

# Position Paper for a NEXT GENERATION PARTICLE EMISSIONS MEASUREMENT METHOD

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Authors:  
Members of the NGPEMM-consortium.

## **Foreword**

Residential solid biomass fuel burning appliances and biomass boilers are an essential component of a net zero CO<sub>2</sub> energy supply for Europe with high regional added value. Biomass burning is still associated with ambient particulate matter pollution, which has been linked to negative human health and environmental impact. This pollution originates from primary particulate matter emitted during combustion as well as from secondary particulate matter generated by atmospheric processes following the emission of gas-phase species. Future efforts to develop new appliances with optimized combustion properties and/or integrate secondary emission reduction technologies must focus on minimizing the negative effects of the emissions without limiting the potential of biomass as a climate-neutral fuel. This must be based on environmentally relevant emission limit values, which in turn will be determined by advanced measurement methods.

The need for new measurement methods and procedures to quantify emissions from biomass-burning stoves and boilers is already foreseeable due to the political will to achieve net-zero CO<sub>2</sub> emissions while maintaining good air quality to protect human health.

This position paper summarizes the opinions of various experts on measurement methods currently under discussion and outlines a new measurement method based on the many years of experience of various consortium partners from industry, academia and government. The measurement method outlined is not based on current legislation but anticipates possible future legal requirements.

## **Gravimetric measurements – total dust measurement with hot filter**

The measurement of total dust by gravimetric filter measurement in hot flue gas is commonly used today but does not meet the requirements for a future measurement method, as it does not detail the diversity of the emissions and does not capture the potential formation of secondary particulate matter. It is therefore difficult to draw conclusions about health or environmental impacts from the mass value obtained from gravimetric filter measurement.

Nevertheless, the gravimetric measurement of total dust has several advantages. It allows comparability with previous measurements, gives laypersons an idea of what is being measured and

makes it possible to compare ambient concentrations against emissions - even though this relationship is subjected to large uncertainties.

Today, the total dust measurement with filters is reaching its detection limit. Validated total dust measurement methods are increasingly being technically adapted in order to accurately measure the very low emission levels of modern biomass burning appliances, such as state of the art boilers. We anticipate that gravimetric total dust measurement will still be required in the long term as a control measurement to ensure that appliances have very low emissions. However, other measurement methods – outside the “comfort zone” of gravimetric filter measurement – will be required to determine the quality of the emissions.

### **Number concentration measurement**

Number concentration is a very easily scalable variable that can be used over a wide range of emission. Together with state-of-the-art devices, this quantity can also be measured with small and inexpensive devices, although the accuracy of inexpensive devices is often questionable. Some studies point out that the number concentrations of particulate matter measured in ambient air provides information about the impact to health.

The problem with measuring the number concentration of flue gases is the measurement location. This metric is not conserved and therefore the number concentration of particles in the flue gas of biomass burning appliances does not allow any conclusions to be drawn about the environmental impact. Furthermore, the dynamics of particle coagulation in the flue gas does not allow conclusions to be drawn about the quality of the combustion. This, together with the formation of particulate matter in the atmosphere, makes it impossible to predict the impact of the emissions based on this metric. In other words, measuring the number concentration in the flue gas from biomass burning appliances does not add relevant information. Nevertheless, complementing the number concentration with size information from, e.g. the size distribution, provides valuable information about total dust emissions. This combination of number and size could be used to determine very low total dust emissions from optimized furnaces and boilers.

### **Supplementary measurements with focus on health and environment/climate**

- **Condensable particulate matter (CPM)**

The term "condensables" is mentioned today by various regulatory authorities without a clear statement about its definition. This refers to species that are in the gas phase under stack conditions and condenses into particulate matter as the emissions cool and are diluted under ambient conditions. It can be assumed that CPM, similar to the different carbon fractions of the following section, will have to be defined by a measurement method.

The measurement of CPM is considered of interest because it provides an indirect estimate of the emitted organic carbon fraction that cannot be captured by current hot filter methods. This, in turn, could give an indirect estimate of the formation of secondary organic aerosols. Both components, organic carbon and secondary organic aerosols, are considered to be relevant to the impact of emissions. Therefore, it can be argued that the measurement of CPM complements the measurement of total dust with a hot filter. Nevertheless, the information gained on the formation of secondary organic aerosols and the organic carbon fraction, through the measurement of CPM, is fraught with great uncertainties.

- **Total Carbon, Black Carbon, Elemental Carbon, Organic Carbon**

Part of the particulate matter emitted by biomass burning appliances consists of carbonaceous compounds. However, measuring the different carbonaceous fractions is not trivial as the definition of these fractions does not refer to specific substances. Instead, fractions such as black carbon, elemental carbon and organic carbon are defined operationally by the measurement method and/or by the behaviour of the sample during analysis. Only the measurement of total carbon is independent from the measurement device, as no division into different fractions is necessary.

There is agreement that carbonaceous particles are probably relevant to the environment and health. Black carbon is also particularly relevant for the climate effects.

- **Secondary Organic Aerosols (SOA)**

The potential formation of secondary organic aerosols in the atmosphere from gaseous emission of furnaces is well known in the scientific community. It is considered an important element when measuring (particle) emissions with relevance to health and environment. The main drawback of this measurement method so far is the lack of experience as a standardize approach. It is sometimes considered only of scientific interest and relegated to expensive measurement campaigns at specialized scientific facilities. In recent years, devices (i.e., oxidation flow-reactors) for producing SOA have become increasingly available on the market. The time therefore seems to have come to take a closer look at this technology.

