Saving in Electronic Devices and Electrical Machines

Abstract

Energy efficiency offers considerable contribution to the social and economic demands for a secure and renewable energy supply [1,2].

Significant energy savings can potentially be made on large-scale applications, but an alternative approach is to generate significant energy savings cumulatively through small-scale savings on individual devices, appliances and applications which are used by millions of people across Europe. In order to make electricity saving more efficient and to facilitate informed choices, it is beneficial to measure not only the total energy consumption or generation of each customer, but also to monitor the electricity consumption of individual appliances of each customer. Efficiency savings can be made both whilst devices are operational or in stand-by mode. Such measurements would have applications also in smart electricity grids and in microscale trade of electricity.

Energy saving technology requires the traceable measurement of efficiency in order to iteratively improve design and minimize the impact of the consumption of electricity on the environment.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008 [3], section on "*Grand Challenges"* related to *Energy* on pages 8 and 23.

Keywords

Energy saving, energy efficiency, electricity, magnetic losses, electronic devices, power and energy meters, energy modelling, smart grids.

Background to the Metrological Challenges

Considerable metrological challenges exist in improving the energy efficiency of devices, applications and processes and in reducing energy consumption. It is necessary to the consumption and to identify where energy savings or improvements in efficiency will have the greatest impact. Improving energy efficiency and reducing energy consumption also contributes to reductions in CO_2 emissions.

Electronic Devices

Electronic devices are fundamental in almost every field of knowledge and industrial and scientific application. According a German market research company, GfK, the global market for electronics products will reach about US$ 724 billion in 2009, which represents about 4 %

growth from 2008. Improved design at the chip level can make a considerable energy saving contribution.

Existing modelling techniques allow behaviour prediction under transient conditions but do not fully account for heat-loss modelling on chip. Thermal coupling among devices affects device performance profoundly and is the cause of additional power losses (mainly heat to the ambient). Furthermore, thermal coupling among devices is responsible for degrading performance, reducing life-time and in consequence is responsible for increased maintenance costs. This modelling needs validation by accurate measurements of energy losses with complex signals.

Magnetics
The increased usage of magnetic materials in energy conversion requires the measurement of the properties for operational conditions not provided by standard methods. Existing normative standards for the measurement of magnetic properties of the materials used in electrical products are not sufficiently detailed and accurate for the energy saving applications currently being developed. Novel magnetic materials enable high efficiency motor drives and generators and the reduction of fuel consumption through environmentally friendly transport. The ability to embed starters/generators within gas turbines is likely to provide a weight saving in the order of 15 %. Typically, a saving of 0.5 % is achieved from a traditional development cycle. New magnetic metrology methods need to be established to provide the material data required. The use of material data, measured under the conditions of use, will shorten the design cycle and reduce the time taken to market. This is particularly important for improvements focused on reducing energy usage.

Standby Power Measurement
Many household appliances and IT equipment have standby modes of operation. A UK government energy review [4] estimated that ~8 % of the UK's domestic electricity usage arises from devices operating in standby mode. According to European Commission calculations, the new “Ecodesign” regulation [5], which incorporates standby power consumption could eventually save the equivalent of Denmark’s annual electricity consumption and prevent up to $14x10^6$ kg of CO_2 from entering the atmosphere. Accurate measurement is required to support new EU regulation [6] and emerging normative standards to reduce the standby power of electrical appliances. Household appliances that have a standby mode must be tested to ensure their energy usage is below the level claimed by the manufacturer. The EU will impose limits of 1 W or 2 W on the maximum allowed power consumption for devices operating in standby mode in 2010 and from 2013, the admissible power consumption level will be lowered to 0.5 W or 1 W.

The power consumption of devices in standby mode [4] is variable with time and the current waveform is non-stationary and complex, often tending to consist of low duty cycle pulses. Such signals make power/energy measurements difficult to achieve and unreliable, leading to discrepant results between power meters. New algorithms and power measurement electronics, together with a calibration service for power measurements to IEC62301 need to be developed in order to support these emerging energy saving standards for standby power.

Consumption Control
Controlling and reducing energy consumption requires knowledge of the overall energy consumption, knowledge of the energy consumption of individual devices and applications, reducing the energy consumption of individual device or application and then controlling usage of the device.

Local control of the supply voltage can be used to reduce energy consumption in industrial and domestic installations. Savings can be as high as 15 % but will depend on the nature of the electrical load. Currently the benefit assessment of efficiency involves the interruption of supply and the installation of cumbersome trial equipment – the difficulty and cost of this test is a major barrier to investment. Non-invasive measurement system needs to be developed to assess the benefit on a plant-by-plant basis. Such a system will need to induce small (due to practicality) voltage changes and detect the resulting small energy changes against a background of ambient voltage/power variation caused by normal load switching. In addition, the use of efficiency management software/algorithms can contribute to the reduction of energy consumption. For example, large server farms and data centres invest in cooling of their server rooms. "Smart" software may reduce energy demand and improve efficiency considerably, which require metrological assessment due to the character of the load to the system, which produce broadband harmonic spurs that cannot be accurately measured with conventional watt-hour meters.

Efficiency of Electrical Machines

It is estimated that 30% of the energy produced is consumed by electrical machines in industries. A realistic improvement of approaching 2% in the accuracy of efficiency measurements of electric machines would allow further optimisation of energy use [7] corresponding to a saving in Germany alone of about €300 million and a similar percentage reduction of CO_2 emission to the atmosphere.

The European Directive 2006/32/EC [7,8] establishes a framework for the setting of the eco-design requirements for energy-using products and the EC 2/1422/CD:2007-04 part 30 defines efficiency classes of single-speed three-phase cage induction motors. However, the measurement of machine-efficiency cannot be assessed with confidence because there is no traceability for measurement of mechanical power under dynamic conditions and for electrical power for frequencies above 20 kHz and a number of kiloVolts. This requires the development of traceable power measurements for mechanical and electrical power up to megawatt levels with wide frequency bandwidth and dynamics (up to tens of kHz and also for on-site applications up to some kV for electrical alternating power) together with measurements of dynamic torque and dynamic rotational frequency in the needed magnitude ranges to ensure traceability of efficiency measurements on electrical machines and drives.

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 from various institutes. 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.

- Develop improved and validated techniques for measurement of micro powers associated with electronic devices and for localised measurement of electrical energy consumption
- Develop magnetic measurement capabilities to assess the power loss in soft magnetic materials
- Develop methods for low level standby power measurements for electrical devices and appliances
- Develop non-invasive measurement techniques for potential energy savings in industrial /commercial installations and machines

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 Directives of the European Commission:

"Ecodesign Directive" 2005/32/EC [5]
"Energy end-use efficiency and energy services Directive", 2006/32/EC [8]

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 industry, regulators and policy makers.

Additional information

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

[1] European Commission's Policy on Energy Efficiency, (http://ec.europa.eu/energy/efficiency/index_en.htm)

[2] See http://www.euractiv.com/en/energy-efficiency/eu-stimulus-plan-include-funds-energy-savings/article-181372

[3] 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

[4] "Energy Review: "The Energy Challenge"", July 2006. See http://www.berr.gov.uk/files/file32003.pdf;

[5] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

http://www.energy.eu/directives/l_19120050722en00290058.pdf

[6] IEC62301: 2005 - Household electrical appliances - Measurement of standby power

[7] See http://www.energy.eu/#saving;

[8] Directive 2006/32/EC of the European Parliament and the Council of 5 April 2006 on energy end-use efficiency and energy services, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:EN:PDF