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$PM_{2.5}$ emissions from Energy from Waste Plant

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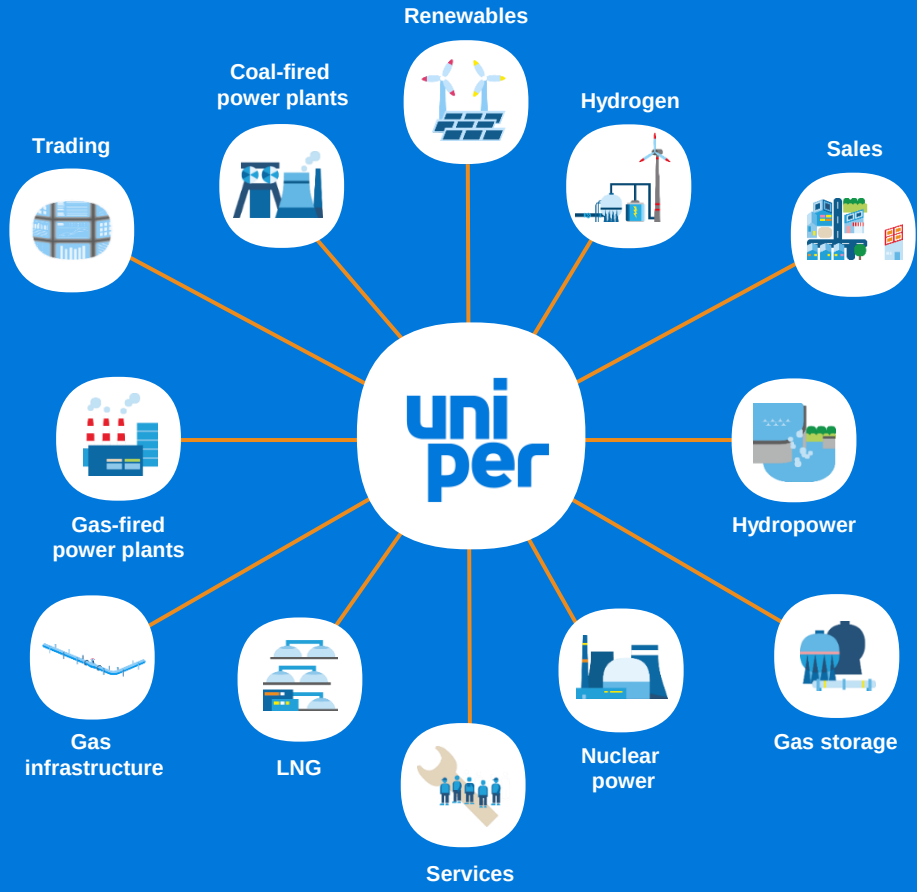
At a glance

- **7,000 employees** ensure security of supply in Europe
- Active in more than **40 countries**
- **~ 22.5 GW** generation capacity
- Entire business to be carbon-neutral by **2040**
- Gas portfolio consisting of roughly **200 TWh**
- **€3.7** Adj. EBIT (HY 2023)

