

Results of a round robin using the Real-LIFE test protocol

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Content

- Real-LIFE test protocol – Procedure
- Stoves and fuel, time line
- Experimental setup
- Data evaluation/calculation
- Results on emission
 - CO, OGC, TPM emission
 - Overall round robin evaluation
- Summary and conclusion

Real-LIFE Test protocol – Procedure (1)

- **1st batch** at natural draught
 - Fuel mass: nominal load (sometimes with smaller logs) + 25 % kindling wood + 1 igniter
 - Ignition from top, according to manual
 - TPM probe must be pre-heated, **ENPME** method (EN 16510-1:2023)
- **2nd batch** at natural draught
 - Fuel mass: nominal load, number of logs according to manual
- **3rd to 5th batch** at **nominal** load with -12 Pa forced draught

Real-LIFE Test protocol – Procedure (2)

- **6th and 7th batch at partial load**
 - Fuel mass: **65 %** of nominal load at -6 Pa forced draught
 - has to be conducted also if manufacturer does not mention partial load
- **8th batch at overload**
 - Fuel mass: **150 %** of nominal load at -14 Pa forced draught (number of logs was increased instead of thickness of logs!)
- Recharging criteria: **(4.0 ± 0.5)** vol-% CO₂ or stove signal
- **3 minutes** time for filter changes between batches → **crucial!**

Log wood stoves

Parameter	Stove A	Stove B
Heat output [kW]	7.0 (4.9 – 9.1)	4.0 (2.0 – 6.5)
Log length [cm]	25	25
Special equipment?	None	None
Year	2017 (many tests)	2023 (new device)
Weight [kg]	200	131

- Stove A (June until December 2023)
 - Lab 1 → Lab 2 → Lab 3 → Lab 4
- Stove B (July until December 2023)
 - Lab 4 → Lab 3 → Lab 2 → Lab 1



Fuel for round robin

- Beech with bark was provided and prepared in correct mass for the different batches, moisture content of about 10 %
- Stove A:
 - ≈ 400 g logs for batch 1 (4 logs)
 - ≈ 820 g logs for batch 2, 3, 4, 5 and 8 (2 or 3 logs)
 - ≈ 550 g logs for batch 6 and 7 (2 logs)
- Stove B:
 - ≈ 275 g logs for batch 1 and 2 (4 logs)
 - ≈ 550 g logs for batch 3, 4, 5 and 8 (2 or 3 logs)
 - ≈ 350 g logs for batch 6 and 7 (2 logs)



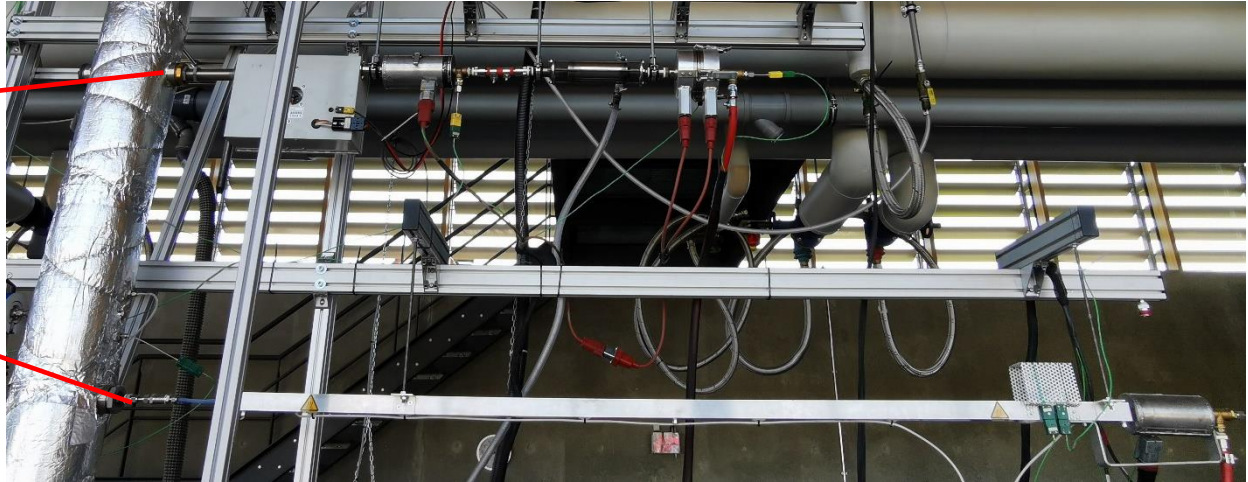
Experimental setup at TFZ



Stove

Hood is open during 1st and 2nd batch (natural draught)

Extended ENPME method: ENPME + Porous Tube
DR 1:8, only during 2nd, 4th, 6th and 8th batch



ENPME method – straight probe (prototype) used for every batch
Only about 3 minutes time for filter changes between batches
Distances according to EN 16510-1:2023, at 180 °C

Data evaluation

- **TPM** emission weighted according to batch duration
- **Gaseous** emission:
 - Each batch evaluated to see effect of load on emission and
 - Entire cycle from ignition until reaching the recharging criteria of 8th batch → also changing times between batches considered
- **Calculation** (not every lab used the defined calculation procedure)
 - First mean value of CO or OGC in ppm and mean value of O₂, then reference calculation to 13 % O₂
 - Conversion of OGC (ppm, wet) was different → harmonization needed

Data considered for evaluation

- Lab 1: Stove A – 3 days, Stove B – 3 days → 😊.

