Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

INNOVHUB
STAZIONI SPERIMENTALI
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innovazione e ricerca

Conception and evaluation of performance of a dilution chamber to collect solid and condensable fractions of PM emitted by wood logs and pellets stoves

IMPRESS II Stakeholder meeting, 11th january 2021

Francesca Hugony, ENEA - DUEE – SIST – NORD
Carmen Morreale, Gabriele Migliavacca ISSI – Area Combustibili

IMPRESS II - WP2: Objective to sutisfy

- ✓ To develop validated reference measurements methods for SVOCs, OGC, PAHs (including benzo[a]pyrene) and PM from small scale combustion sources.

- ✓ To provide input to the development and/or revision of standards related to the emissions of semi-volatile organic compounds (SVOCs), particulate matter (PM), polyaromatic hydrocarbons (PAHs) and organic gaseous carbon (OGC)

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

IMPRESS II – WP2: Background

EN 16510-1:2018 Residential solid fuel burning appliances - Part 1: General requirements and test methods

- ✓ It also covers the CO, NOx, OGC/total hydrocarbons and PM emission test methods
- ✓ OGC: with FID (VOC)
- ✓ PM: 3 different methods
  1. Gases extraction after combustion chamber; T filter 70°-160°C; constant sampling volume (HF)
  2. Gases extraction at a dilution tunnel (DR: 10-20); T filter 30-40°C; isokinetic (DT)
  3. Electrostatic precipitator

→ Eco-Design dir. ≠ thresholds for PM

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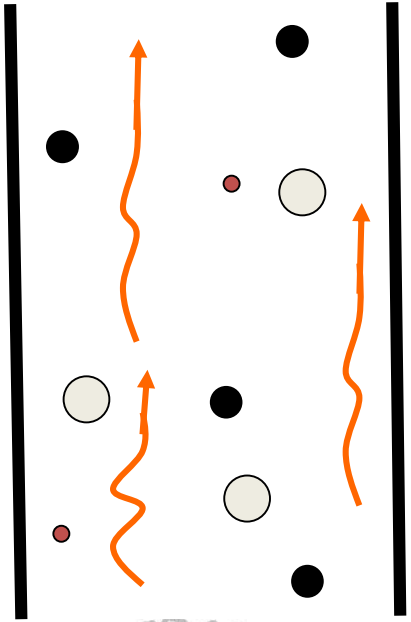
IMPRESS II - WP2: Objective to sutisfy



VOC: Volatile Organic Compounds

SVOC (PAH), VVOC

Inorganic Gas Emissions

NOx, SO2, CO, CO2, H2O

COC: Condensable Organic Compounds (C/H < 2)

Soot: Elemental C (C/H > 8)

Primary Inorganic Particles (PIA)

Salts

[1] Nussbaumer, NYSERDA final Report, 2008

Lowering of the temperature and changing of their surface pressure, they can form solid particles due to nucleation and condensation processes [1]. leading to the formation of **condensable particles.**

Organics are the main contributor to the total mass of particles (93%; wood boiler) [2]

