

Summary of the 1st International Real-LIFE Emissions Workshop on Small-scale Combustion

The Real-LIFE Emissions project consortium organized the first international workshop on 9th November 2022. The workshop emphasized the discussions on the measurement methods and particulate emission components produced from the small-scale solid fuel combustion. The workshop brought more than 130 scientists, combustion appliance manufacturers, regulators, and experts in the field together from 17 countries and discussed current issues and solutions for the residential combustion emissions, sampling methods and several other ongoing projects and activities related to residential combustion emissions measurement in different EU countries (e.g. Norway and Switzerland). There were three sessions and 11 presentations including 6 presentations from external institutions in three different EU countries. The workshop held both online and onsite and a lot of discussions were held both at the venue and in the Q&A chat panel. The workshop was able to communicate with the experts in the field and exchange knowledge about the novel sampling methods and health and environmental impacts of particle components from residential combustion between the project members and external experts. A summary of the workshop activities such as presentations, discussions and knowledge exchanges is briefly presented below:

1. Before starting the sessions, Dr. Jarkko Tissari welcomed everyone present in the workshop and briefly introduced the project and its objectives to audiences.
2. In session I, Prof. Otto Hänninen from Finnish Institute for Health and Welfare (THL) presented health impacts of air pollution focusing on the impacts of particle emissions from combustion. In his presentation, e.g. PM_{2.5} and PM₁₀ concentrations, particle number concentration of ultrafine particles, and surface area of particles were regarded as important parameters for health perspective while PM_{2.5} mass was taken as the best established risk indicator as it is considered now. However, he said many well-known particle physical factors have health impacts that are not well known.
3. Dr. Harri Kokkola from Finnish Meteorological institute presented the climate effects of the composition of small-scale combustion emissions and he said black carbon (BC) from the residential combustion is the most important chemical compound of the particulate matter affecting especially in the arctic climate warming. In addition, he also informed that size distribution and optical properties are also important parameters for climate effects. As he said, there is knowledge gap on how aging changes the cloud activity of particulate matter, hygroscopicity, level of mixing of different aerosol compounds, optical properties and climate model friendly parameterizations at the moment.
4. Dr. Karna Dahal from the University of Eastern Finland (UEF) presented the important physical and chemical properties of particulate and gaseous emissions from small scale solid fuel combustion based on the literature reviews and existing data done for the work in Action A2. He presented required emission components to be measured are: PM, NO_x, OGC/THC, and CO

while other important emission parameters are: PM_{2.5}, BC or alternatively elemental carbon (EC), individual volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), particle size distribution (PSD), and secondary aerosols (SOAs + SIAs). Important parameters for health are especially: PM_{2.5}, UFP, PSD, BC, PAH, and metals while important parameters for climate are: BC, BrC, AAE, PM_{2.5}, and PSD. He also presented the classification of measurable emission compounds.

5. In Session II, Petr Kubesa from the University of Ostrava presented different PM measurement methods including both the full flow and partial flow dilution methods for local space heaters burning solid fuels based on the literature reviews done in Action A1. He also presented results from VSB campaign focused on PM sampling methods. There was also a good discussion about different sampling methods both onsite and online, but no major conclusion regarding the methods was taken. According to the VSB campaign, EN-PME method produced higher PM concentration than the hot filter method. This was mainly because of the different starting time and duration of the sampling methods i.e. test protocols. Regarding the Full flow dilution tunnel (FFDT) method and EN-PME method, FFDT method produced higher PM emissions than EN-PME method mainly due to the largely differences in the methodologies. This proves once again dilution sampling method collects more condensed particles than hot flue gas sampling method
6. Prof. Jorma Jokiniemi from the University of Eastern Finland (UEF) presented a novel dilution sampling method for the measurement of residential combustion emissions which is the combination of porous tube and ejector dilution system. In his presentation, he reported that the particle losses during sampling/dilution of residential combustion emissions is minimal with this kind of sampling method.
7. Third presentation in session II was delivered by Claudia Schön from Technology and Support Centre in the Centre of Excellence for Renewable Resources (TFZ), Germany. She presented preliminary results from ongoing campaign at TFZ for the comparison of different sampling methods in hot and diluted flue gas. In her results, it was observed that there was little concentration of organics with the measurement of hot flue gas while the concentration increased with the diluted gas indicating dilution is important for capturing organic emissions. Similarly, the comparison between different sampling methods showed porous tube providing/collecting the highest emissions following dilution tunnel, hot filter and EN-PME in nominal load condition in log wood stove indicating that different sampling methods have impact on the measurement of particles. However, the concentration of particle emissions impacted also by the use of different wood species (higher with beech compared to spruce) in nominal condition in pellet stove. Yet, the increase in particle emissions with dilution in pellet stove was slightly lower compared to log wood stove indicating type of stoves also impact on the formation of emissions. The message of the presentation is there is clear increase in particle mass when flue gas is diluted.
8. The last presentation of Session II was delivered by Dr. Benjamin Cea from The French National Institute for Industrial Environment and Risks (INERIS). He presented PM emissions (solid+

