Technologie- und Förderzentrum
im Kompetenzzentrum
für Nachwachsende Rohstoffe

INFLUENCE OF USER BEHAVIOUR ON EMISSIONS FROM LOGWOOD STOVES

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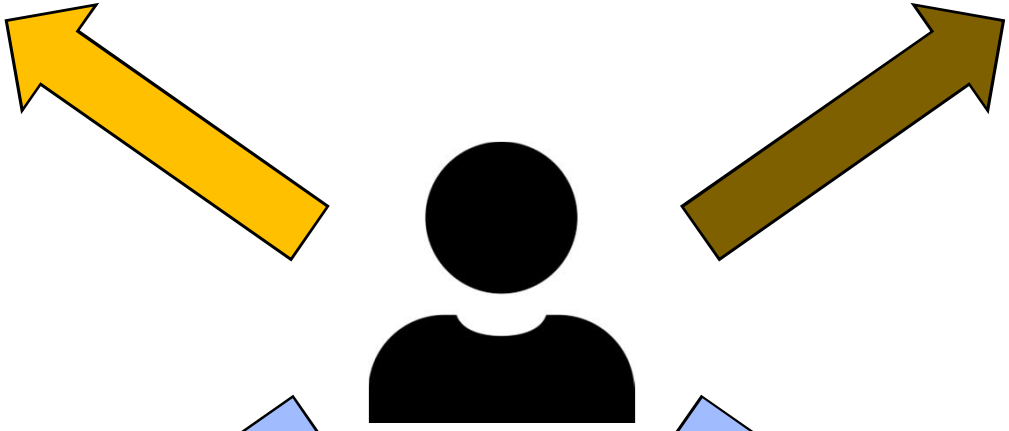
User influence on emissions in a log wood stove

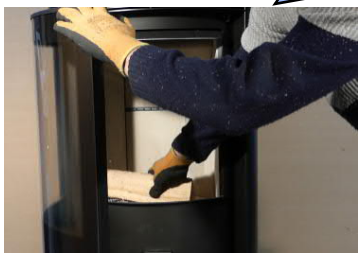
Ignition:
- type of igniter
- type of kindling
- mode of ignition

Fuel type and condition:
- hardwood, softwood
- briquettes
- moisture content
- shape
- etc.



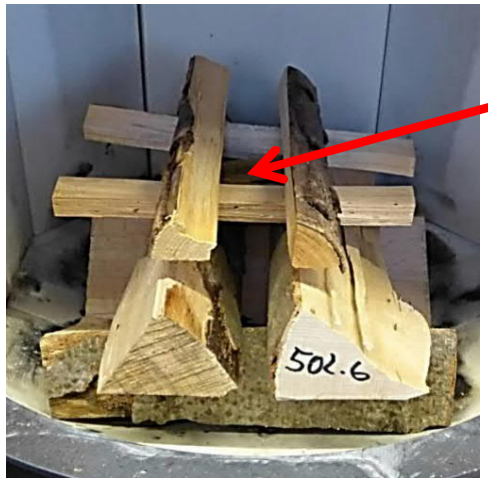
Air adjustment:
- leak of air (throttling)
- too much air
- primary/secondary air ratio

Mode of recharging:
- overload
- too less fuel
- log orientation
- timeframe of recharging



Ignition modes

top-down ignition
with kindling (A1)

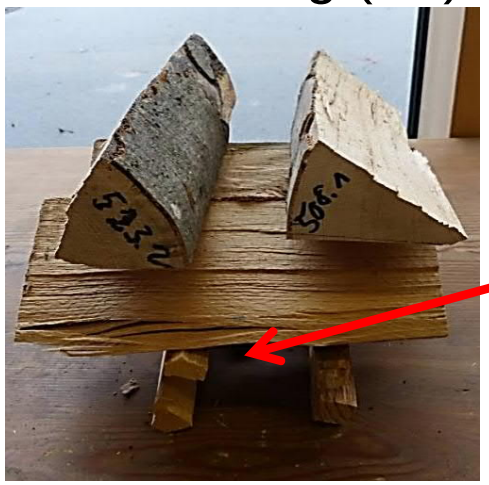


igniter

bottom-up ignition
without kindling (A2)

