Potential European Partnership on Metrology
Call 2021 – Green Deal and Normative

Selected Research Topic number: **SRT-v20**
Version: 1.1

Important information about these documents

This call is being held ahead of any agreement from the Commission that the relevant funding will be available. At present the relevant legislation is still under discussion in both Council and Parliament, and there is no certainty on the detailed arrangements for funding selected projects. The funding of any selected project, and the terms and conditions of participation in the projects, are dependent on completion of the legislative process and the subsequent contractual processes between the European Commission and EURAMET. Proposers submit to this call at their own risk.

Background

Last year, EURAMET submitted a draft proposal to the EC for a further research programme to be established under article 185 of the Treaty on the Functioning of the European Union (TFEU) to follow on from EMRP and EMPIR. This was published by the EC at https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/european-partnerships-horizon-europe/candidates-digital-industry-and-space_en

The initiative would be called the European Partnership on Metrology and would aim to create, by 2030, a sustainable and effective system for metrology at European level that ensures Europe has a world-class metrology system that:

- Provides metrology solutions, fundamental metrological reference data and methods, offering fit-for-purpose solutions supporting and stimulating European innovation and responding to societal challenges.
- Supports and enables effective design and implementation of regulation and standards that underpin public policies that address societal challenges.

The Commission commissioned an impact assessment into this proposal and 11 others in similar priority areas, and, based on those findings, published their own proposal for the Partnership, their response to the impact assessment and a draft of the Decision on 23rd February 2021. See:

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:89:FIN

https://ec.europa.eu/commission/presscorner/detail/en/ip_21_702

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0035&qid=1614677899327

That draft Decision is currently under discussion in the European Council and the European Parliament.

Under the assumption that the Council and Parliament pass the basic act which would form the legal basis for this research programme, and that the participating countries named in the Draft Decision submit the required commitment letters, EURAMET is publishing these potential Selected Research Topics and draft guidance notes. These documents are not approved by the Commission nor will they lead to a binding decision by EURAMET e.V. for any further negotiation or funding. All published guides and templates are subject to amendment by the EC and EURAMET e.V. as further information becomes known.

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Title: Metrology for data-driven combustion engine optimisation and flexibility using carbon-neutral fuels

Abstract

Advances in metrology are required to facilitate the transition to long-distance carbon-neutral transportation. Accordingly, several key metrological actions are needed to enhance the ability of internal combustion engines (ICEs) to adapt flexibly to the introduction of renewable fuels. Proposals addressing this SRT should focus on developing traceable methods to measure the composition and impurities of carbon-neutral fuels and assessing the traceability of dynamic pressure and temperature measurements for emissions reduction. Furthermore, temperature measurements to improve selective catalytic reduction should be introduced and online traceability of measurements of emissions developed. The research should conduct comprehensive demonstrations and a machine learning approach should be applied to enhance impact.

Keywords

System metrology, cleaner combustion engines, fuel flexibility, fuel composition, dynamic temperature, dynamic pressure, catalytic reaction temperature, exhaust emission measurement, machine learning.

Background to the Metrological Challenges

The supply of and need for renewable fuels must be evolved simultaneously to generate the economic basis for a commercially self-sustainable long-distance transport sector based on carbon-neutral fuels. Since renewable fuels have been rarely exploited for combustion engine operation, the measurement improvements proposed here are mainly based on traditional combustion engines used with fossil fuels. For the renewable fuel specific subjects there is no existing metrological infrastructure. Research activities addressed by this SRT will underpin several European directives, including on promoting the use of energy from renewable sources, and on reducing the sulphur content of certain liquid fuels. Furthermore, improved fuel efficiency and improved methods for exhaust control will mean a competitive advantage for European industries, not only in transport but also in many areas of manufacturing.

Adaptation of combustion engines to renewable, carbon-neutral fuels requires new metrological methodologies and infrastructure to assess the quality of these alternative fuels. Energy content as well as the composition and impurities of the fuel are important parameters both for the flexible optimisation of engines running a specific fuel (mixture), and for the documentation of adherence to future emissions regulation and legal metrology requirements. Reference materials for traceable measurements of relevant impurities in the respective fuel environments must be developed to facilitate the transition to these fuels.

Based on the composition of the fuel, accurate knowledge of the pressure and temperature inside the engine is essential for optimising engine performance in terms of fuel consumption and the emission of pollutants. To increase the flexibility of the engine to the consumption of renewable fuels, there is a need to improve the combustion control while the sensors need to cope with the demanding conditions where high pressure and temperature coexists. The necessary control of combustion inside ICEs has not yet been achieved with current calibration and measurement technologies. The reported measurement uncertainties for dynamic pressure and temperature are around 2 % and 5 %, respectively, which is not sufficient considering a target uncertainty of 1 % in ICEs.