[2] Elsasser et al. Energy Fuels 2013, 27, 4959−4968

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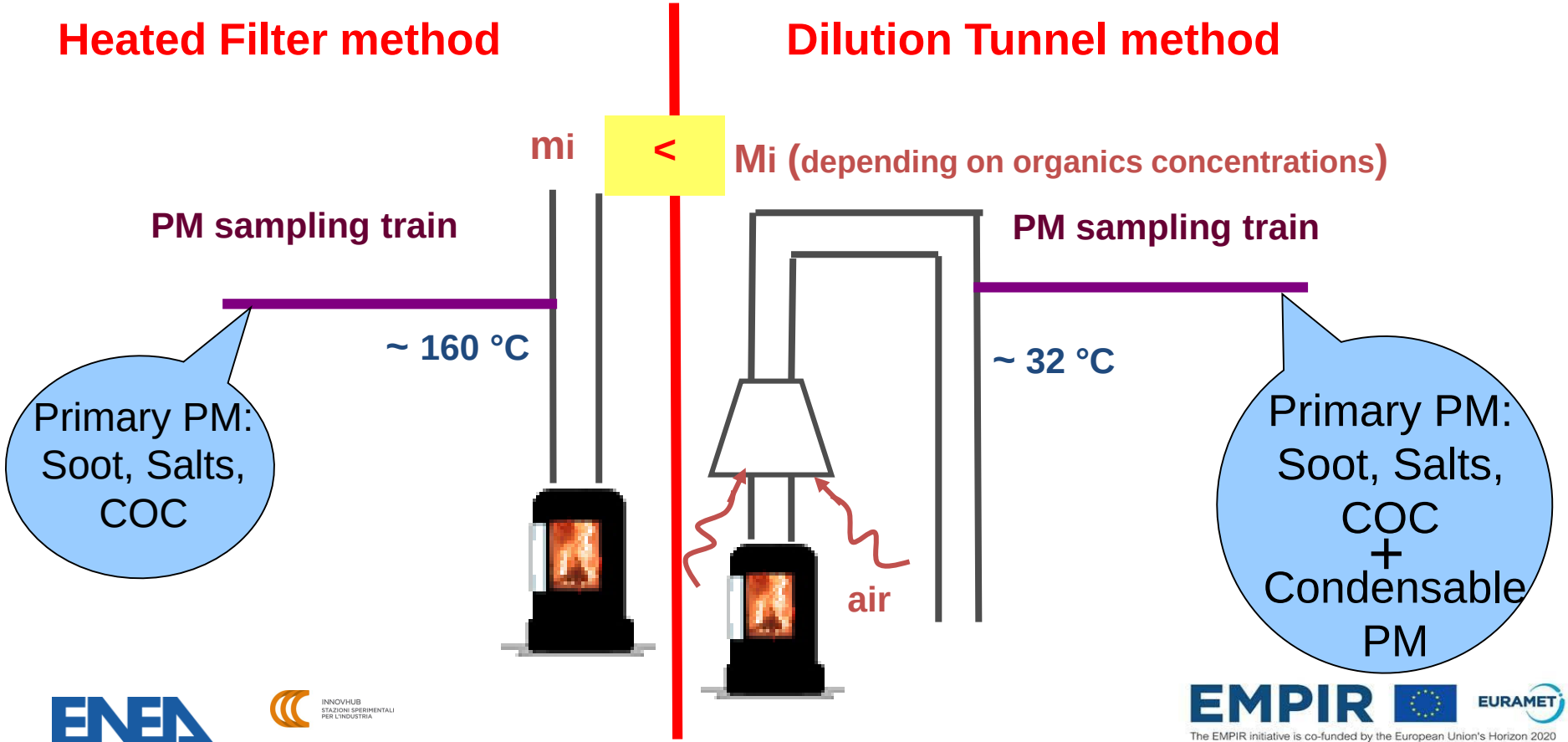
IMPRESS II – WP2: Comparison of Std methods



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IMPRESS II - WP2

Advanced set-up, candidate to be the harmonized EU method (Standard, Eco-Design)

A2.1.2	INERIS, RISE and DTI will each perform on the INERIS Stack Simulator Facility solid PM and OGC measurements in accordance with EN_PME_TEST. The partners will then carry out an intercomparison and the results will be summarised by INERIS in a paper.	**INERIS,** RISE, DTI
A2.1.3	DTU with support from INERIS will perform at least three PM/OGC (including PAH and SVOC) in-situ/on-line UV measurements at the Stack Simulator facilities of INERIS. These results will be compared with EN_PME_TEST method and summarised in a presentation.	**DTU**, INERIS
A2.1.7	ENEA, INERIS, RISE, ISSI, DTI and DTU will perform at their sampling facilities a total of 80 parallel tests of condensable and solid PM measurements using the dilution chamber developed in A2.1.5 against heated filter, dilution tunnel methods on a wood stove (10 tests) and a pellet stove (10 tests).	**ENEA,** INERIS, RISE, ISSI, DTI, DTU
A2.1.8	INERIS, RISE, ENEA, ISSI and DTI will perform at their sampling facilities a total of 80 parallel tests of SVOCs (including PAHs) measurements will be performed using the dilution chamber developed in A2.1.5 and other SVOCs methods identified in A2.1.4 against traditional method on a wood stove (10 tests) and a pellet stove (10 tests).	**INE** EN