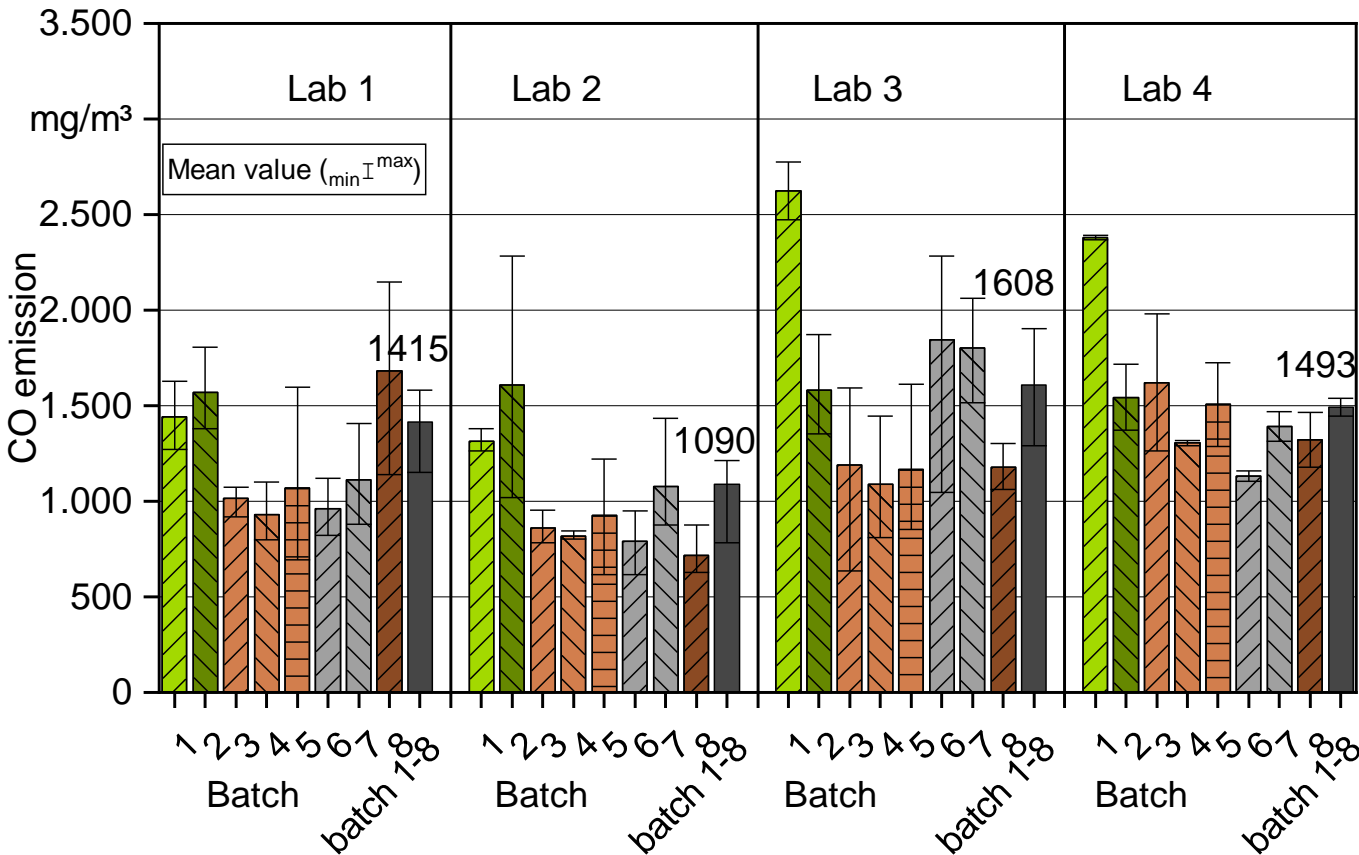
- Lab 2: Stove A – 3 days, Stove B – 2 days
 - General remark for stove B
 - On 3rd day: recharging too late at e. g. 1.7 vol% CO₂ → poor reignition → test day excluded from further evaluation
 - In general for all days: one additional batch between nominal load and partial load without further information regarding fuel mass (break needed) was performed → this batch was excluded from entire evaluation