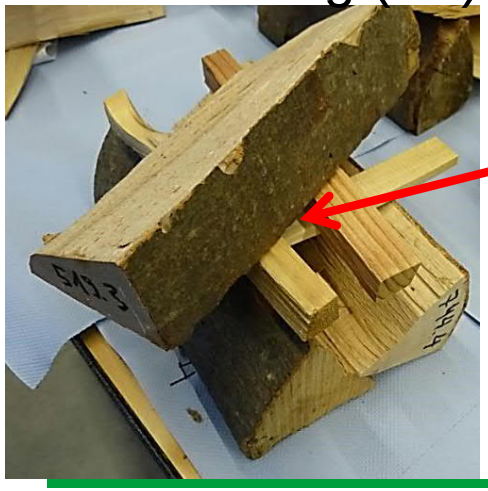
igniter

bottom-up ignition
with kindling (A3)



igniter

ignition from the center
with kindling (A4)



igniter

bottom-up ignition
with kindling and paper (A5)

logs and
kindling
randomly
inserted

crumpled
newspaper

igniter: wax
soaked wood
fiber

kindling: ready
thin chopped
spruce

Recharging scenarios

No	Variant name	Description	Fuel mass charged
V1	"orderly operation"	standard operation according to user manual, recharging at flame extinction	2.2 kg ± 0.04 kg
V2	"open primary air"	maloperation after ignition: air dampers remain in start position	2.2 kg ± 0.04 kg
V3	"reduced air supply"	fuel save mode (oxygen depletion), deliberate power throttling at nominal fuel load	2.2 kg ± 0.04 kg
V4	"overloading at medium air supply"	reserve heating by overloading, 1.7 -fold fuel mass (charging of 5 logs)	3.7 kg ± 0.04 kg
V5	"overlong logs at medium air supply"	too long logs of ca. 40 – 50 cm, they lean at the refractory lining with only little contact to the ember	2.2 kg ± 0.04 kg
V6	"too wet fuel at medium air supply"	wood moisture too high, at about M = 30%	2.2 kg ± 0.04 kg
V7	"too dry fuel at medium air supply"	wood moisture too low, at about M = 7 %	2.2 kg ± 0.04 kg
V8	"too late recharging, about 85 min after flame extinction"	very late recharging when the ember provides just enough heat for ignition	2.2 kg ± 0.04 kg
V9	"continuous recharging of single logs"	„quasi-continuous“ fuel feeding by frequent charging of small portions (i.e. single logs) triggered by scale reading, applying 50 % of usual recharging mass, flame never extinguishes	logs of 0.7 kg each ± 0.04 kg

