Real-LIFE Emissions project

LIFE20 PRE/FI/000006 (2021-2024)

In a pan-European preparatory project under the LIFE programme, testing methods for real emissions from solid fuels - primarily wood burning - were harmonized.

When developing and comparing testing methods, masonry heaters, stoves, and boilers intended for household use were utilized.

The project was co-funded by the European Commission's LIFE programme. The project partners' own funding covered 40% of the project's costs.

Ongoing experiment in a testing laboratory of the Technical University of Ostrava

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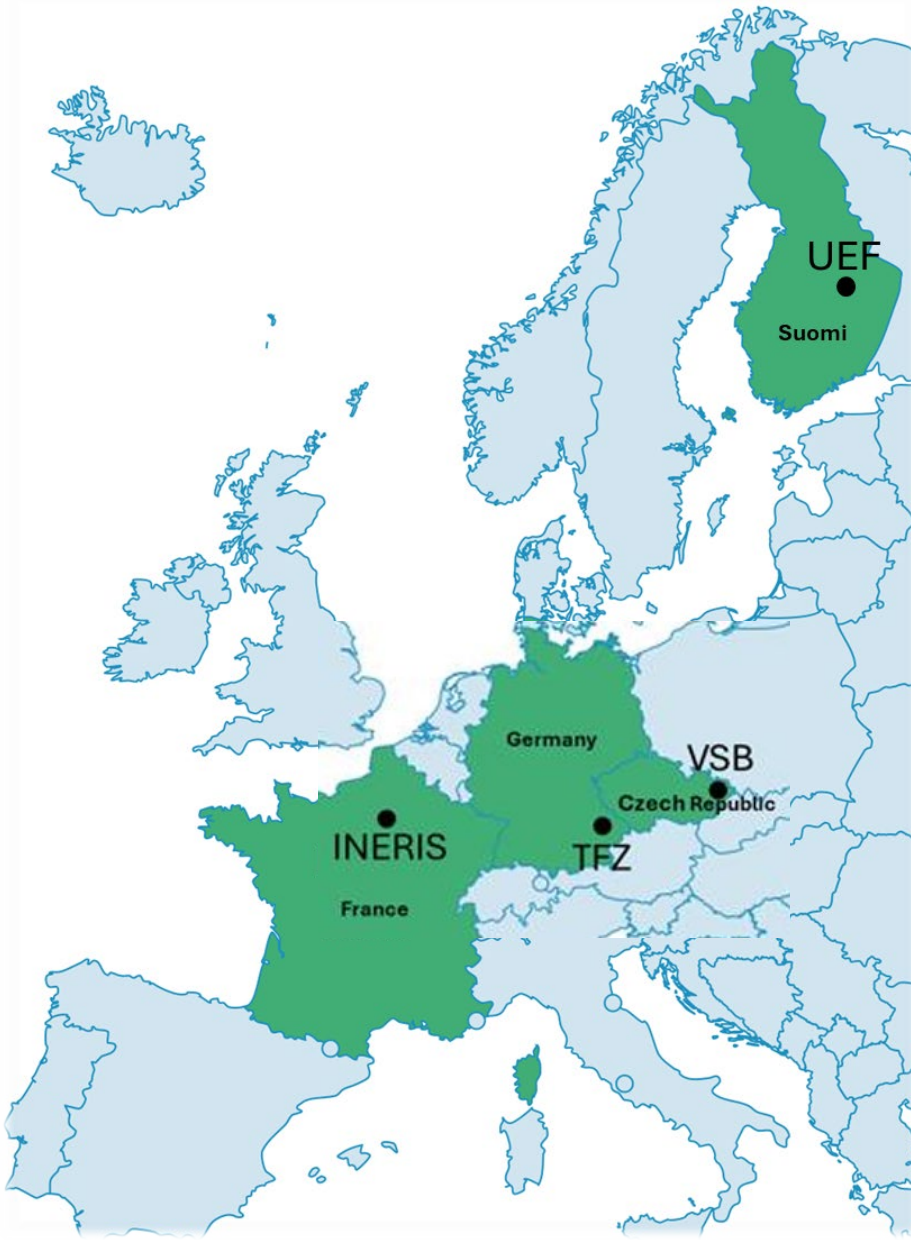
Emissions from small-scale combustion of solid fuels e.g. wood, are significant and have harmful effects on human health and the environment. Particulate emissions (PM) are particularly harmful, but previous measurement methods have not adequately accounted for the different chemical compounds in particulate emissions.

The goal of the project was to improve the measurement methods and testing procedures for these emissions so that they better reflect real usage and conditions, such as when wood or pellets are burned in various types of household masonry heaters and boilers.

The project, led by the University of Eastern Finland, included Central European research institutions as partners: INERIS from France, TFZ from Germany, and VSB from the Czech Republic. All partners participated in the development of testing methods and the comparison of testing procedures through combustion experiments.



