



**RÉPUBLIQUE  
FRANÇAISE**

*Liberté  
Égalité  
Fraternité*



*maîtriser le risque  
pour un développement durable*

## **CCQM WORKSHOP ON PARTICLE METROLOGY 25 TO 27 OCTOBER 2022, BREAK OUT SESSION 26 OCTOBER**

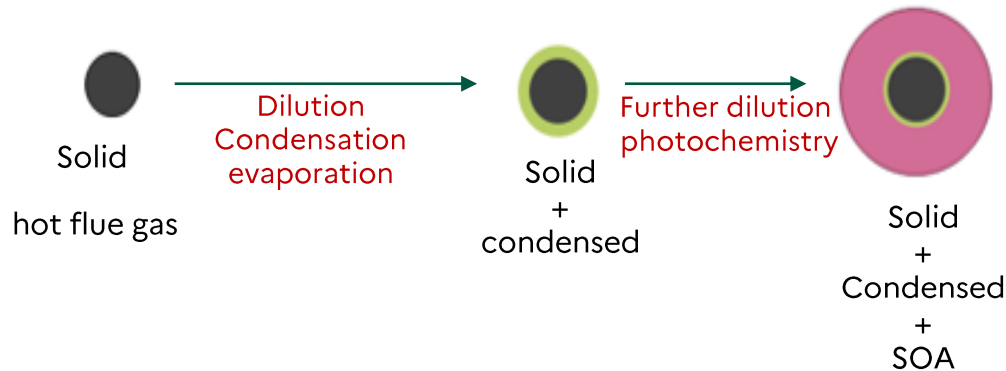
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**PM emissions from residential wood combustion appliances:  
why and how to characterize condensables ?**

## Air pollution due to domestic wood combustion

- Wood combustion appliances : main source of contribution to PM and PAHs emissions in most European countries (exemple France, CITEPA 2022 PM2.5 43%)
- Development of biomass combustion as an alternative to fossil energy (climate change mitigation/renewable energy/more recently increase of cost of energies)
- Aerosols emitted by wood combustion include solid and condensable particles

**Condensables:** class of organic compounds that are vapour phase at stack conditions, but which undergo both condensation and evaporation processes as the stack air is cooled and diluted upon discharge into ambient air