Development of a new test method for condesable PM measurement

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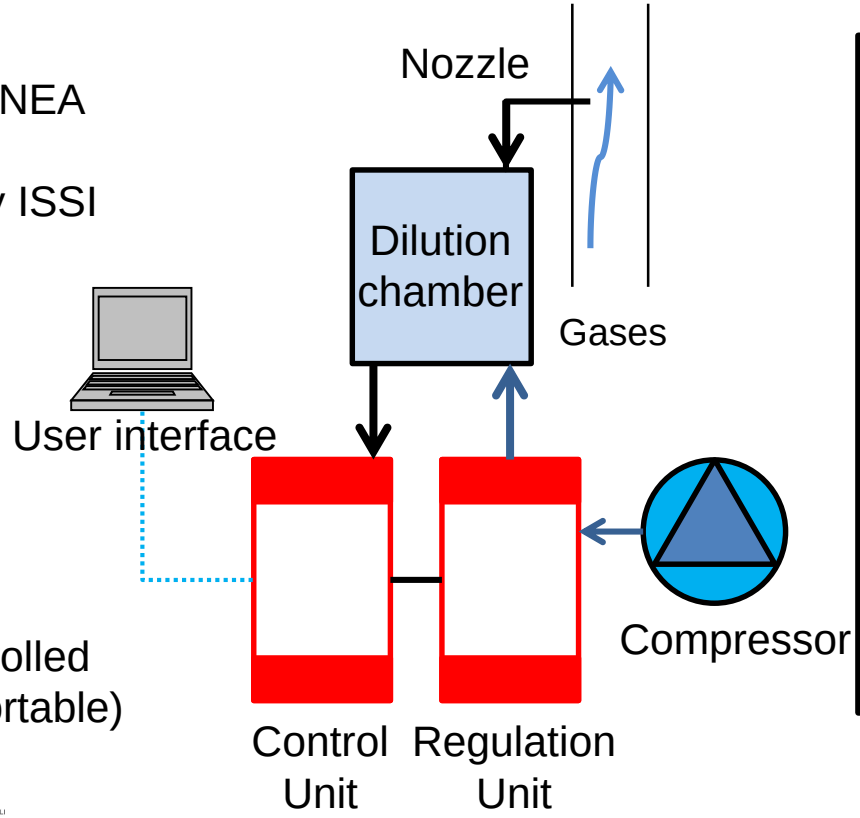
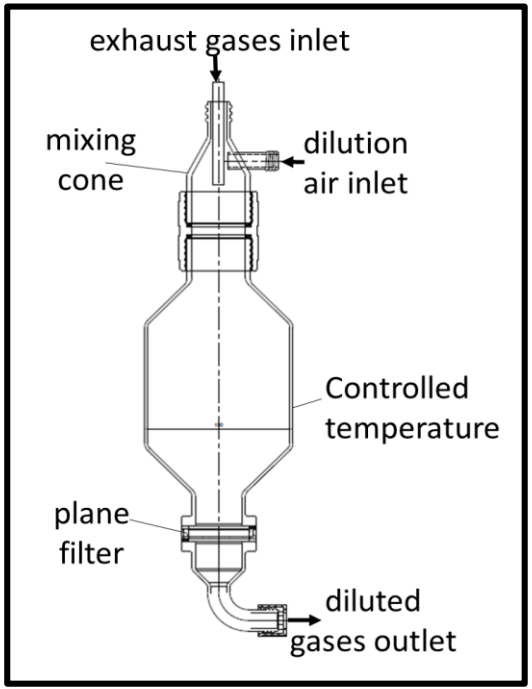
ISSI/ENEA dilution chamber method