Partners

University of Eastern Finland (UEF, Kuopio Finland; the Technical University of Ostrava (VB) Czech Republic; The French National Institute for Industrial Environment and Risk (INERIS), Vernuil-en-Halatte, France; Technology and Support Centre in the Centre of Excellence for Renewable Resources (TFZ), Straubing, Germany

At the University of Eastern Finland’s SIMO testing laboratory, it was possible to monitor and study the formation of emissions from fireplaces in real time during different phases of combustion

Main objectives:

Investigate measurement methods and testing procedures that better represent real emissions from small-scale solid fuel combustion.

Evaluate the benefits of using emission factors that better reflect real conditions in environmental impact studies.

Support organizations that enforce regulations and ensure their perspectives are considered in the project.

Generate new knowledge on differences in measurement methods and testing procedures through carefully designed combustion experiments.

Disseminate new and existing knowledge to various stakeholders.

Project tasks and results

Sampling and dilution methods

Various measurement methods are used to determine emissions from small-scale wood combustion devices, and the results may not be comparable. Some methods sample directly from hot flue gases, while others dilute the sample before collection. Especially for organic particles, results can differ significantly between hot gas and dilution methods.

Based on literature, four viable dilution methods were identified, with the combination of porous tube and ejector diluter (PTD + ED) being the most promising.

Additionally, a new sampling method was developed in the project, the extended ENPME method, which showed promising results in testing.

The image shows particle samples collected using the PTD+ED method, which adhered to filters. Particle mass is determined by the difference between final and initial filter weights. Gaseous samples are analyzed to determine the amount of gaseous organic compounds

Project tasks and results

Emission components

Current standardized measurement methods focus on solid particles, but other compounds such as condensable particles, black carbon or elemental carbon (BC or EC), and polycyclic aromatic hydrocarbons (PAHs) are important for climate and health impacts. Including condensable particle measurements in emission tests is recommended based on literature. It is also recommended to measure secondary organic aerosols (SOA) formed in the atmosphere in the future. Measuring particle number (PN) is not useful for evaluating combustion emissions, as the number is not linked to combustion efficiency.

At the University of Eastern Finland campus, near Lake Kallavesi, is the small-scale combustion simulator (SIMO), a mobile research unit where all measurements/ tests conducted by the university for the project were performed.

The simulator was built and equipped in a project co-funded by the European Regional Development Fund (2016–2019). The unit allows testing of fireplaces, sauna stoves, and related products. In addition to emissions, the unit studies sauna heating and the effect of ventilation on device performance and energy efficiency.

Two shipping containers house a mechanical ventilation system simulating a small house and comprehensive, scientifically valid measurement and sampling equipment.

Project tasks and results

Testing protocols

The project compared various testing protocols based on literature, which differ in combustion rates, fuel types, wood amounts, number of tests, test setups, measured emission compounds, sampling duration, and other characteristics. Therefore, the choice of testing method significantly affects measurement results and the types of emissions that can be identified.

It is important to agree on how and under what conditions the device is used. The project focused on developing a testing method that simulates real use of wood heating devices.

As a result of research and development, a new Real-LIFE testing method was created, which includes an ignition phase and three power levels, with emissions measured at each phase.

Batch 1 Ignition	**Batch 2** Pre-heating	**Batch 3** Nominal load	**Batch 4** Nominal load	**Batch 5** Nominal load	**Batch 6** Partial load	**Batch 7** Partial load	**Batch 8** Overload
TPM		TPM	TPM	TPM	TPM	TPM	TPM
Natural draught (4 m chimney)		-12 Pa			-6 Pa		-14 Pa

The Real-LIFE test for stoves includes four phases and eight fuel loads. Emissions are measured from each phase.

Project tasks and results

Intercomparison Campaign of particle emission measurements

The extended ENPME method consists of an ENPME sampling device compliant with EN 16510-1:2022, a porous tube diluter (PTD), and filter collections from both stages.

Comparison measurements tested the extended ENPME method with full flow and partial flow. The methods gave consistent results for solid particles but differed for condensable particles. Further research is needed to finalize the extended ENPME method.

INERIS research institute in France has a testing environment for comparing combustion emission measurement devices, with a long flue channel allowing installation of many instruments for simultaneous measurement.

The image shows the particle emission intercomparison campaign conducted in autumn 2023, with participation from all project partners.

Project tasks and results

Emission factors and limits for small-scale combustion devices

Modifications to sampling and testing protocols will affect emission factors and limits. Real-LIFE test protocol was validated within round robin campaign and applied on total of 11 appliances, showing the importance of including all combustion phases in emission measurements. Results showed that all combustion phases must be included in emission measurements to obtain realistic emission factors for climate and health impact assessments.

The round robin with four participants (all were project partners) was performed using two different log wood stoves, which were shipped to all partners (INERIS, UEF, TFZ and VSB). The fuel and uniform ignition aids was also provided to all partners in the correct mass and log sizes to avoid any fuel-based influences on the emissions while performing the Real-LIFE test protocol. The goal was that the Real-LIFE test protocol was performed three times for each stove and all data was sent to TFZ for further evaluation.

Project tasks and results

Economic and environmental impacts of implementing the method

Implementing the new sampling and testing methods increases testing costs but enables more reliable emission measurements, which are highly beneficial for assessing the impact of fireplace emissions on air quality and human health.