Data considered for evaluation

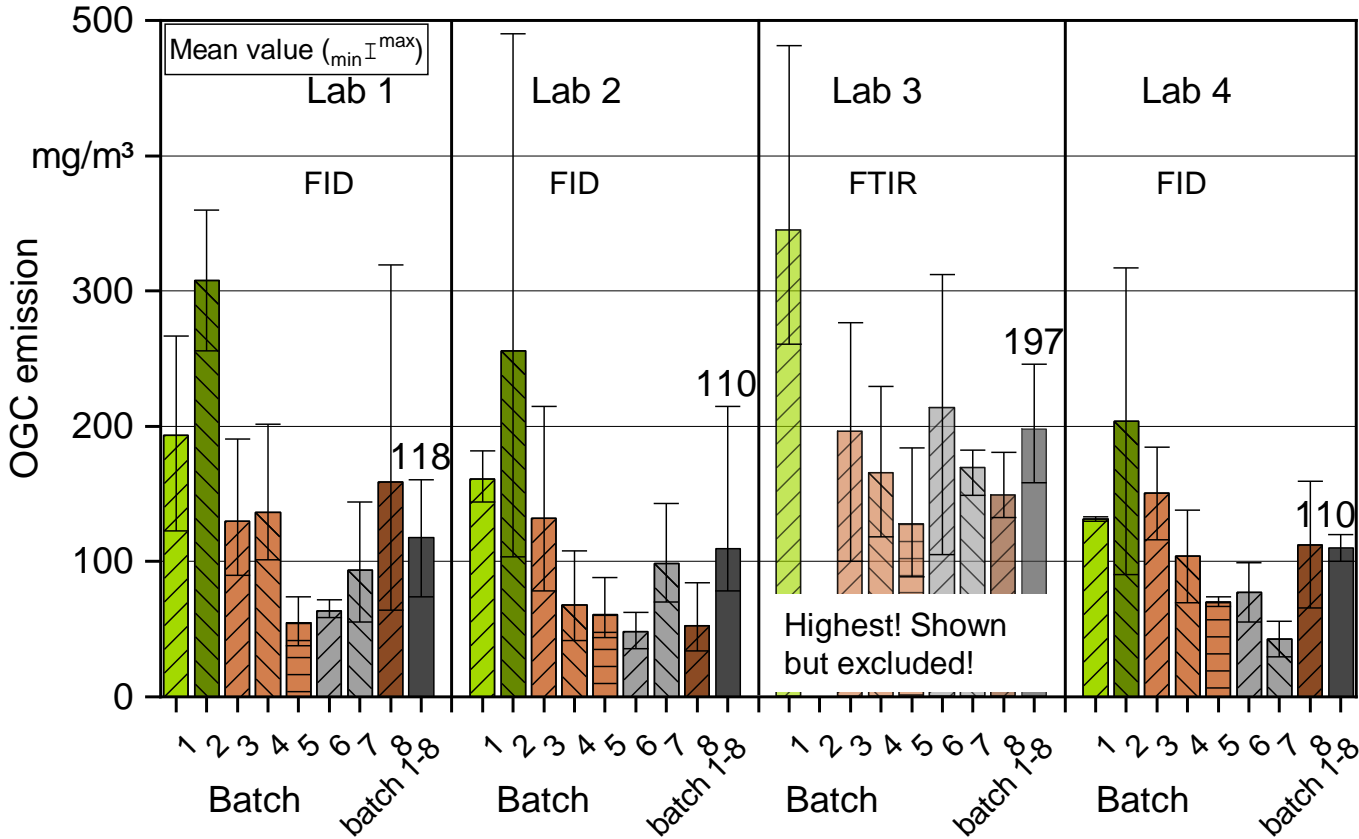
- Lab 3: Stove A – 3 days, Stove B – 3 days
 - no natural draught was possible during 1st and 2nd batch
 - Recalculation was necessary
 - FTIR was used for OGC determination

- Lab 4: Stove A – 2 days, Stove B – 3 days
 - stove A was tested at only natural draught conditions on 3rd testing day
→ excluded for round robin evaluation