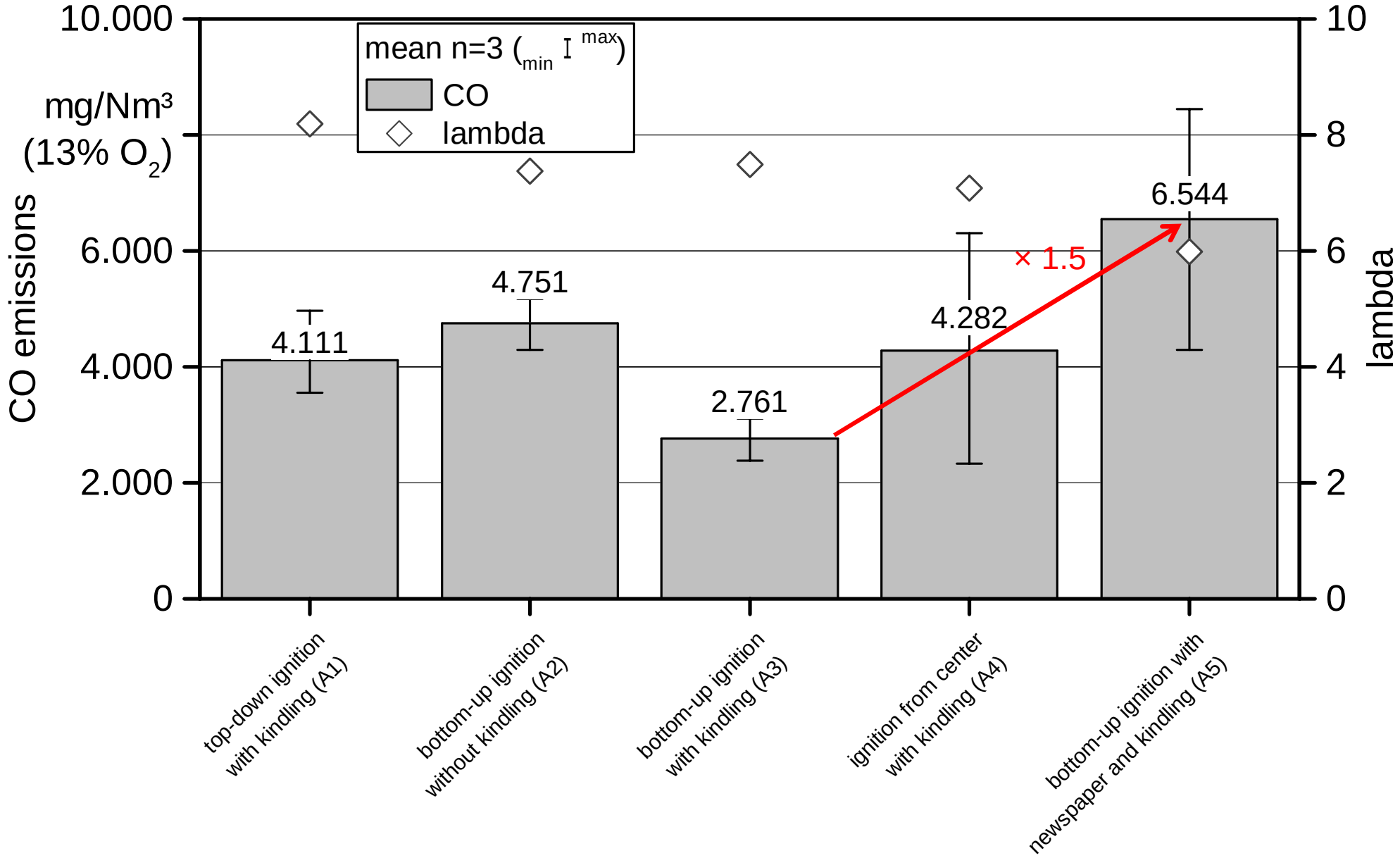
Methodology

- 3 repetitions of each variant
- All ignition modes tested from cold status
- Intermediate batches after ignition and between variants → comparable bed of ember
- Particle sampling from closing the door after ignition/recharging till flames are extinguished (recharging criteria)
- Temperature for TPM filtration, pre/post-treatment and OGC measurement at 180°C
- Continuous flue gas sampling, evaluation of gaseous emissions for TPM sampling time frames
- All test runs at natural draught

