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Metrology to underpin future regulation of industrial emissions

Background

Accurate measurement of emissions of pollutants and greenhouse gasses (GHGs) to the atmosphere is vital in enabling action to control and reduce air pollution in order to protect European citizens and the Environment. The European Climate Change Programme (ECCP) is targeting an 80-95% reduction in emissions by 2050 compared to 1990 levels. However, current evidence shows that emissions are only likely to be reduced to 30% by 2030, hence we are not on track and more stringent emission limits will be necessary as will measurement methods to enable monitoring and enforcement.

The emission of pollutants from industrial sources has a direct impact on air quality. As stated by the European Environment Agency EEA, the EU's long-term objective is to achieve levels of air quality that do not result in unacceptable impacts on, and risks to, human health and the environment. These emissions also have an economic impact, the EEA state on their website that the cost of air pollution from the 10,000 largest polluting facilities in Europe was **€102 to €169 billion** in 2009.

Need for the project

Monitoring of emissions of pollutants to air to ensure compliance with EU directives and national legislation is the key to enforcing emission limits and thereby enabling their reduction and control. Industry needs to measure and report emissions for regulatory purposes including assessing stack emissions against concentration limit values, reporting annual mass emissions, and determining emissions of GHGs from area sources.

The EU's Industrial Emissions Directive (IED) and Best Available Technology Reference (BREF) Documents are introducing lower emission limit values, in some cases requiring measurements not achievable by current standard methods, and novel reporting requirements – for example annual mass emission values for emissions trading and the quantification of emissions from area sources (e.g. fugitive leaks of VOCs from industrial plant and GHGs from landfills)

Improved technologies, methods and protocols are required by industry (e.g. operators in the manufacturing, waste sectors), regulatory authorities, equipment suppliers and stack monitoring providers to enable these lower limits and novel emissions sources to be controlled.

Industry and regulators require a robust metrology infrastructure to underpin the monitoring and reporting framework. This work will remove many of the current technological obstacles to allow the reporting and therefore the control of industrial emissions within the framework of increasingly lower limit values.

Scientific and technical objectives

The overarching aims of the project are:

- To provide a metrological evaluation of existing emissions monitoring techniques in order to determine where measurement science is insufficient to defensibly enforce recent, and future, reductions in emission limits driven by directive and BREF requirements;
- To provide metrological support and uncertainty methodologies to assess the uncertainty in mass emission (i.e. flow multiplied by concentration) data;
- To carry out developmental work of the next generation of monitoring techniques and author protocols, to provide measurement methods for CEN (European Committee for Standardization) standardisation within the EU regulatory framework. Also, to provide stack simulation facilities to enable development

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of future monitoring methods and provide a mechanism for testing monitoring organisations sampling proficiency;

- To carry out work to provide validation data for next generation monitoring techniques and protocols under real-world conditions (e.g. field trail at a landfill site).

These overarching aims will be met via the following JRP objectives:

- Objective 1: "…development of alternative methods / techniques to traceably calibrate (in-situ) on-line stack monitoring instrumentation…" shall be met by carrying out development of techniques that have the future potential to be applied to stack monitoring (e.g. TDLAS - Tunable diode laser absorption spectroscopy) and authorship of protocols to standardise the use of techniques already demonstrated as being in principle capable of meeting stack monitoring requirements. The protocols will be submitted to CEN for acceptance as Technical Specification documents to formerly allow the pan-European use of such techniques (e.g. FTIR - Fourier transform infrared spectroscopy) for regulatory purposes.
- Objective 2: "…characterisation of uncertainties associated with combining infrequent, independent flow measurements with continuous concentration data" shall be met through developing a stack flow model using OpenFoam software which will be validated using real stack data. Using the model, sensitivities, for example spatial dependence, will be probed in order to identify key error sources. In addition, a key output will be a guidance document providing procedure for the estimation of flow uncertainties and subsequent propagation upon combination with continuous concentration data in order to provide robust estimates of uncertainties associated with annualised mass emissions.
- Object 3: "…validate facilities able to test sampling proficiency…" shall be met through validation of new particulate capability augmented onto the existing NPL Stack Simulator facility and validation of a new stack simulator facility at VSL for gaseous sampling. Significant further value will be added in terms of analyses of historical proficiency testing data in order to determine the extent to which the EU's stack monitoring industry has kept pace with increasingly stringent regulation and how it will cope with further near future reductions in emission limits.
- Objective 4: "...improved and robust remote sensing techniques.....for fugitive emissions…" shall be met by developing DIAL (Differential Absorption Lidar), TDLAS and IR (infrared) camera for application to open path measurements of area emitting sources. In addition, the NPL Area Source simulator will provide a key facility to determine the performance characteristics of such open path techniques.
- Objective 5: "…suite of metrologically robust protocols / standards covering the use of open path techniques…" shall be met through drafting of protocols to provide methods for the application of DIAL, TDLAS and IR camera to monitoring emissions from area emitters. Furthermore, the developed techniques and protocols shall be tested in a field trial at an applicable industrial site (e.g. landfill) as part of determining the overall performance characteristics / uncertainty budgets.