The production of pollutants in the engine is directly linked to the chemical components in the fuel and the temperature of the combustion. Presently, there is no online measurement of the reaction temperature at the surface of the selective catalytic reduction (SCR) system. Current state-of-art reactors mainly use multipoint thermocouples to monitor the temperature, which, however, inadequately represent any local temperature offsets. Furthermore, there are no direct temperature measurements on after-cleaning catalytic systems, which hinders a more adequate temperature control and potentially deteriorates the performance. Online in engines, the only temperature probes are single-point thermocouples, before and after the reactors, which are prone to malfunction due to the harsh environment. Significant improvements of the dynamic temperature measurement capability up to 700 °C are needed to monitor the reactions in the SCR and to ensure reliable NO_x reduction. Additionally, there is a need to introduce traceability to a suite of emission components relevant to the renewable fuels considered here, including NO_2, NO, H_2O, NH_3, CO_2, SO_2, as well as particle mass fraction (PM) and particle number density (PN), the latter two due to the current introduction of particle filters into the maritime industry.

Finally, there is a need to introduce the developed measurement capabilities in a full-scale demonstration, which in addition enhances the impact of the proposed research. To support future regulations in combustion engine emissions and energy efficiency there is a need to assess the uncertainty of the predictions. In this SRT, the use of machine learning and data-driven algorithms will extend the ability on assessment and improvement of the performance of sensors as well as the engines because the complexity of the underlying models precludes or hinders the use of more conventional methods.

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 the traceable measurement and characterisation of renewable carbon-neutral fuels in combustion engines for long distance transportation by introducing a range of online traceable measurement technologies and in-process assessment of uncertainties in a combined demonstration within the transport sector, e.g. in a marine engine application.

The specific objectives are

1. To develop a robust methodology for the metrological quality assessment of carbon-neutral fuels for combustion engines, including those using alternative fuels e.g. methanol, ammonia, or biomethane. Sensors and methods should be developed for traceable measurement of the energy content of the fuel and the fuel composition before the fuel is supplied to the combustion engine. Reference materials as well as suitable production methods for reference liquids and/or gases should be developed for at least two different renewable fuels to ensure traceability for the composition measurements.
2. To develop traceable in-engine measurements to assess and optimise the quality and efficiency of the combustion process using renewable fuels. Traceable calibration methods, measurement standards, and sensors for dynamic pressure and gas temperature should be developed to optimise the combustion process in the engine. Traceability should be established in ranges up to 30 MPa for pressure and up to 3000 °C for temperature with a target uncertainty level of 1 %.
3. To develop traceable measurement tools to enhance the reduction of pollutants from the combustion engine. Traceable dynamic temperature measurements up to 700 °C should be developed to allow for control of catalyst reactivity, to adapt to variations in renewable fuel compositions, and to optimise the NO_x removal in the selective catalyst reduction process. Traceable emission measurement methods should be developed for dynamic measurements of typical emissions in air, e.g., NO_2, NO, H_2O, NH_3, CO_2, SO_2, as well as PM and PN. The methods should be applied for dynamic emission measurements and for traceable quantification of methane and ammonia slip in the combustion process.
4. To demonstrate and validate the developed measurement methodologies (Objectives 1 to 3) in combination for ICE operation and optimisation using different renewable fuels. To build a predictive model using, e.g., a predictive chemical kinetics mechanism and/or a machine learning approach, to choose optimal engine operation conditions and minimise pollutant emissions resulting from the optimal combustion and post-catalytic cleaning. The prediction algorithm and the measurement methodologies should provide the basis of the engine control optimisation and will facilitate the adaptation of ICE's to be used with a variety of carbon-neutral fuels of a given fuel composition.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories, instrumentation manufacturers), standards developing organisations (ISO), OIML, IEA (International Energy Agency), and end users (sensor manufacturers, marine engine producers).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EURAMET EMN on Energy Gases, the EMN on Mathematics and Statistics, and EMPIR projects 16ENG09 LNG III, 17IND07 DynPT, 19ENG09 BIOFMET, 19ENV09 MetroPEMS and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.2 M€, and has defined an upper limit of 2.7 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

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,
- Transfer knowledge to the sensor and marine engine manufacturing sector.

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 the potential European Partnership on Metrology 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.