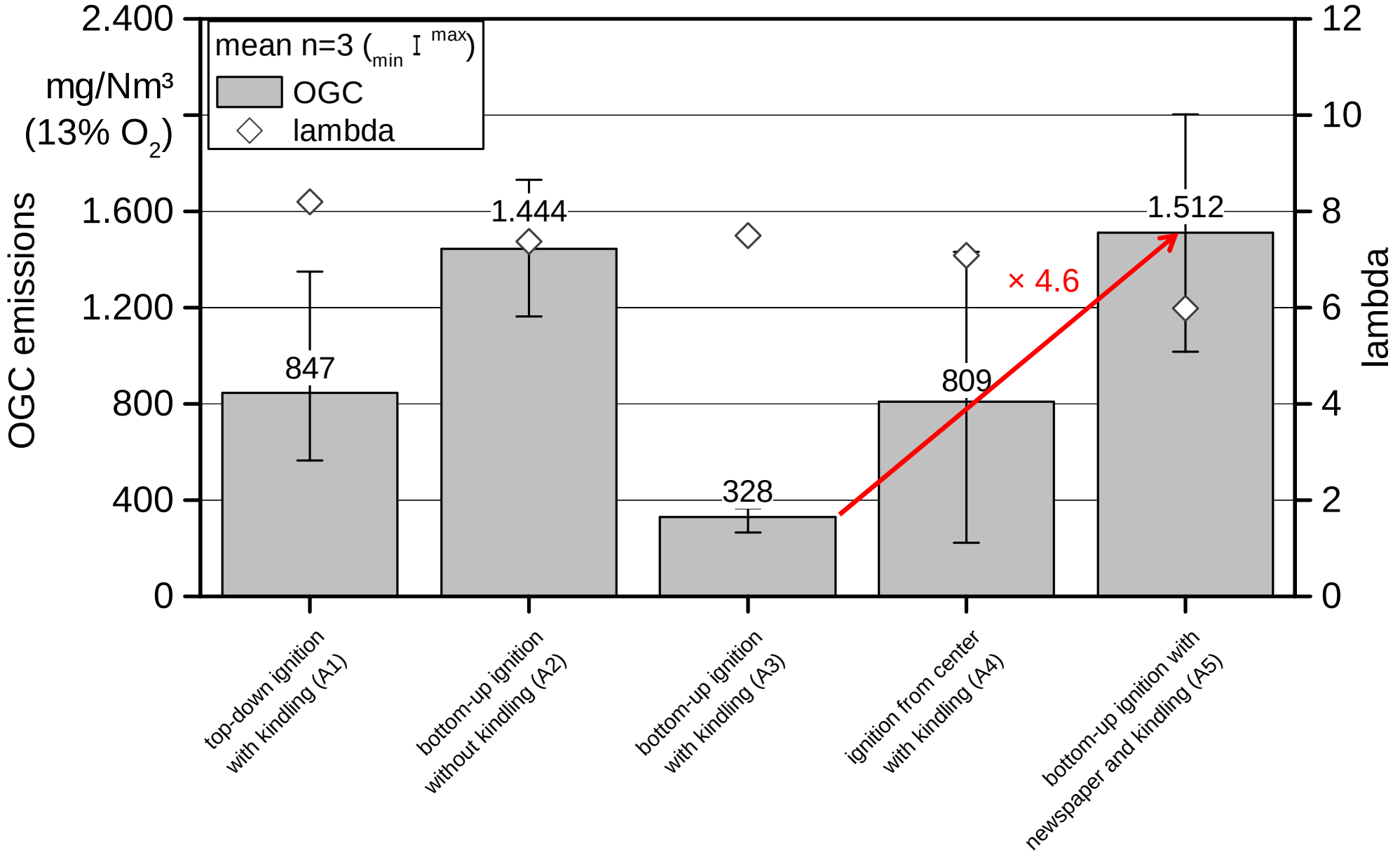
Stove used: Spartherm Sino L

- nominal heat output 7 kW
- nominal load 2.2 kg/batch
- very air tight
- air adjustment: combined single hand lever

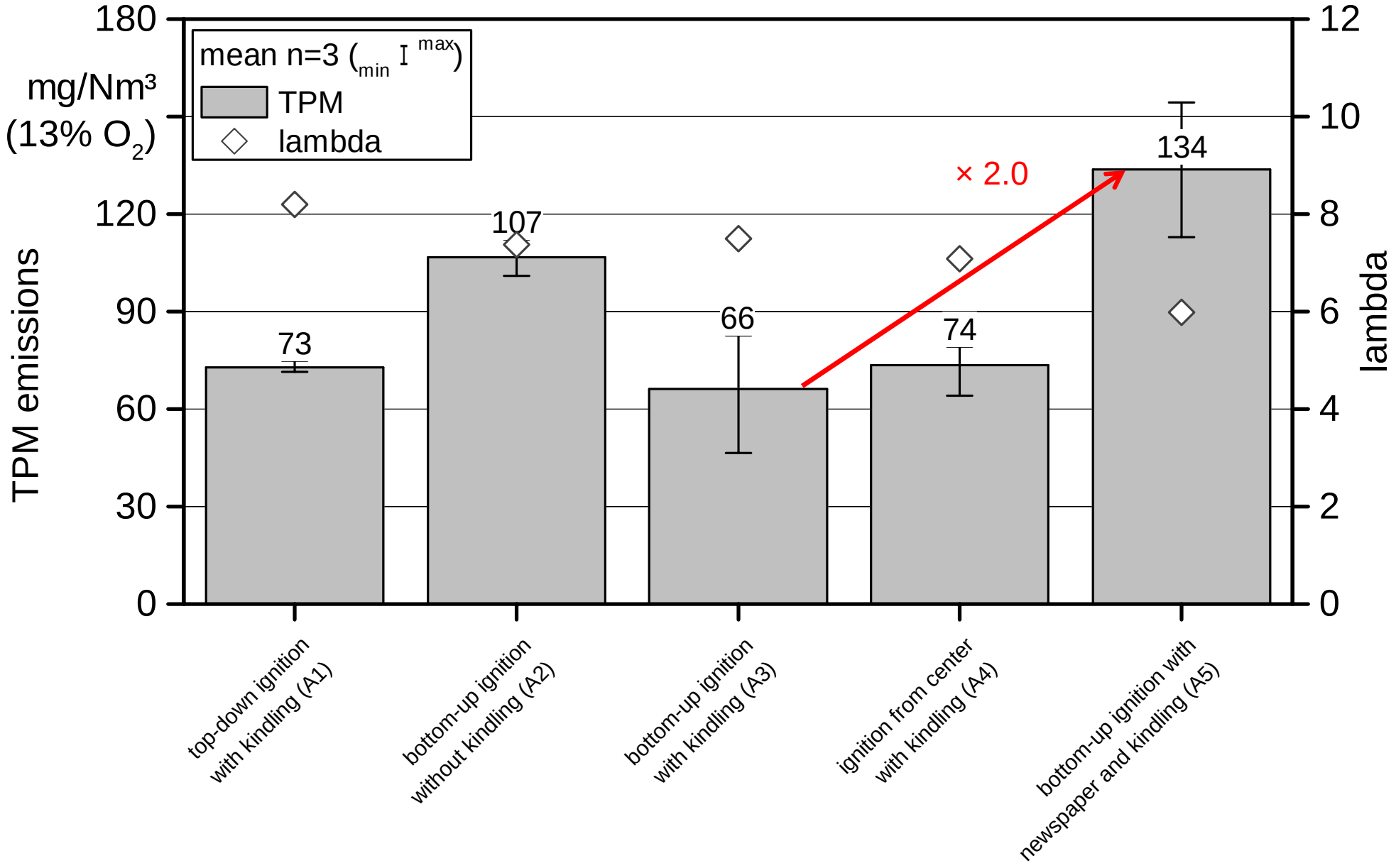
CO emissions: Ignition (natural draught)