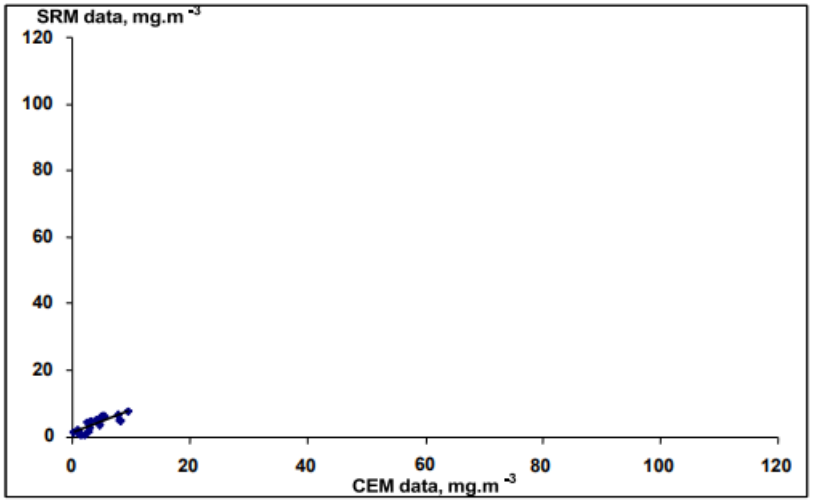


Background

- Energy from Waste (EfW) plant ← Environmental Permitting Regulations ←
- Industrial Emissions Directive (IED) and Waste Incineration BREF
- Emission Limit Value (ELV) for total dust in mg/Nm^3 @ 6 to 11 $\%O_2$ dry (273K, 101.3 kPa)
- Dust = Total (Filterable) Particulate Matter (TPM)
- IED Daily ELV = 10 mg/Nm^3 ; ½ Hourly ELV = 30 mg/Nm^3
- WI-BREF Daily BAT-AEL = < 2 – 5 mg/m^3
- Continuous monitoring with CEMS calibration based on extractive gravimetric sampling (EN 13284-1) according to EN 13284-2 and EN 14181 [BAT 4]
- Bag filters are a generally applicable Best Available Technique (BAT) for dust control
- Emissions from abated plant are very low (<< 2 mg/Nm^3)
- Not possible to derive a CEMS QAL2 calibration function via EN 13284-1

UK Technical Guidance Note M20 (QA of CEMS)

- Low level data cluster (accept if linear with $R^2 \geq 0.5$ for dust)
- If the emissions are typically < Maximum Permissible Uncertainty (MPU) of 1.5 mg/Nm^3 then an Annual Surveillance Test (AST) is permitted with 5 * 1.5h tests



In order to derive a reliable calibration function EN 14181 requires the following:

- A good spread of data, or medium to high-level clusters (including values near zero)
- An acceptable level of accuracy and precision for the Standard Reference Method (SRM) or reference materials
- A regression line which passes through zero, or near to zero (<5% of the Daily ELV)

- 'Procedure (c)' enables zero and span data to be added to the calibration

UK Technical Guidance Note M20 (Environment Agency)

- Whenever there are low-level clusters, the uncertainty of the SRM will be proportionally greater … there will be a greater degree of relative scatter of data points … the test laboratory cannot produce a reliable calibration function
- Surrogates may be useful for zero, span and linearity tests, but the resultant data cannot be meaningfully related to PM concentrations so ‘Procedure c’ cannot be used
- In these cases, there are three options available to set up a CEM:
  - If the SRM average PM > SRM uncertainty then it may be feasible to use the average value to calibrate the CEM
  - If there are sufficient data available from the site, or from similar sites with higher emissions, then the CEM supplier or test laboratory can calibrate the CEM based on experience and a best estimate of the CEM response.
  - Otherwise, the CEM cannot be used as a quantitative monitor, however, it can serve as a qualitative indicator:
    - verify that the emissions are low
    - check linearity, zero and span settings using surrogates
    - set the monitor to its most sensitive range to trend emissions for process control

UK Mass Emissions Reporting

- If the CEMS are calibrated then use the reported CEMS data (mg/Nm^3) with the measured stack flow (Nm^3/s) calibrated under EN ISO 16911-2
- If the CEMS are set up as indicative monitors, as per TGN M20, then use a conservative estimate of the annual total PM emission:
  - the normalised annual flow (for each line in the case of a multi-line plant) times
  - the highest single periodic monitoring result obtained over the last 3 years (for each line if applicable)
    - periodic monitoring includes all attempted QAL2/AST data (average of data set)
    - any further periodic monitoring specified in the permit or agreed in writing with Environment Agency (average of triplicate or more sample from any other single test campaign under normal operating conditions
  - Alternatively, Operators may instead assume that the plant operates constantly at 30% of the daily ELV (i.e. the maximum allowable uncertainty of 1.5 mg/Nm^3) and multiply this figure by the normalised annual flow

Assume TPM = PM_{10} = $PM_{2.5}$

Government funded project (Defra)