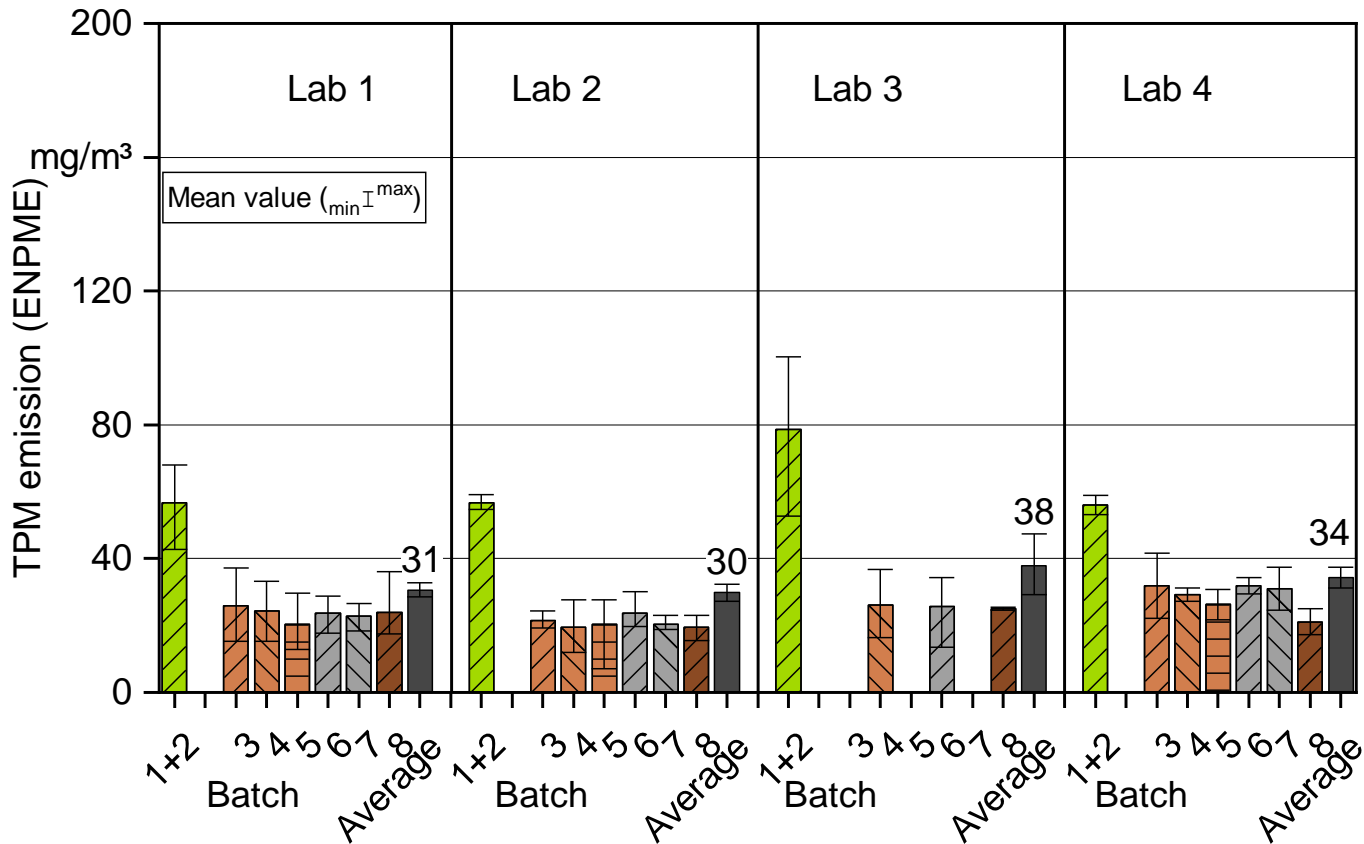
Stove A – CO emission



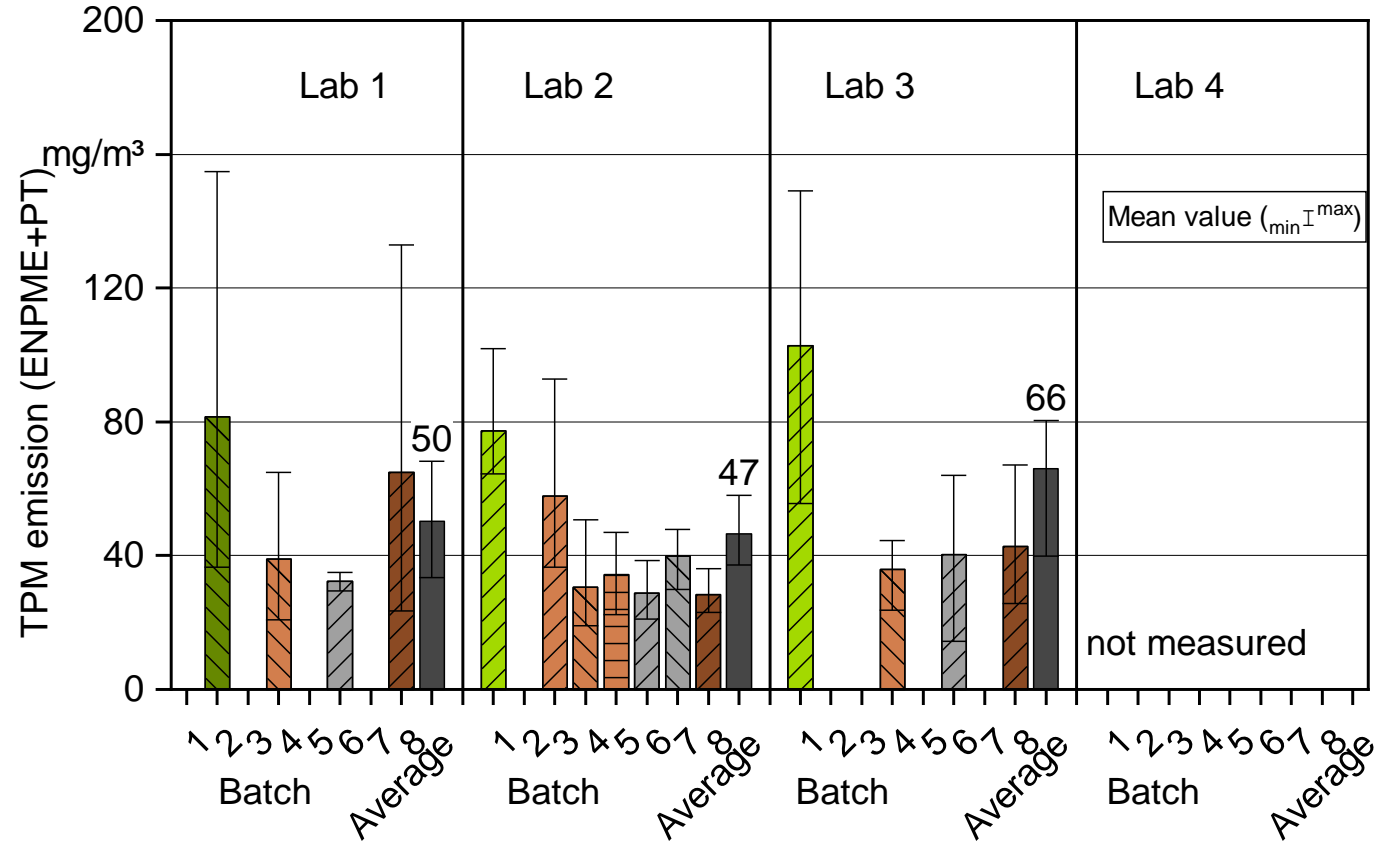
Stove A – OGC emission



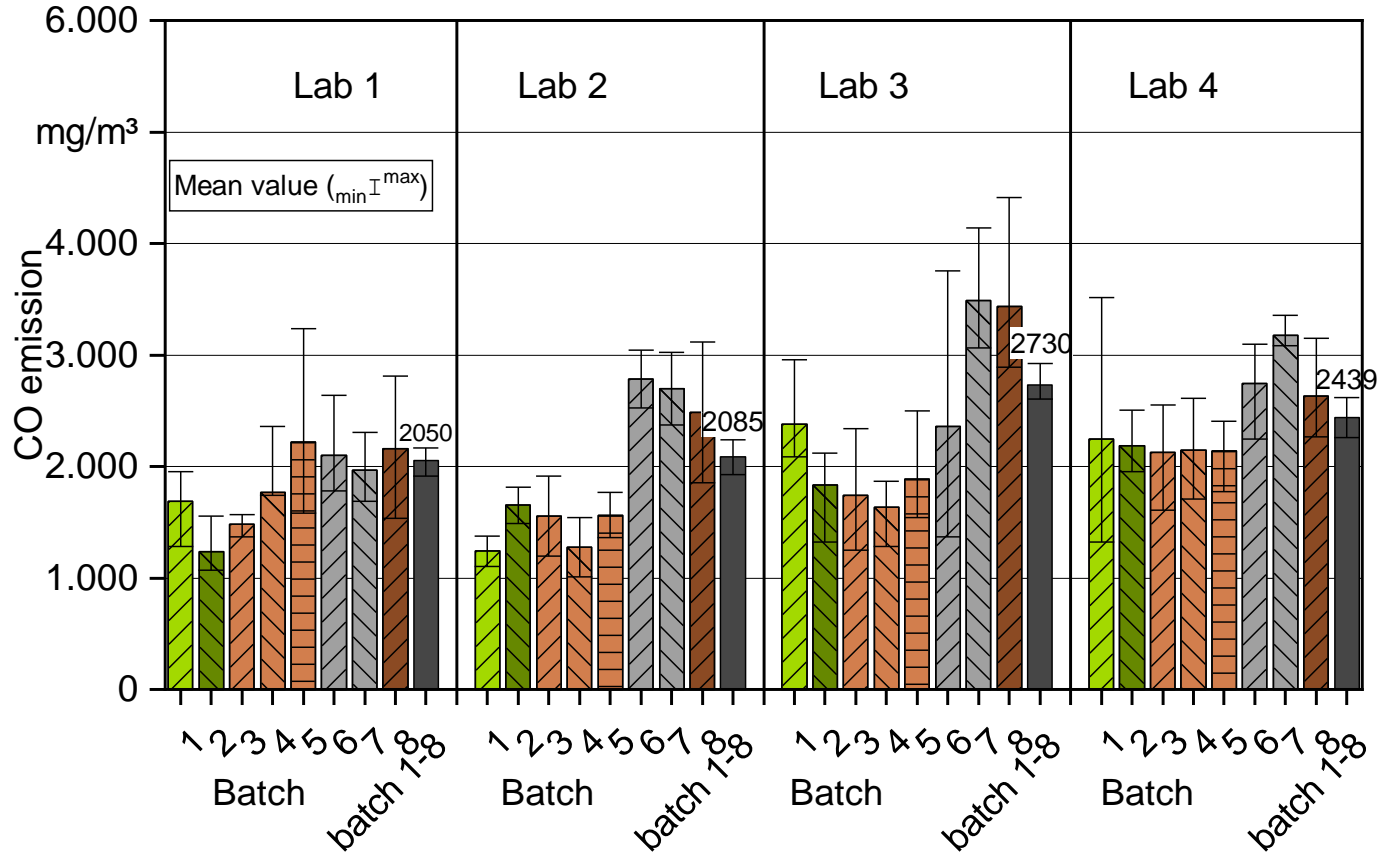