OGC emissions: Ignition (natural draught)



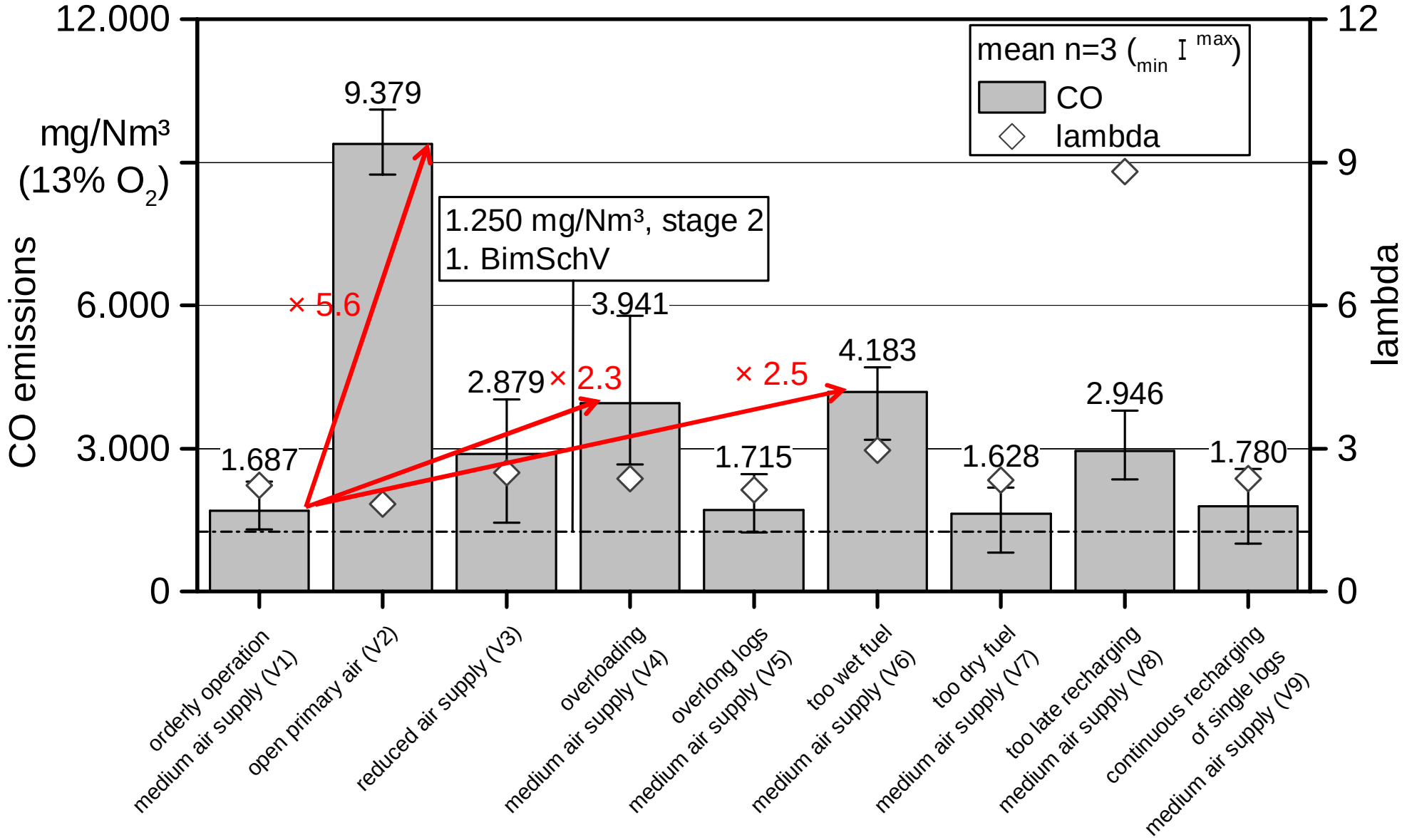
TPM emissions: Ignition (natural draught)