condensable) results from four different PM sampling methods (dilution tunnel, porous tube, washing bottles filled with isopropanol (IPA), dilution chamber) used during the ongoing Ineris measurement campaigns for the measurement of residential wood combustion emissions. The presented results showed that the IPA method measured more particles compared to dilution tunnel and porous tube in the most experiments and porous tube provided/collected slightly lower particles compared to dilution tunnel, but all these methods showed good correlation between them in nominal combustion conditions. If the cold start was considered, porous tube produced slightly higher emissions than dilution tunnel method and much higher than IPA method, but was very good correlation between porous tube and dilution tunnel methods. This indicates that combustion conditions i.e. test protocols and user practices affect on the formation of emissions.

9. In IIIrd session, Michael Sattler from Ökozentrum Langenbruck in Switzerland emphasized why next generation particulate emissions measurement is needed in his presentation. The talk was in line with the objectives of Real-LIFE emissions project. He informed that a Swiss project will contribute to a new initiative in Europe for a next-generation particle measurement method. A report will be ready by Q1/23 and there will be stakeholder meeting in 2023 to discuss on how to proceed with project plan for necessary research and development works.
10. Dr. Alejandro Keller from the University of Applied Sciences and Arts Northwestern Switzerland presented measurement methods for RWC and emission components to be considered for a future standard. He suggested that number concentration is not a good metric for RWC emission measurement, but surface area can be a good metric. He argued that number-based metric would kill current and future emission reduction developments that promote the use of filters integrated into the appliance, especially those situated in or near to the combustion chamber. In addition, ultrafine particles (particle size) are important for health perspectives. He also reiterated the importance of secondary organic aerosol (SOAs) from biomass burning. Similarly, he suggested a new method to measure total primary carbon and SOA with an oxidation flow reactor (OFR) in combination with a gravimetric measurement method.
11. Dr. Josef Wüest from the University of Applied Sciences and Arts Northwestern Switzerland presented particle count and diameter as an alternative to the filter method. He highlighted an instrument (Dilution Size Classifier (DiSC)) to measure LDSA and reiterated LDSA could be a new metric for particle emission measurement in residential combustion.
12. Franziska Kausch from SINTEF Energy Research AS in Norway presented characterization of gaseous species and PM using dilution approaches and comparison of the Norwegian standard NS3058/59 and EN16510 with EN-PME. She presented the results from various load conditions in different wood stoves to test these methods. The presented results in her presentation showed that the stoves with small combustion chamber produced low emissions including OGC and high fuel load produced low OGC but opposite for CO emissions. She suggested the overload test is required for better measurement results and proposed amendments for that.

Apart from this, there were also very good discussions in the Q & A chat panel. There was the discussion about the definition of condensables, emphasizing that this should be defined correctly in the future measurement methods. One attendee in the chat suggested LDSA can be a new dose metric as stated also in the presentations. There was also a lot of discussions about various sampling methods such as dilution tunnel, porous tube and ejector diluter method and disadvantages of dilution tunnel method (e.g. it is not well mixed). It was informed by an attendee in the chat that method 5H is no longer valid in US and US EPA is assessing real-time PM measurement methods with new requirements for dilution tunnels at the moment.

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