Stove A – TPM emission with ENPME



Stove A – TPM emission with extended ENPME

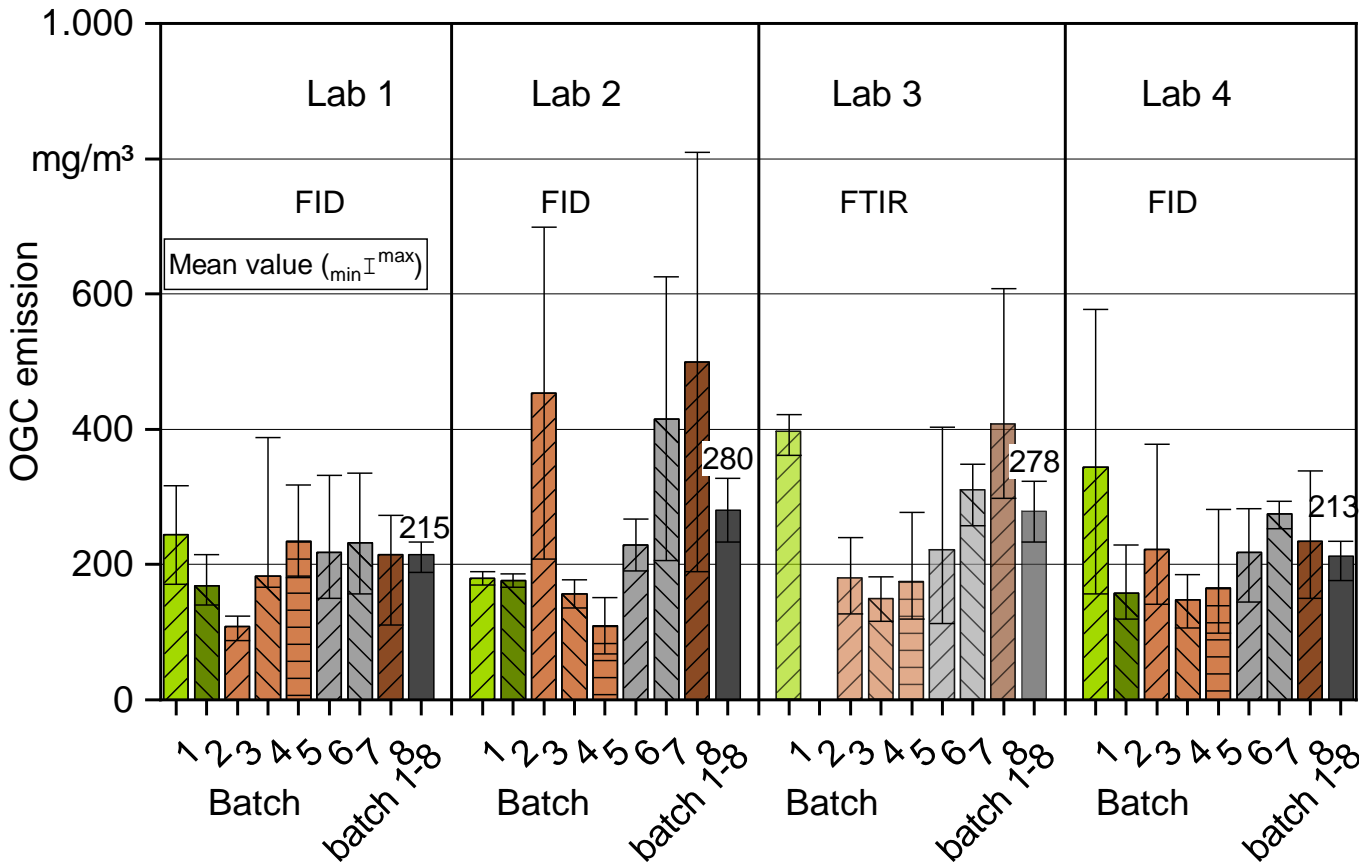


Stove B – CO emission