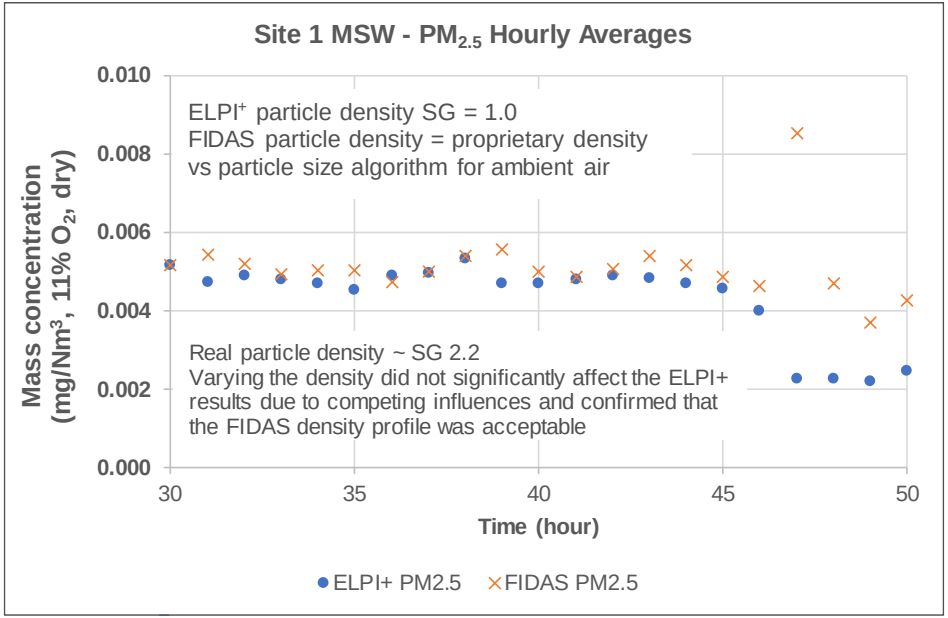
- Characterise $PM_{2.5}$ emissions at 3 EfW plants including 2 Municpal Solid Waste (MSW) incinerators and 1 waste-wood co-incinerator, using advanced instrumentation and focusing on emissions < 2 mg/m^3
- How low is low? Obtain hourly average mass concentration data and compare with CEMS response (QAL2) (all sites fitted with light-scattering CEMS)
- Obtain $PM_{2.5}$ and PM_{10} data since only TSP is measured for compliance and confirm that these emissions are very low
- Supported by gravimetric measurements to ISO 23210:2009 (insufficient mass).
- Determine Particle Size Distributions (PSD)
- Compare results with current reporting assumptions
- Review certified CEMS equipment in Europe and other regions
- Review literature to identify other potential candidate reference methods