New dilution chamber designed by ISSI and ENEA

One protoype owned by ISSI



Dilution chamber



Characteristics:

- ✓ Based on Dilution
- ✓ Overcome DT disadvantages (controlled air, controlled DR, portable)

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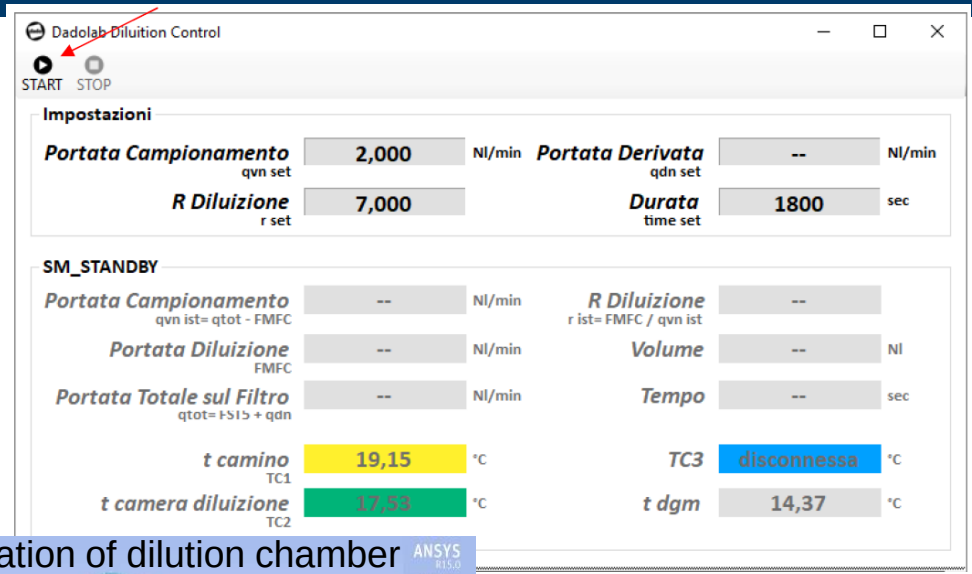
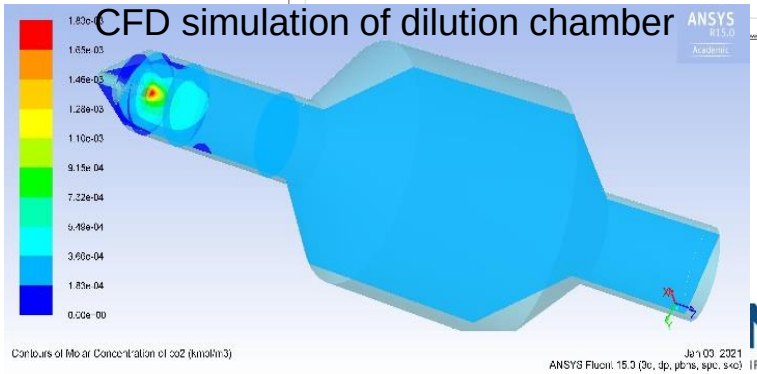
ISSI/ENEA dilution chamber method

- ✓ Automatic regulation and control
- ✓ Constant Volume sampling (no isokinetic)
- ✓ Heated nozzle (Tgases)
- ✓ Integrated plane filter (47mm)
- ✓ Air dilution pre-treated
- ✓ Pre-mixing cone
- ✓ Residence time: 0,5-3s



CFD simulation of dilution chamber



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ISSI/ENEA dilution chamber method

ISSI Lab

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IMPRESS II - WP2: experimental campaign