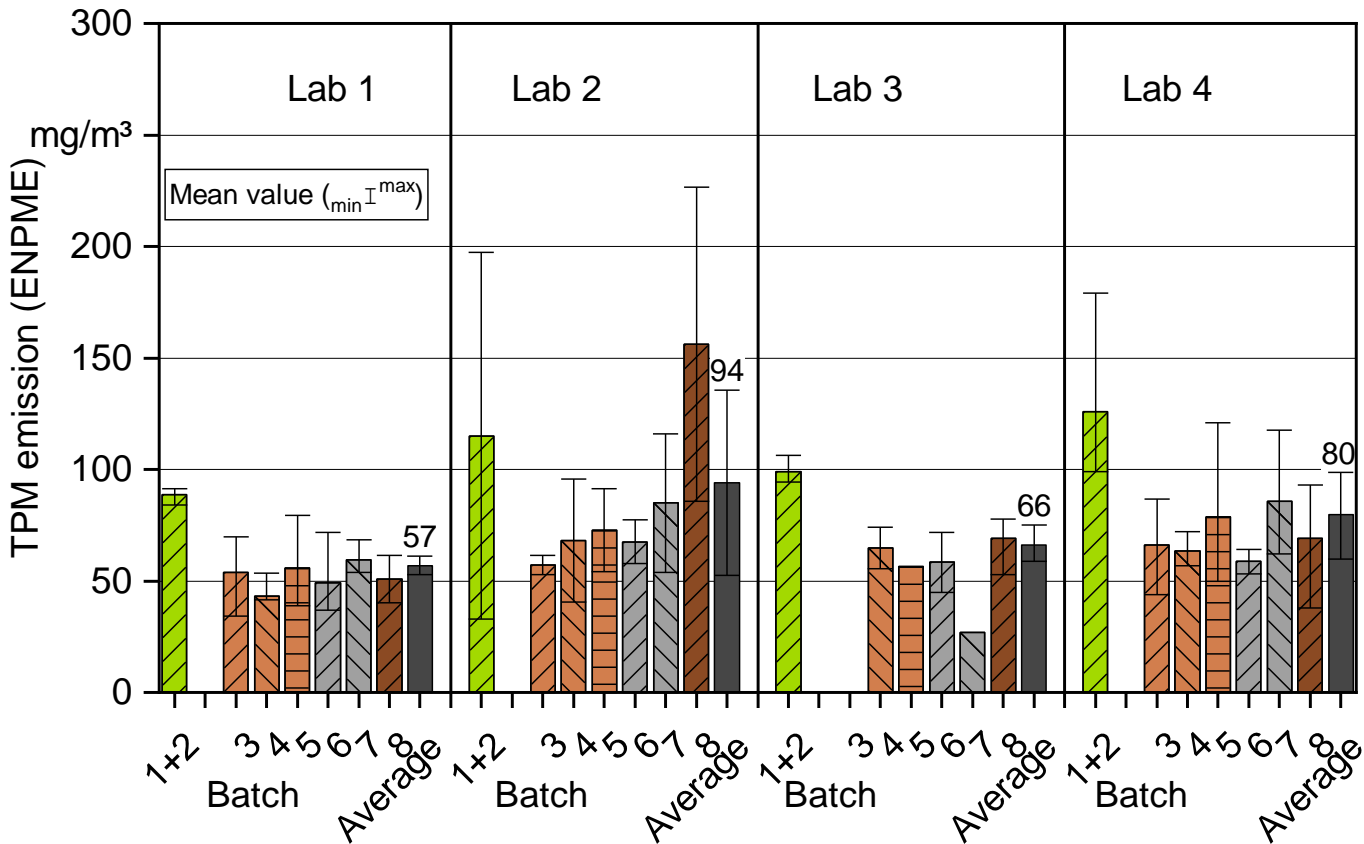


At Lab 2 an intermediate batch between nominal and partial load was conducted without further information → off the testing procedure!