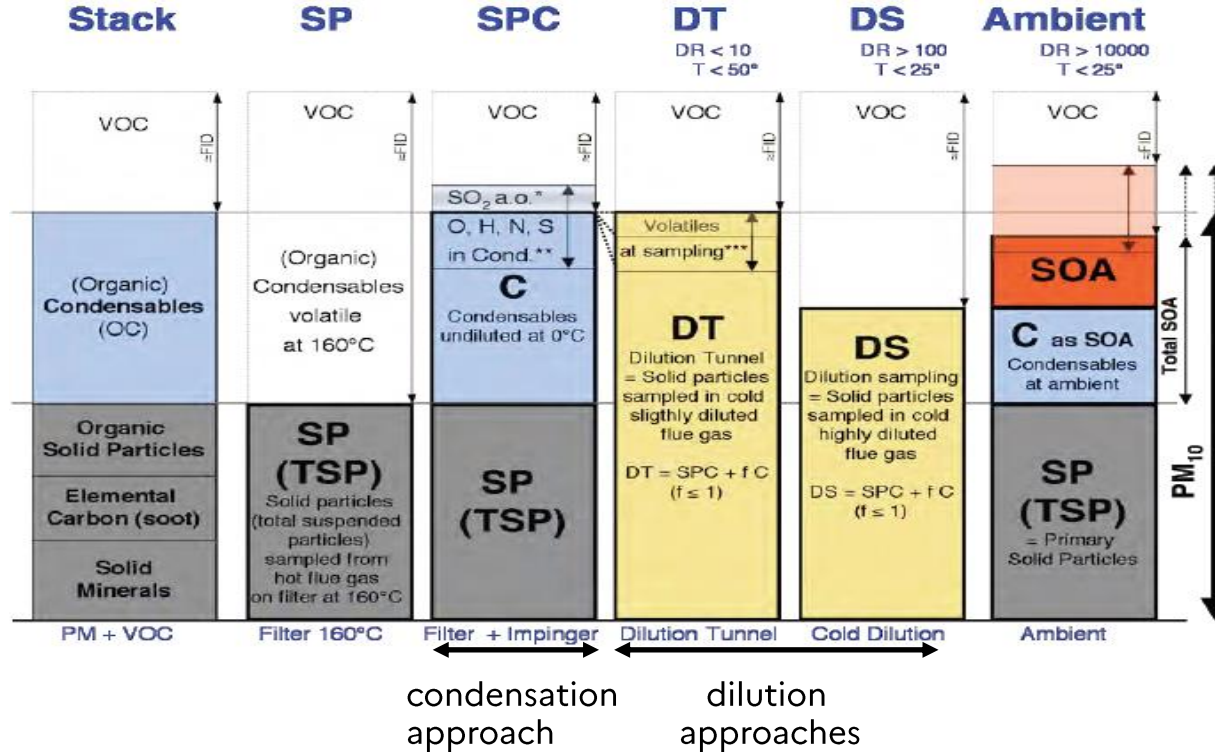


Sources:  
*Emissions of particles and organic compounds from small and medium scaled biomass combustion, RISE, Impress 2 project, EMEP Technical Report MSC-W 4/2020),*

# Why is it so important to characterize condensables?

- Condensables emitted by domestic wood combustion represent a large part of particles measured in ambient air in winter
- Emissions of condensables:
  - are strongly linked to the quality of combustion and the performance of appliances;
  - represent the major part of the aerosol emitted when woodlog appliances are operated under real life conditions of combustion.
- Condensables have significant implications for the modelling of organic aerosol and therefore PM levels in the European atmosphere (EMEP Technical Report MSC-W 4/2020), inconsistent inclusion of condensables in national emission inventories leads to (*Denier Van Der Gon et al. 2015*):
  - underestimation of emissions from wood burning by a factor of 2 to 3 for countries with inventories where condensables are not included;
  - major underestimations of organic aerosol modelled in winter time, in comparison with observed concentrations, especially for regions dominated by residential wood combustion

# Inclusion of condensables , a method dependant problematic



Source: Nussbaumer, 2008

## Condensation approaches

### Principle:

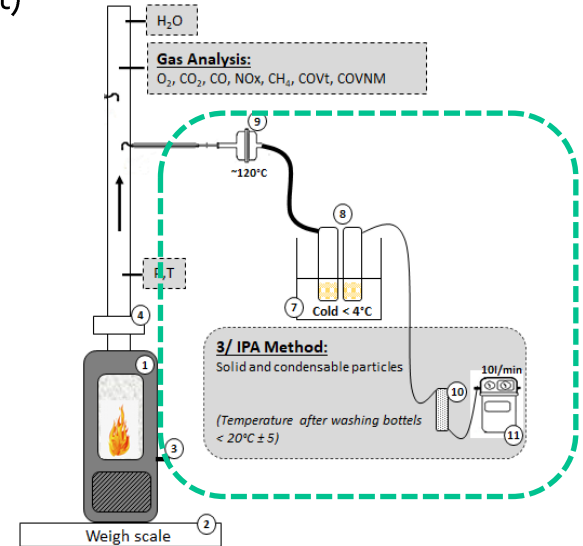
Hot flue gas from the stove sucked through a heated filter combined to cooled impingers filled in with a condensation solution (water or solvent)  
 Solid PM mass determined by weighing of the filter, condensables PM determined by dry extract of the condensation solution

### Sampling conditions:

- Flue gas temperature between 120 and 160°C
- Impinger temperature sampling
- separate sampling of solid particles and condensable

### Methods:

- US EPA 5H (American standard): US EPA 5H (American standard): Heated filter+ water impingers
- Heated filter+ isopropanol impingers (Ineris internal method)