Lab	HF/EN-PME-TEST	Heated filter + washing bottles	Dilution Tunnel	Dilution chamber method	OGC /FID
DTI	X		X	X	X
RISE	X		X	X	X
ISSI/ENEA	X		X	X	X
INERIS	X	X	X	X	X

SVOCs analysis	
DTI	FID; FTIR TD/GC/MS analysis of filters collected using the dilution chamber (PAHs)
RISE	FID; FTIR TD/GC/MS analysis of adsorption tubes (BTEX and PAHs)
ISSI/ENEA	GC/MS analysis of filters collected using the dilution chamber, dilution tunnel and heated filter (PAHs)
INERIS	FID GC/MS analysis of filters and IPA solutions collected using the heated filter+wahshing bottle method (PAHs and SVOCs by volatility class)

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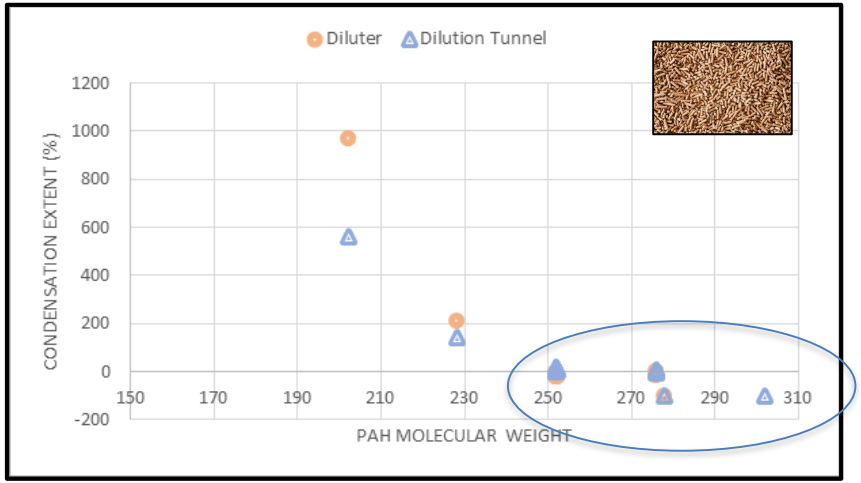
WP2: PAH analsys (IT) for DC verification

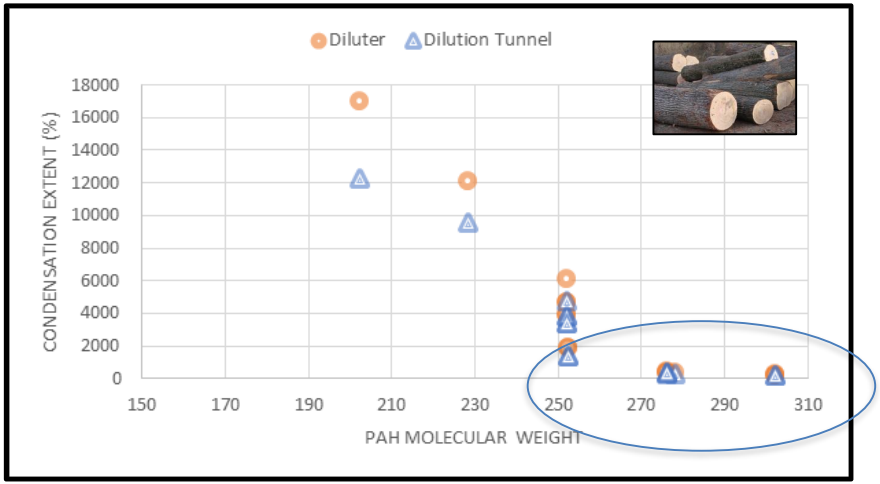
Calculation

- ✓ PAH/PM [%]
- ✓ PAH% in Dil/DT respect to HF
- ✓ PAH species categorize by their molecular weight

