

## **Title: Loss measurements on power transformers and reactors**

### **Abstract**

Losses in the electricity grid represent large costs and significant CO<sub>2</sub> emissions. Therefore the recent Ecodesign Directive 2009/125/EC requires all power transformer manufacturers to unambiguously prove that their products comply with the efficiency requirements of this Directive. As a consequence, CENELEC TC14 has expressed a need for metrology research in the area of power transformers and reactors, in order to provide accurate and reliable measurement of the losses from them. However, this will be challenging research given the high efficiency and operating conditions of power transformers and reactors and therefore new measurement systems for more accurate loss measurements in such conditions, together with calibration facilities for these new measurement systems are required.

### **Keywords**

Power transformer, power reactor, Ecodesign Directive, loss measurements, energy efficiency, high voltage, calibration system

### **Background to the Metrological Challenges**

Energy efficiency is not only a crucial theme in energy use, but in the whole energy chain from generation, transmission, distribution, to the end user. Even small improvements in efficiency have a large impact on the environmental footprint of the energy infrastructure when they are made in devices that convert large amounts of energy (such as power plants and grid power transformers). Therefore, metrological research is crucial for the development of characterisation and test methods for loss mechanisms and to accurately quantify the efficiency improvements realised by new technologies.

In their continuous drive for lower energy losses manufacturers are constantly improving their designs in terms of efficiency and maximum operational voltage, and at the same time balancing this with cost effectiveness. For utilities using High Voltage (HV) power transformers and reactors, and Market Surveillance Authorities (who verify conformity to the Ecodesign Directive) it is of utmost importance that manufacturers are able to unambiguously prove their products comply with the efficiency requirements. However, in order to prove this, highly accurate and reliable loss measurement systems are needed, as well as more accurate reference calibration systems.

HV power transformers and reactors are inherently reactive components, with extremely low power factors during operation. Constant technological improvements in efficiency are also reducing energy losses and their associated power factors even further. At such power factor levels and given the complexity of high-end loss measurements, there is a need for guidance on uncertainty analysis. Such guidance is needed on the evaluation of uncertainty in loss measurements of high-energy performance power transformers and of large reactors, and is needed to ensure a correct and consistent approach to uncertainty analysis. A working group of IEC/TC14 has recently begun to update the IEC 60076-19 technical standard on the “determination of uncertainties in the measurement of the losses of power transformers and reactors” and further input to this is required as identified within the CEN-EURAMET STAIR process [1].

### **Objectives**

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to support standardisation in loss measurements on power transformers and reactors.

The specific objectives are

1. To develop measurement systems and techniques to improve the accuracy of loss measurements of power transformers and reactors at very low power factors. The target accuracy is 30 ppm to 50 ppm, at voltage levels up to 500 kV, and current levels up to 4 kA.
2. To develop reference facilities for the calibration and verification of the measurement systems in objective 1. The aim is to generate and measure power loss at very low power factors in both laboratory and industrial conditions with a target accuracy of 10 ppm to 20 ppm, at voltage levels up to 500 kV, and current levels up to 4 kA.
3. To produce guidance on the evaluation of uncertainty for loss measurements of high-power, high-efficiency power transformers and large reactors.
4. To facilitate the uptake of the measurement systems and techniques developed in the project to contribute to the standards development work of technical committees such as IEC TC14 and CEN/LEC TC14. To ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them, and in a form that can be incorporated into the standards at the earliest opportunity. In addition, to disseminate the outputs of the project to market surveillance authorities, and ensure their take up by instrument and power transformer manufacturers.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMPIR JRP 14IND08 EIPow and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

## Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies, in particular IEC TC14 and CEN/LEC TC14,
- Transfer knowledge to the electrical energy sector, manufacturers of power transformers and to Market Surveillance Authorities involved in electrical compliance and regulation.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

## **Time-scale**

The project should be of up to 3 years duration.

## **Additional information**

[1] The documents from CEN outlining their priorities can be found at

[http://msu.euramet.org/current\\_calls/pre\\_norm\\_2016/documents/SRT\\_related\\_CEN\\_priorities/cen\\_priority\\_09\\_2016.docx](http://msu.euramet.org/current_calls/pre_norm_2016/documents/SRT_related_CEN_priorities/cen_priority_09_2016.docx)

The following Standardisation requests from the EC may be relevant:

[Mandate M/495 Standardisation mandate to CEN, CENELEC et ETSI under Directive 2009/125/EC relating to harmonised standards in the field of Ecodesign](#)

[Amendment to the mandate M/495 amendment no. 2 to M/495 technical update \(Annex B of M/495\)- Details of request to CEN, CENELEC and ETSI for standardization in the field of small, medium and large power transformers \(ENTR LOT 2\)](#)