## Dilution approaches: full flow dilution tunnel

### Principle:

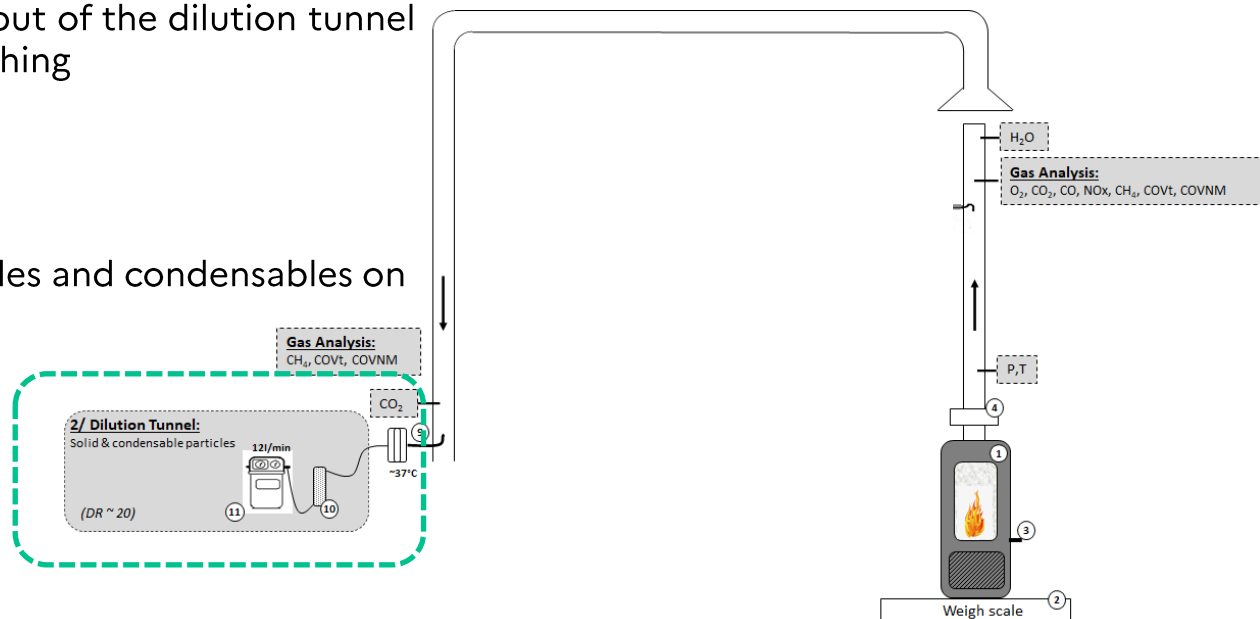
- Hot flue gas from the stove entirely sucked through the tunnel and mixed/diluted with non filtered ambient air
- PM collected on a filter at the output of the dilution tunnel
- PM mass determined by filter weighing

### Sampling conditions:

- dilution ratio about 10-20
- Temperature 35-40°C
- combined sampling of solid particles and condensables on a filter under ambient conditions

### Methods:

- US EPA 5G (American standard)
- NS 3058-2 (Norwegian standard)



## Dilution approaches: partial flow dilution

### Principle:

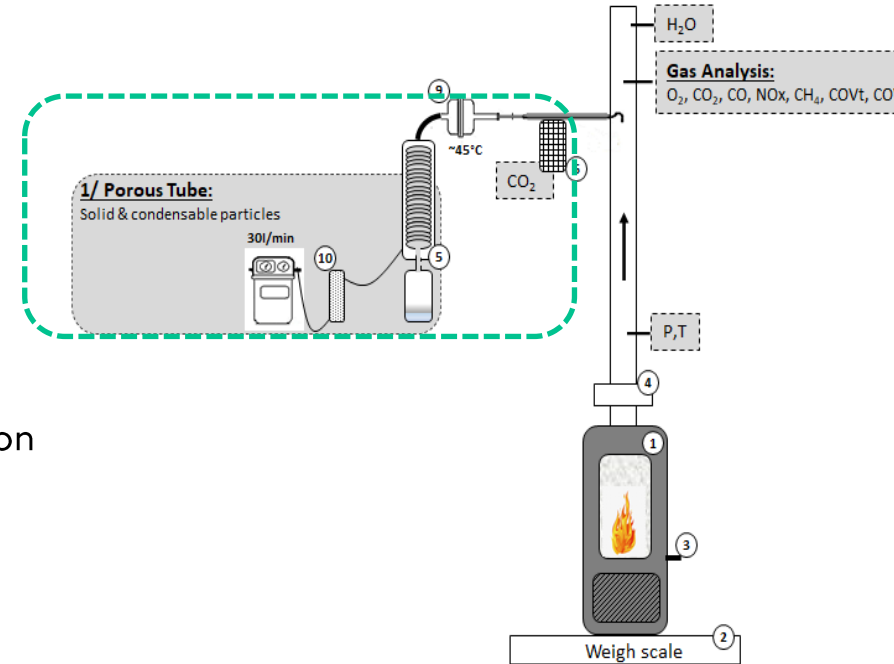
- Hot flue gas from the stove partially sucked through a probe connected to a dilution tube/chamber, mixed to/diluted with filtered air
- PM collected on a filter at the outlet of the dilution tube or chamber
- PM mass determined by filter weighing