Comments

- ✓ PAH increasing wood logs: 10 times pellet
- ✓ Species>250amu: solid @T(HF)
- ✓ Species<250amu: effect of condensation





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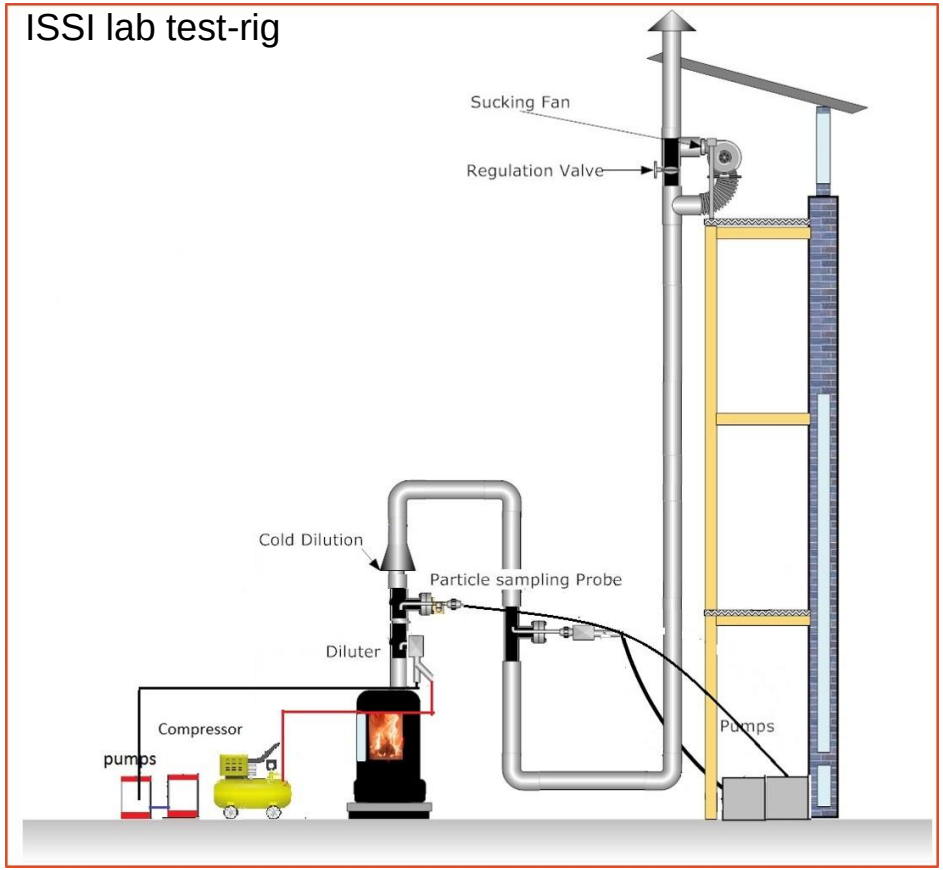
WP2: experimental campaign

ISSI lab test-rig



Pellet and wood logs stoves	6-10 kW

Sampling conditions	DC	HF/EN-PME	DT
Gas flow extraction [NL/min]	2	8-9	6-9
Dilution Ratio	8-9	0	8-25
T sampling [°C]	30-40°C (230-500°C)	80-120-180°C	30-60
Sampling duration [min]	20/30	20/30	20/30