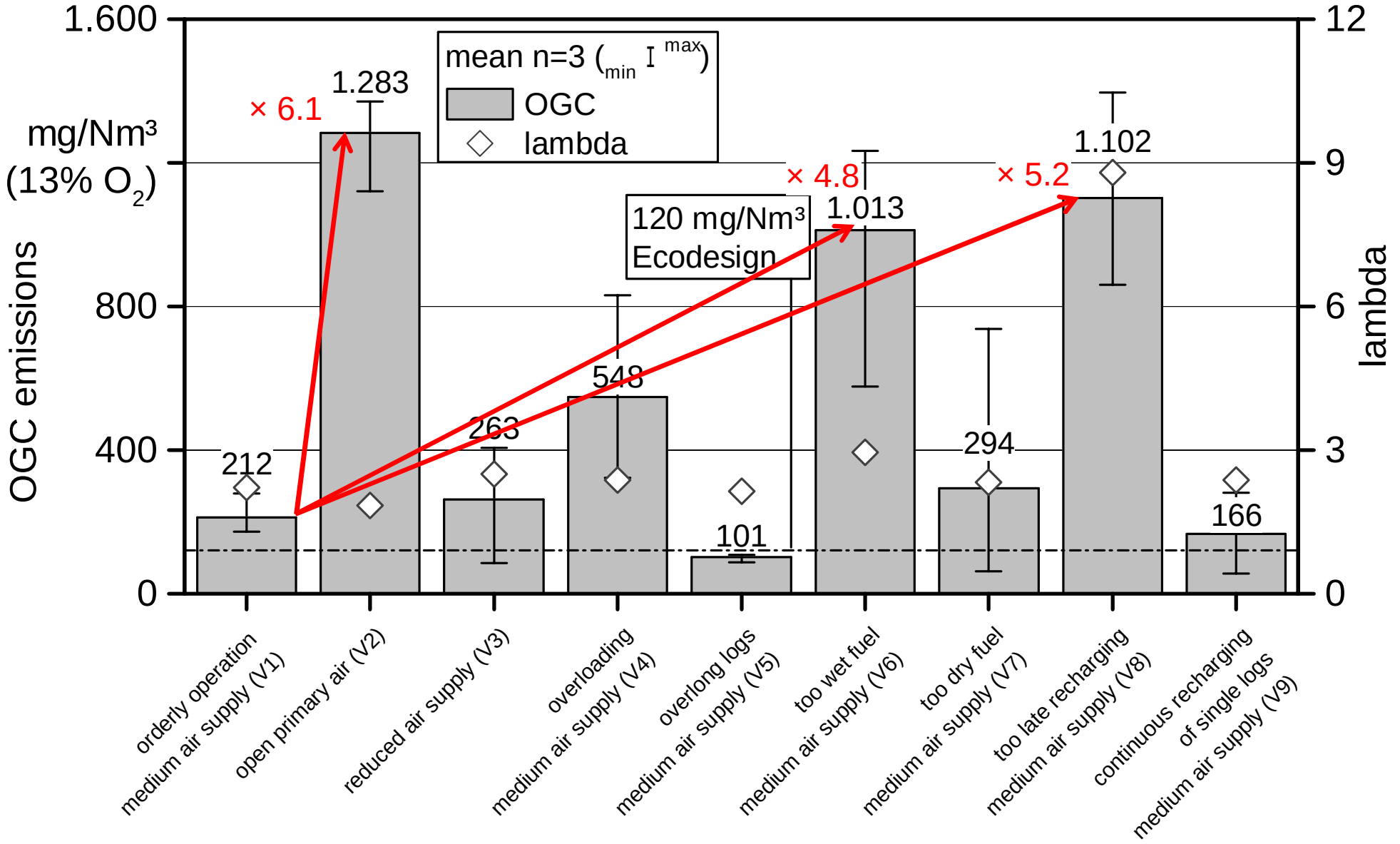
Conclusions: Ignition (natural draught)