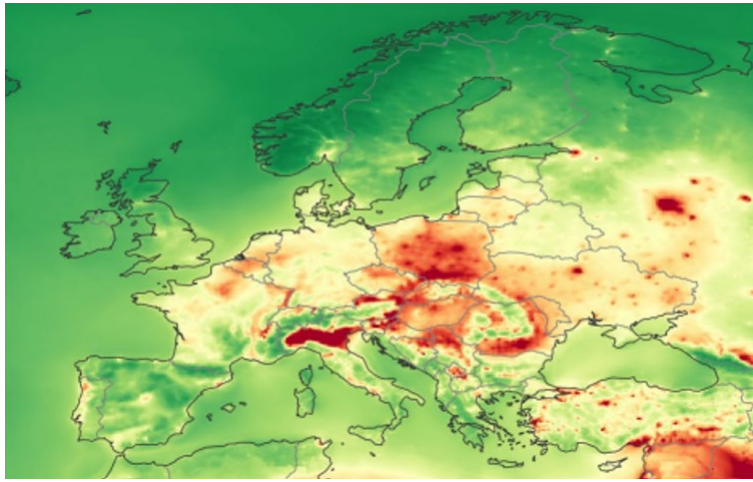
When calculating testing costs, the following were considered:

- Usage time of measurement equipment
- Applied interest rate
- Capital repayment factor
- Annual maintenance and repair costs as a percentage of equipment price
- Number of devices tested per year
- Unit cost of consumables: filters and fuel
- Average labor cost (€/h)

Using the Real-LIFE testing method and extended ENPME method increases testing costs from approximately €510 to €1564.

Air quality models are tools used to assess the impact of emissions on air quality. According to assessments made with these models, the amount of emissions from fireplaces and small boilers in the atmosphere is higher than current estimates when using emission factors produced in the project.

Using real emission factors improves the accuracy of air quality models and supports better environmental policy.



Proposals for short-term and long-term particle measurement methods

One of the main goals of the project was to propose better short-term (available in the near future) and long-term particle mass measurement methods

For short-term, the extended ENPME method (Figure 3) is proposed, and for long-term, the PTD+ED partial flow dilution method (Figure 4)

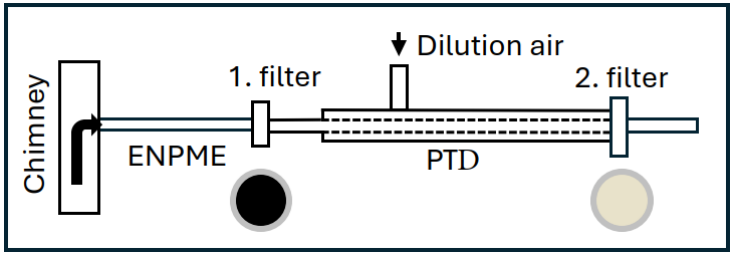


Figure 3. Diagram of the extended ENPME method, which includes an ENPME sampling probe and a porous tube diluter (PTD), with filters in both stages.

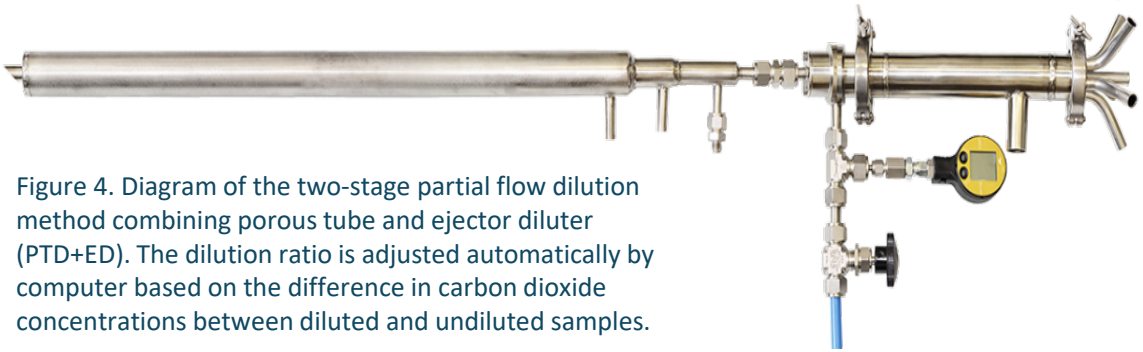


Figure 4. Diagram of the two-stage partial flow dilution method combining porous tube and ejector diluter (PTD+ED). The dilution ratio is adjusted automatically by computer based on the difference in carbon dioxide concentrations between diluted and undiluted samples.

Real-LIFE Emissions

Conclusion

The pan-European Real-LIFE Emissions project developed new testing and measurement methods that better represent real particle emissions from fireplaces and small boilers.

The results will be used in developing legislation regulating fireplace manufacturing and in assessing health and climate impacts.The results are particularly important for improving the accuracy of air quality modeling and achieving emission reductions. Detailed results are available on the project website.

Continuing research and validation are necessary to finalize these methods and incorporate them into European standards.

Project teams on the front of the TFZ testing laboratory

https://sites.uef.fi/real-life-emissions

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