### **Suitability to measure after ESP's**

In the future, small scale solid fuel burning appliances and boilers will reduce particulate matter emissions by improving their combustion. In addition, secondary emission reduction measures such as electrostatic precipitators (integrated or at the end of the exhaust duct) will become state of the art. This leads to the clear requirement that a future measurement method must be able to quantify emissions from appliances equipped with secondary emission reduction technology. In particular, electrostatic precipitators can cause sampling problems due to the electrical charging of particulate matter.

### **Price for measurement equipment.**

The price of a measuring device that meets all the requirements of a future measuring probe cannot be defined now.

There are basically two views on price:

- The price of a measuring device is measured by the relevance of the information supplied. A measuring device that perfectly meets all requirements may well cost a lot of money. If the measuring device can be used for a large number of measurements by the test centres, amortisation is possible within a reasonable period of time.
- The price of a new measuring device must take the buyer's perception into account. High acquisition costs delay the purchase of a new measuring device and thus prevent the rapid introduction of a new measuring method, or the new measuring method may be rejected in advance without proper evaluation if the price is perceived as too high.

## Proposal for a Project setup to define a Next Generation Particle Emission Measurement Method

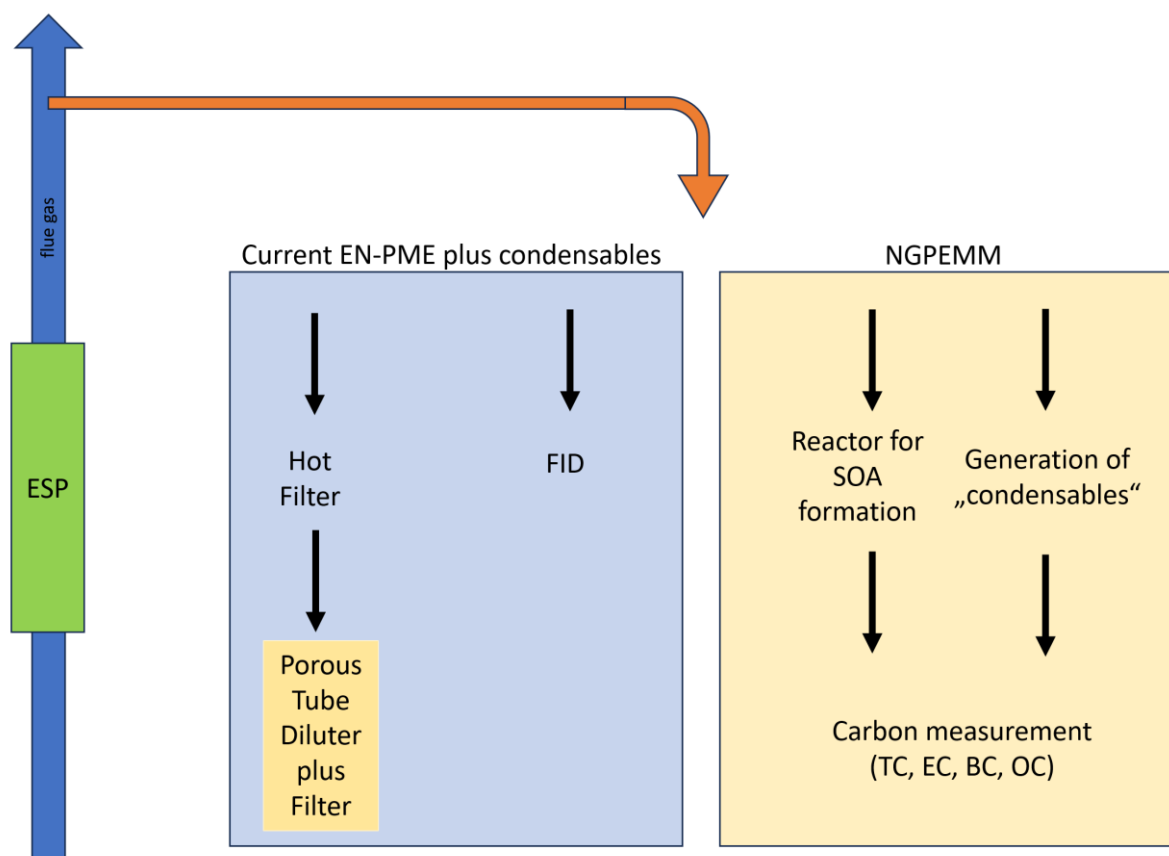
The need to replace the current measurement method (EN-PME) with a measurement method that provides significantly more information about the effects on health and environment is undisputed. This is also shown by the various current efforts to measure the "condensables" in addition to the EN-PME method. We expect this process to take approximately 10 to 15 years based on the experience with the introduction of the EN-PME method.

A future measurement that not only detects particle emissions directly at the end of the exhaust duct, but also enables an estimate of the particles subsequently generated in the atmosphere, is welcomed by all stakeholders.

In addition, in the future a metric is needed that provides an estimate of the environmental and health effects of the emitted particles (or potential particle precursors).

The approach for a future measurement method can be seen as an optimized measurement of the Parameters, that up to now are approached by measuring the condensable fraction in the flue gas.

Proposed measurement Setup for the research project NGPEMM:



This setup is the starting point for the definition of an upcoming research project with the goal to define a Next Generation Particle Emissions Measurement Method. This setup allows to compare current measurement methods extended with the measurement of condensables (left part in blue) with future methods of particle analysis such as carbon content measurement with optimal pre-treatment such as a reactor for SOA-formation or techniques to condense flue gases (right part in yellow).

This position paper only defines the basic elements of an upcoming research project to develop a NGPEMM. The detailed project layout will be defined in further meetings until March 2024 among the consortium partners/stakeholders willing to participate. The start of the research project is planned for 2025.