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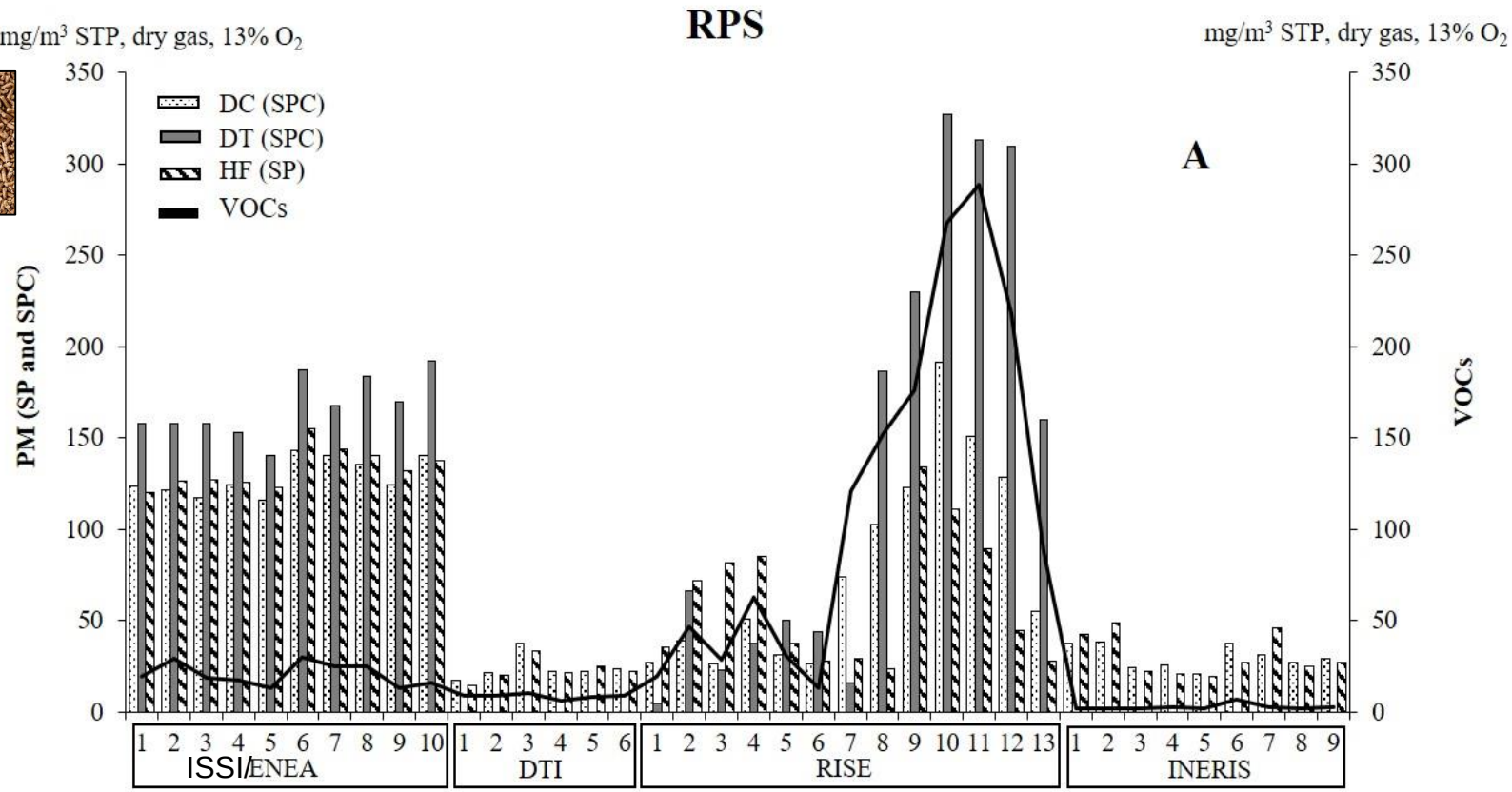
WP2: experimental campaign