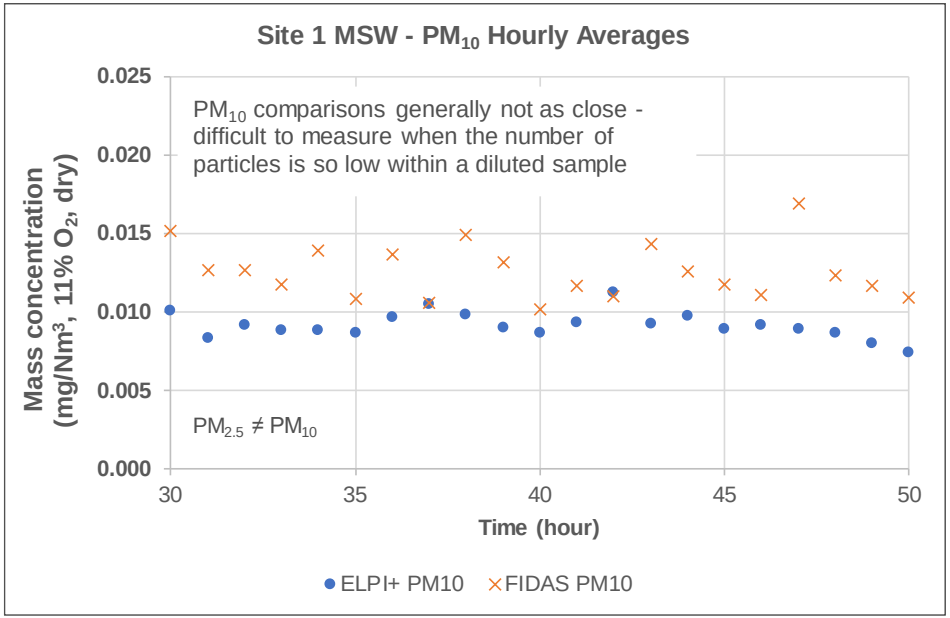
Field trials

- Primary measurement tool – used for the majority of industrial field trial studies - heated Dekati ELPI^{+} with no sample dilution (low pressure impactor with aerodynamic PM separation and particle counting by electrical discharge)
- Sintered plates and greased aluminium foils for particle collection
- Secondary measurement tool – air quality instrument measuring a diluted or dried sample – Palas FIDAS 200 – Optical light scattering of single particles
- Iso-kinetic sampling

Site 1 mass emission results (indoor sampling)

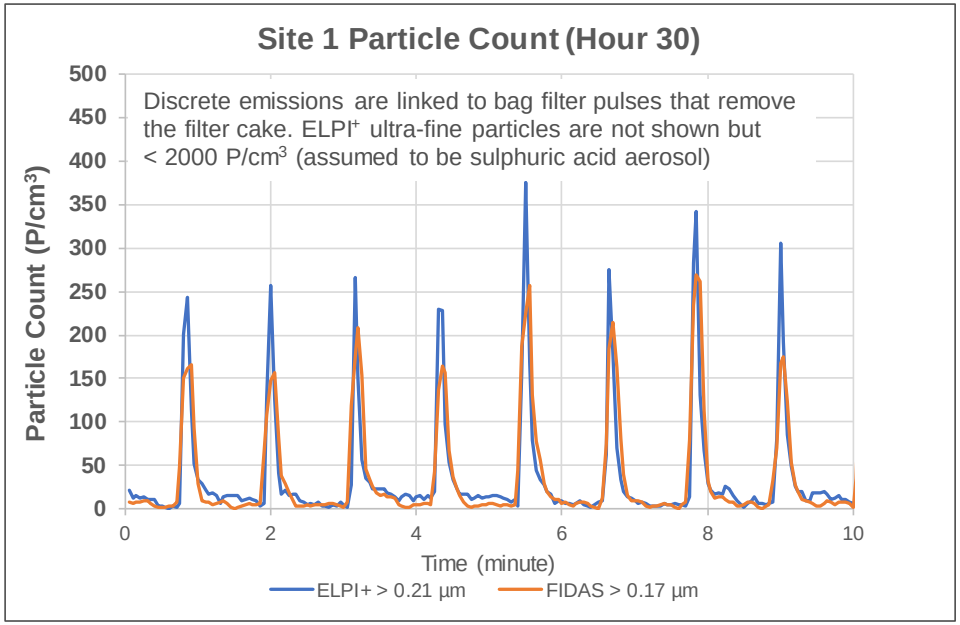
- Hourly average mass concentrations from test instruments (FIDAS dilution at ~ 10:1 - sufficient for indoor ambient conditions)
- CEMS generally did not respond - reading zero or zero offset - no QAL2