### Sampling conditions:

- Variable dilution ratio
- Temperature 35-50°C
- combined sampling of solid particles and condensables on a filter under ambient conditions

### Methods:

- Porous tube
- Dilution chamber (*Hugony et al, 2019; C ea et al, 2021*)



# Ineris experimental platform



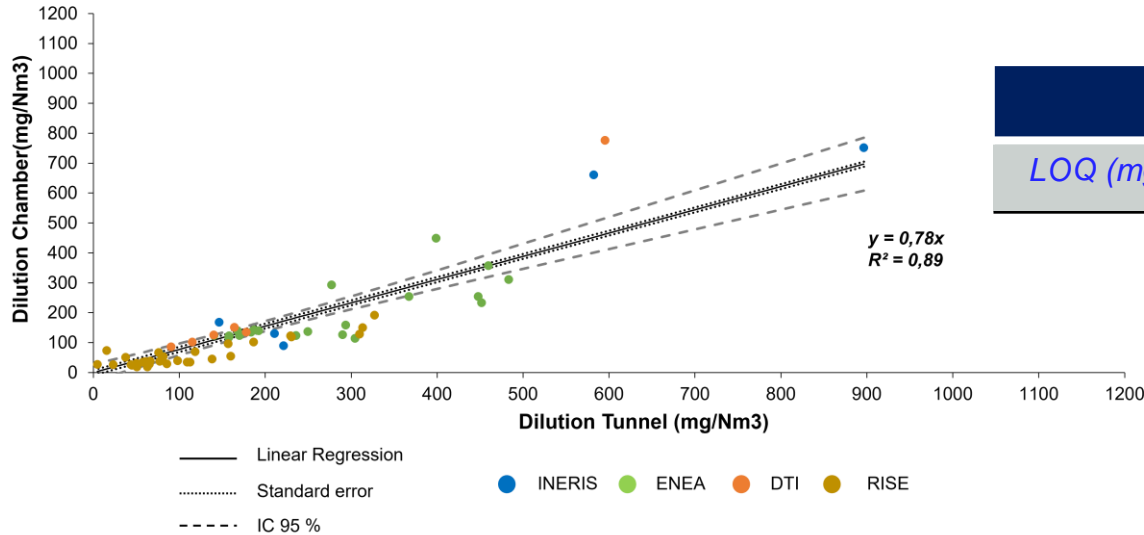


## Performances and comparability DT/SPC

	Correlation	Correlation factor (R <sup>2</sup> )	Source
<b>SPC (water) vs DT</b>	SPC eau= 1,820 (DT) <sup>0,83</sup>	0,52	US EPA
<b>SPC (IPA) méthode DT</b>	SPC IPA = 0,97 (DT)	0,92	INERIS

## Performances and comparability

DT/Dilution chamber, *Céa et al 2021*



	DC method	DT method
LOQ (mg/Nm <sup>3</sup> )	16,3	53,3



*Impress 2 project 2017-2022, EMPIR project coordinated by NPL*

## Performances and comparability

DT/Porous tube  
SPC/Porous tube

On going work...



*Real LIFE emissions project, 2021-2024, Life project coordinated by UEF*

# Conclusions

**Wood combustion appliances : main source of contribution to PM and PAHs emissions in most European countries (exemple France, CITEPA 2022 PM2.5 43%)**

**Condensables emitted by domestic wood combustion represent a large part of particles measured in ambient air in winter**

**Condensables have significant implications for the modelling of organic aerosol and therefore PM levels in the European atmosphere (EMEP Technical Report MSC-W 4/2020), they need to be consistently included in European emission inventories**

**Measurement methods allowing inclusion of condensables are based on dilution and condensations**

**-standard methods**

**-newer methods being evaluated**