- bottom-up ignition performs best
- but for TPM not significantly!
- worst emissions when ignititing with newspaper
- kindling is needed for appropriate temperature development

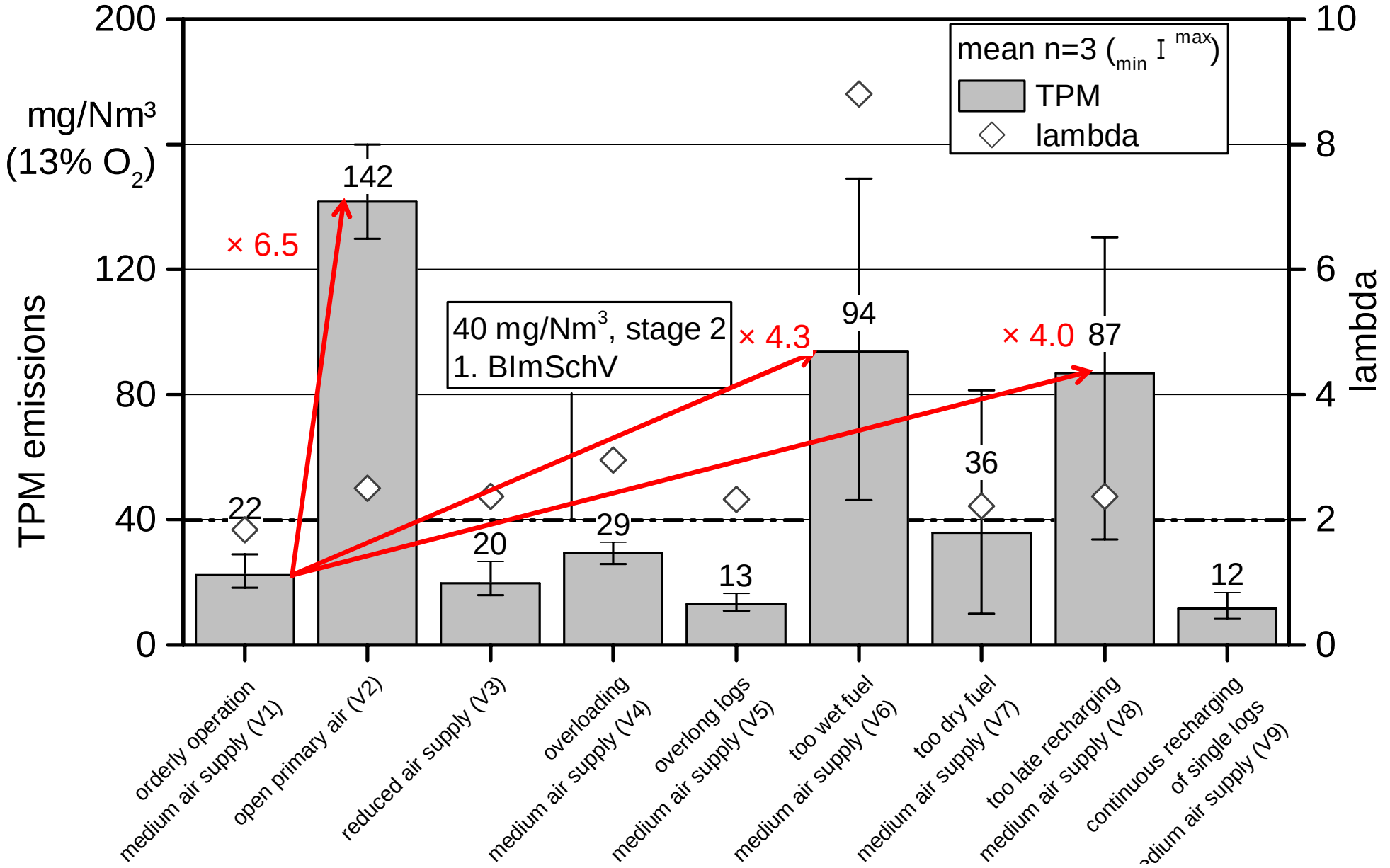
CO emissions: Recharging



OGC emissions: Recharging



TPM emissions: Recharging



Conclusions: Recharging

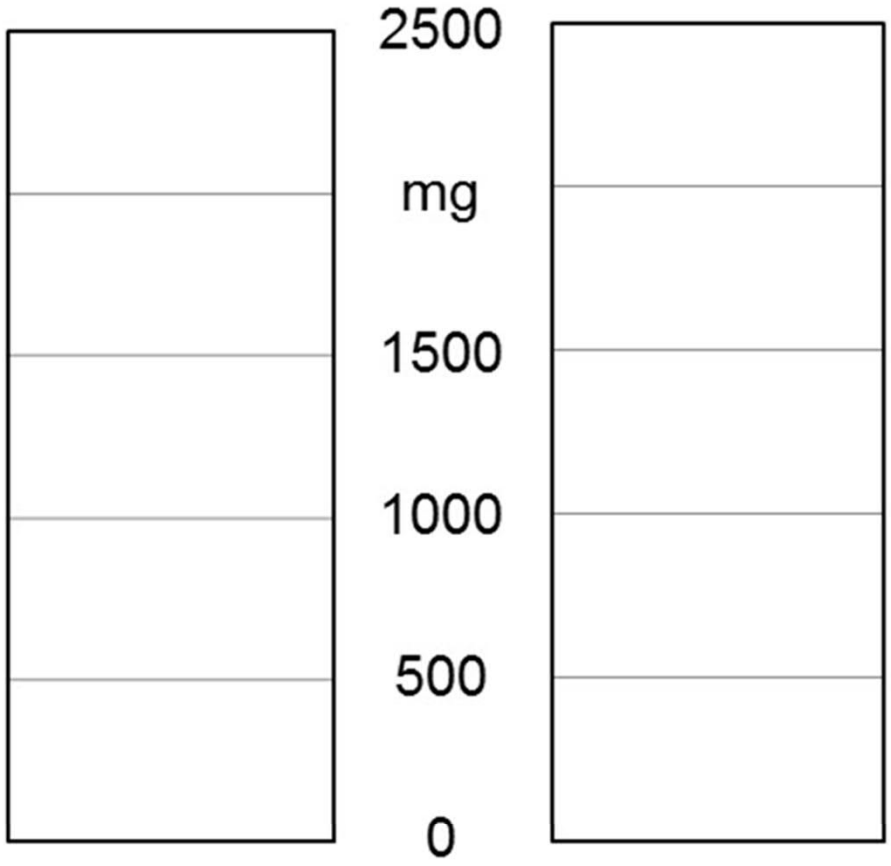
- low emissions for orderly operation, reduced air supply, overlong logs, too dry fuel and continuous recharging of single logs
- very high emissions for open primary air, too wet fuel and late recharging
- TPM emissions below thresholds are possible in practice if the stove is operated correctly
- Open primary air and the effect of too late recharging could be easily avoided by a automated combustion air control

Optimal air setting

Primary air closed

- Primary air closed after ignition batch
- Steady, smooth batch with optimal residence time of combustion gases
- ***Low particle discharge***

Particle discharge



Wrong air setting

Primary air open

- Primary air remains open after ignition batch
- Very hot and short batch with elevated fuel conversion rate (short residence time)
- ***High particle discharge***

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More educational videos can be found at:

http://www.tfz.bayern.de/festbrennstoffe/energetischenutzung/211672/index.php

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Conclusions (1)

- The general advantage of the "top down" compared to the "bottom up" ignition mode is not confirmed in this study (for natural and constant draught).