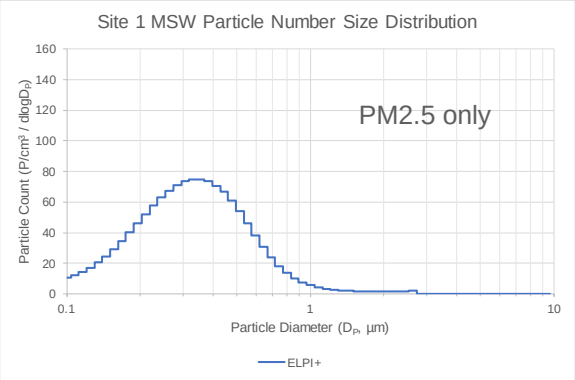


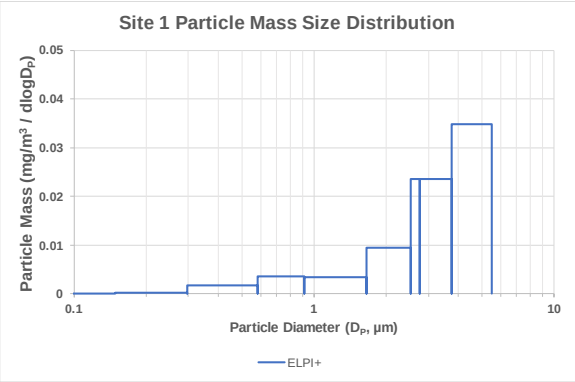


Site 1 PSD results

- Particle numbers peak when the bag filter is pulsed to remove the filter cake
- Could be related to bag stretch and/or leakage paths







Other sites

- $PM_{2.5}$ emissions were comparable between sites and between instruments at circa 0.005 mg/Nm^3 with filterable particle numbers peaking at ~ 0.3 µm (MPP*)
- PM_{10} emissions were much more variable between sites and between instruments in the range 0.010 to 0.15 mg/Nm^3 due to a combination of factors:
  - Higher large particle emissions due to small bag tears/holes with some continuous emission between bag pulses and, at one site, overly frequent bag pulsing
  - Inherently greater uncertainty in the number of large particles which are very sparse but represent most of the PM_{10} mass emission
  - Loss of large particles in the FIDAS sampling train (permeation drier was used for the two remaining sites due to outdoor stack sampling conditions)
- The ratio $PM_{2.5}$ to PM_{10} is therefore also variable but with a maximum of 0.44 from the ELPI$^+$ results, i.e., 44% of the PM_{10} emission

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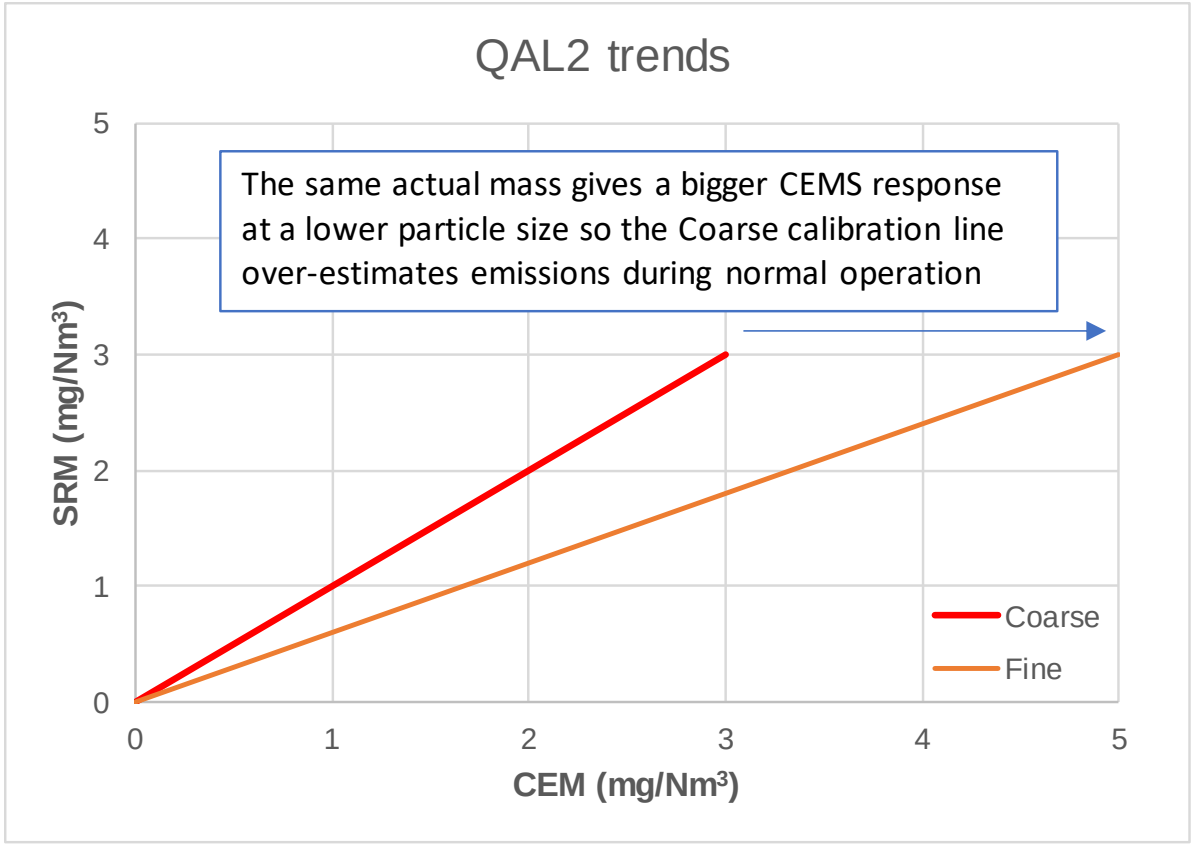
* MPP = Most Penetrating Particle size