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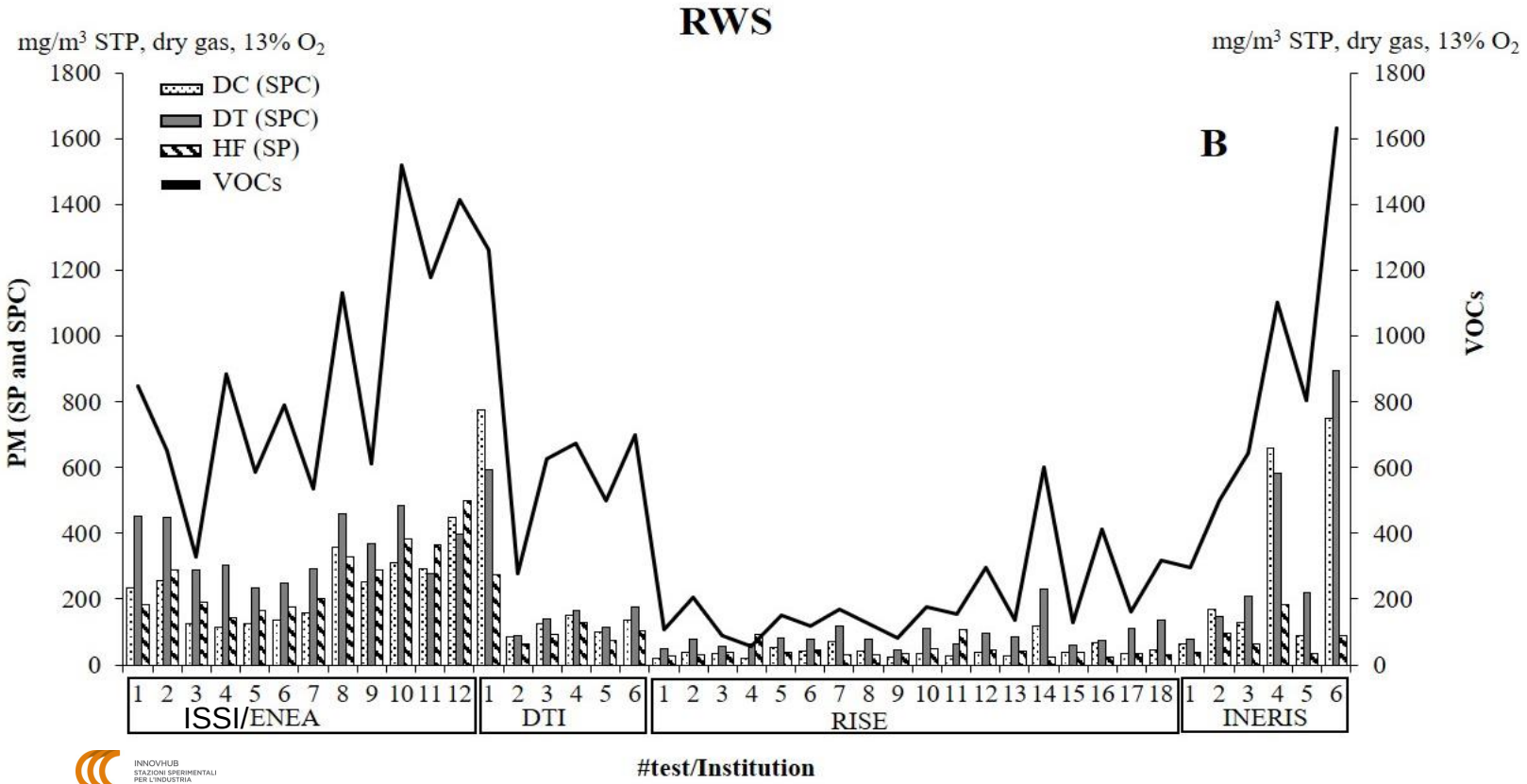
WP2: experimental campaign



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Coclusions

- ✓ To reduce the impact on air quality of the solid biomass heating generators all over Europe, it's important to find a unique harmonized method to measure PM (CE Mandate)

- ✓ The new method should take into account SVOCs (toxic and carcerogenic), therefore it should be based on dilution to measure also condensable PM

- ✓ The new method based on Dilution Chamber, set up by IMPRESS II, could be feasible to these purposes. System engineering and further testing is required!!

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Thank you!
Any questions?

ENEA

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