Expected results and potential impact

The technical work in this project has been designed to achieve the top level objectives needed to support future regulation of industrial emissions. The project will also create impact by targeted knowledge transfer, dissemination and exploitation activities to ensure that stakeholders will obtain maximum benefit from this project.

The project will address metrology needs in stack emissions monitoring, annual mass emission reporting and area source emission quantification. It will

- Address traceable measurements of pollutants in stacks, assessing the capabilities of current reference methods to meet the challenges of lower emission limit values, developing test facilities within the European NMI community to test and validate methods and to support the development of next generation monitoring methods.
- It will develop improved approaches to determining the uncertainties in flow measurement and in annual mass emission values.
- It will provide protocols and methodologies for measuring and monitoring emissions from area (including fugitive sources), including the emissions of GHGs such as methane. Protocols will be

developed, and assessed using simulated emission facilities developed within this project, and field validation at an industrial source. These activities will include regular interaction with industry and regulator groups via workshops, conferences, dissemination to key websites and various publications in relevant technical journals and trade magazines. A key dissemination route will be through the development of international (CEN and ISO) measurement standards. Seminars and technical training workshops will take place throughout the project. Findings of the research will be presented at a number of external conferences by members of the project team. Exploitation of the work will be through a number of committees and forums including regulatory and industry groups.

Successful delivery of the three technical work packages will result in the development of measurement and monitoring technologies, methodologies and guidance to support industry and regulators and new CEN standards. In particular this will include improved reference monitoring methods, improved understanding of the uncertainties in mass emissions reporting, and the development of methods and standardised protocols for measuring emissions from area and fugitive emissions.

There have been many achievements within the first half of the project. Particular highlights include:

- active engagement in European and International standardisation activities, including convenorship of three key Working Groups within CEN TC264 covering the measurement of stack gas emissions using FTIR (WG36), determination of VOC fugitive emission (WG38), Quality Assurance of automated measuring systems (WG9), and task leadership within WG16 concerning reference measurement methods for NO_x, SO_2, O_2, CO and water vapour
    - Furthermore, completion of several measurement method protocols being promulgated within the above mentioned CEN working groups
        - Protocol for measurement of stack emissions using FTIR ⇒ CEN / TC264 / WG36
        - Protocol for the measurement of SO_2 emissions from stack using optical techniques ⇒ CEN / TC264 / WG16.
- the publication of a peer-reviewed paper
    - Coleman, M.D., Render, S., Dimopoulos, C., Lilley, A., Robinson, R.A., Smith, T.O.M., Camm, R., Standring, R., *Testing equivalency of an alternative method based on portable FTIR to the European Standard Reference Methods for monitoring emissions to air of CO, NOx, SO_2, HCl, and H_2O.* Journal of the Air & Waste Management Association, 65:8 (2015) 1011-1019.
- the development of an new Area Source Facility which can produce controlled emissions which simulate those from a range of industrial emission sources.
- a new database of the results of emission monitoring proficiency testing schemes from various European countries.
- the completion of a series of reviews of the application of different optical techniques to emission measurements covering Optical Gas Imaging, Laser Absorption Spectrometry and Solar Occultation Flux measurements.
- extensive knowledge transfer and dissemination activities through direct consultation with stakeholders and participation in key stakeholder events, including presentations at 14 relevant conferences and workshops.

JRP start date and duration:	1 June 2014, 36 months
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