- Consequently, manufacturers should develop precise manuals that describe the best ignition mode specifically for each stove type or geometry.
- The use of suitable starter blocks and proper kindling material is essential for achieving low emissions at cold start conditions. No crumpled newspaper shall be used.
- Wrong air settings can dramatically raise emissions. Easily made mistakes such as the "forgotten" closure of primary air supply after the cold start batch, can dramatically increase pollutant discharge by a factor of 6.
- The use of overlong (inadequate) logs, which need to lean against refractory lining, can be unproblematic when the stove is properly designed with a high and slim geometry.

Conclusions (2)

- Too "wet fuel" (here: M=30 %) leads to approx. 2.5- to 5-times higher emissions for CO, OGC and PM, compared to proper fuel.
- Extremely late recharging without short term primary air adjustment for rapid re-ignition shall be avoided. In this case a short term flap opening for grate air supply (e.g. for 15 to 30 seconds) would be required. This could easily be accomplished by a simple air control technology which should be integrated by the manufacturer.
- User instructions are often poor or even misleading. This should best be avoided by creating a (standardized) "quick-user-guide" which should be based on experimental evaluation performed by the manufacturer.
- The potential for emission reduction by introducing automatically controlled combustion air supply in comparison to manually operated stoves should be assessed in future studies, inluding false manual stove operation

Thanks for your attention!

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