Alternative TSP/$PM_{2.5}$ reporting options for indicative CEMS

- Report mass emissions based on uncalibrated CEMS data since actual emissions are at or below the detection limits of light scatter CEMS and the SRM:
  - Ensure that the CEMS are properly zeroed and subject to QAL3 (zero & span checks) and linearity testing
  - Report the CEMS data (~ zero) during normal operation (better estimate than the gravimetric SRM)
  - If the CEMS indicate above a threshold concentration attempt a QAL2 calibration
- Calibrate CEMS using deliberately leaked or re-injected bag filter dust as allowed under EN 13284-2 (not currently allowed in UK):
  - The CEMS response will be closer to that during abnormal operation when larger particles are emitted (the most important and most significant mass releases)
  - During normal operation, the calibrated response will over-estimate the emissions

TSP/$PM_{2.5}$ reporting options for indicative CEMS



TSP/$PM_{2.5}$ reporting options for indicative CEMS

- Develop more sensitive CEMS and a more sensitive SRM, possibly both based on optical counting with particle sizing and sample dilution, enabling calibration at ultra-low PM concentrations (but able to indicate high concentrations)
- How low a concentration do we need to be able to measure?
- Bigger picture - target development on industries where emissions are less well characterised and potentially contribute a greater proportion of the total $PM_{2.5}$ inventory?
- Other metrics?

Summary

- Calibration of CEMS at EfW plants is not generally possible during normal operation with bag filters
- Current UK mass emissions reporting of $PM_{2.5}$ from EfW plants is biased high due to the reporting of gravimetric results at detection limit and the assumption that $PM_{2.5}$ = TPM
- Based on field trial results, actual $PM_{2.5}$ emissions are very low (~ 0.005 mg/m^3) and do not dominate the overall TPM emission (depends on state of bag filter)
- Unsurprisingly, the filterable particle number concentrations peak at 0.3 µm
- Ultrafine PM emissions are assumed to be sulphuric acid aerosol - these fall within the range of published results which do not significantly impact background concentrations in ambient air
- Reasonable agreement between different measurement techniques has been demonstrated using an advanced particle sizer (ELPI$^+$) and an ambient optical counter/sizer with sample dilution which has potential to be developed as a CEM and/or SRM
- For indicative only CEMS:
  - Base reporting on the CEMS regardless since emissions are close to zero with a high uncertainty
  - Calibrate CEMS using deliberately leaked or re-injected bag filter dust
  - Develop improved CEMS and Reference Methods
- Bigger picture – how close to zero do we need to be? Which other sectors are emitting more $PM_{2.5}$?

Thank you for listening

For any further questions, please contact me at:

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