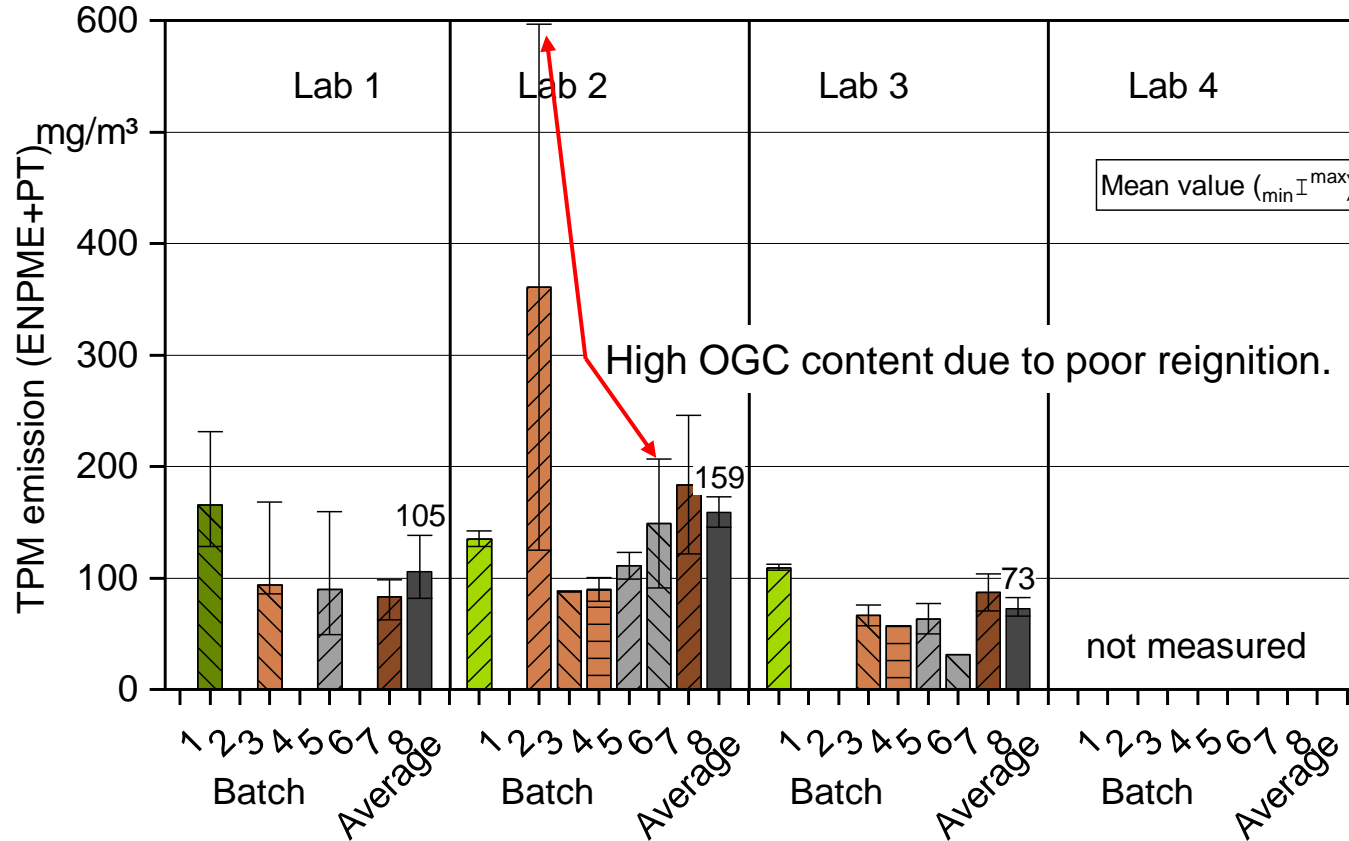
Stove B – OGC emission



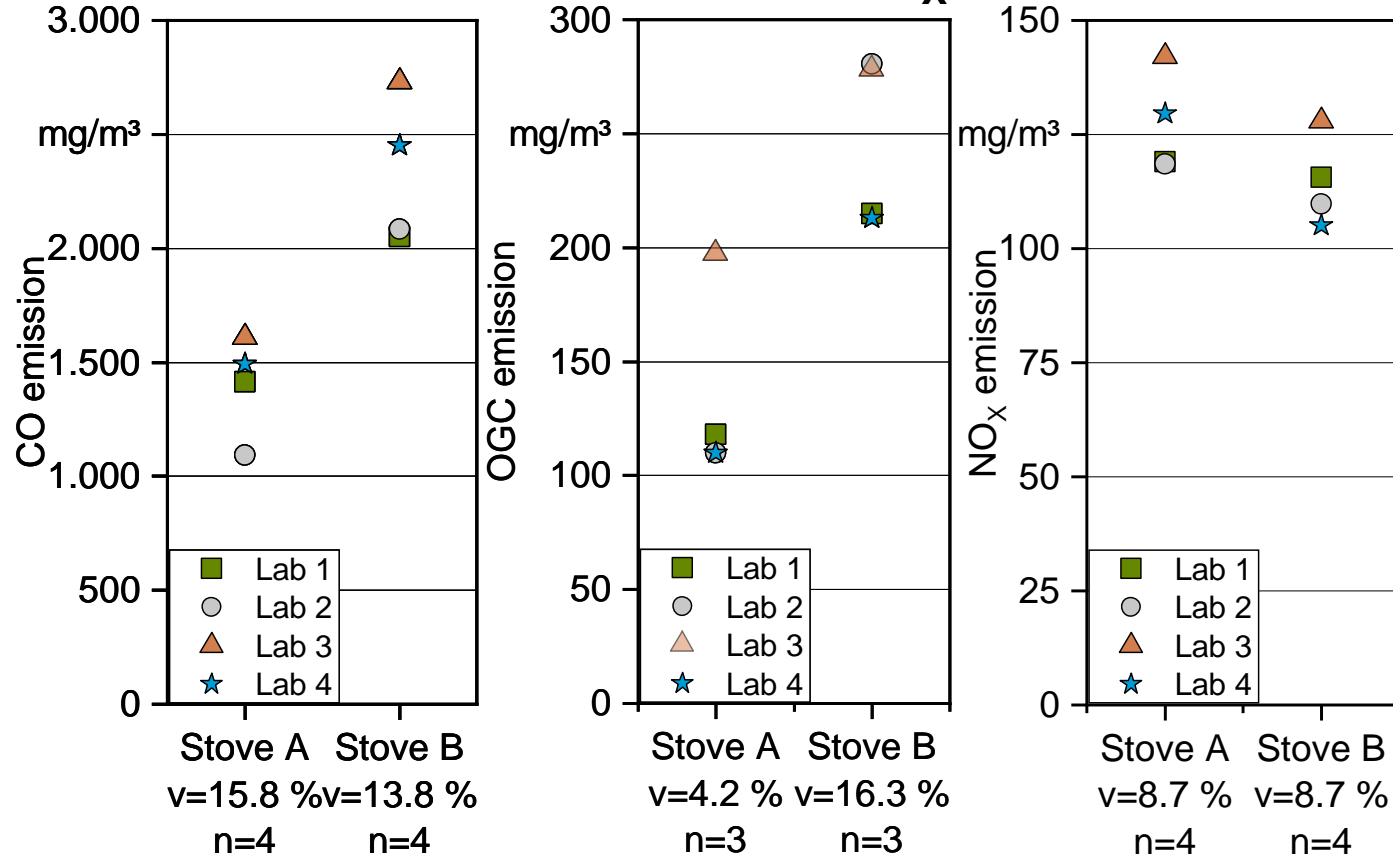
Stove B – TPM emission with ENPME



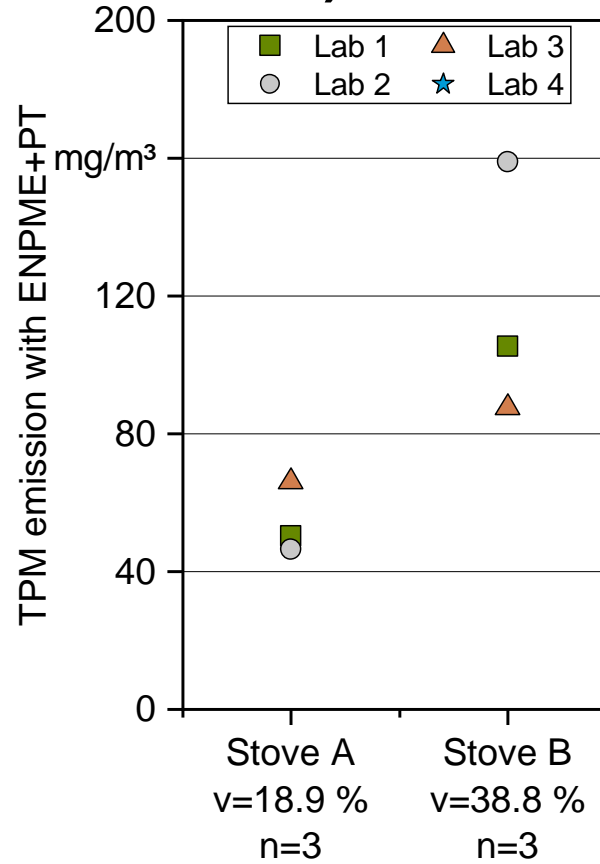
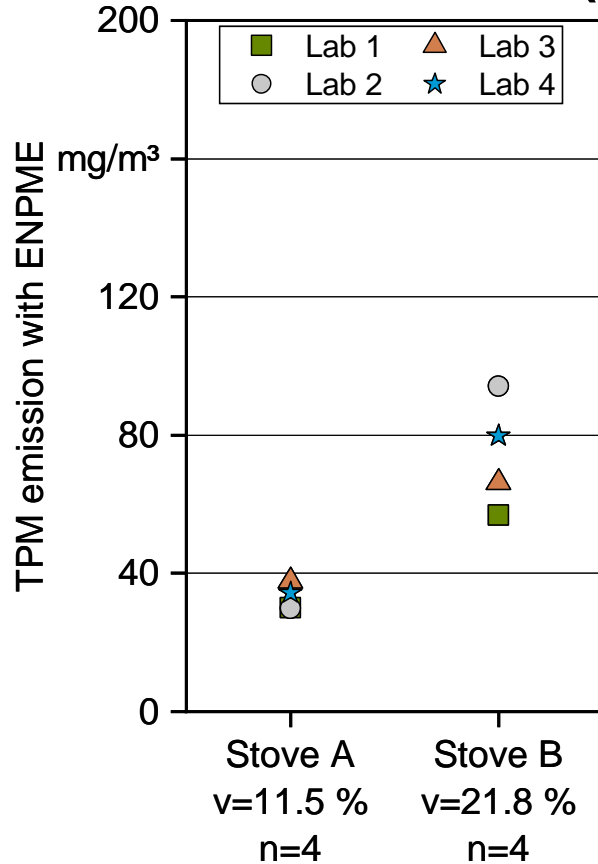
Stove B – TPM emission with extended ENPME



Round Robin – CO, OGC and NO_x emission



Round Robin – TPM (+ Porous Tube) emission



Summary of Round Robin (1)

- Two log wood stoves were shipped around to four laboratories
- Beech with bark was provided to all in correct mass
- Real-LIFE test protocol was applied by four laboratories → protocol was mostly followed, but not always (intermediate batches, missing TPM measurement, longer breaks between batches, no natural draught)
- Measurement equipment with suitable measurement ranges required (high CO concentrations e. g. during overload or poor reignition of fuel → cut-off has to be avoided, otherwise: underestimation of emission)
- Calculation procedure must be defined and uniformly applied

Summary of Round Robin (2)

- CO, OGC, NO_x and TPM emission were measured during 8 batches (ignition and different load conditions)
- OGC values determined with FID cannot be compared with values from FTIR
- All emissions showed good repeatability for the Real-LIFE test protocol 😊!
- **Recommendation:** Round Robin with stoves should be performed more often also with other laboratories!

Thank you for your attention!



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