

Emissions from 11 small scale appliances during Real-LIFE operation

10th of October 2024, Ostrava/online
3rd International Workshop

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Appliances used for database generation (1)

Parameter / Stove	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6
Type	Log wood stove	Log wood stove	Log wood stove	Log wood stove	Log wood stove	Log wood stove
Catalyst?	yes	no	yes	no	no	no
ESP?	yes	no	no	no	no	no
Price (about) [€]	8000	3500	5000	3000	400	480
Heat output (range)	8 kW	7 (4.9-9.1) kW	5 kW	4 kW (2-6.5)	6 kW	7 kW
Year	2022	2017	2021	2023	2024	2023
Log length [cm]	20	25	17	25	25	25
Grate?	no	yes	no	yes	yes	yes
Combustion chamber volume [l]	61	46	40	40	41	51
Weight [kg]	346	200	240	131	85	110

Appliances used for database generation (2)

Parameter / Stove	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Type	Log wood stove	Inset	Log wood stove	Log wood stove	Inset
Catalyst?	no	no	no	no	no
ESP?	no	no	no	no	no
Price (about) [€]	unknown	1800	1600	1750	1000
Heat output (range)	5 kW	5 kW	6 kW	7 kW	10.5 kW
Year	2005	2022	2022	2017	1998
Log length [cm]	25	33	30	25	50
Grate?	yes	yes	yes	yes	yes
Combustion chamber volume [l]	37	37	17	62	83
Weight [kg]	250	109	80	135	130

Limiting values – Overview

Parameter	1 st BlmSchV, stage 2	EcoDesign 2022	Blue Angel* 2024	Flame Verte (7 stars)	Nordic Swan
CO [mg/m ³]	1250	1500	500	1500	1250
OGC [mg/m ³]	-	120	70	-	100
NO _x [mg/m ³]	-	200	180	200	-
TPM (hot) [mg/m ³]	40	40	15	40	2 g/kg (diluted)
Remark	nominal load	nominal load	test protocol without overload	nominal load	NS 3058 with different heat outputs

* Test protocol deviates from EN 16510.

Real-LIFE test protocol – Procedure (in brief)

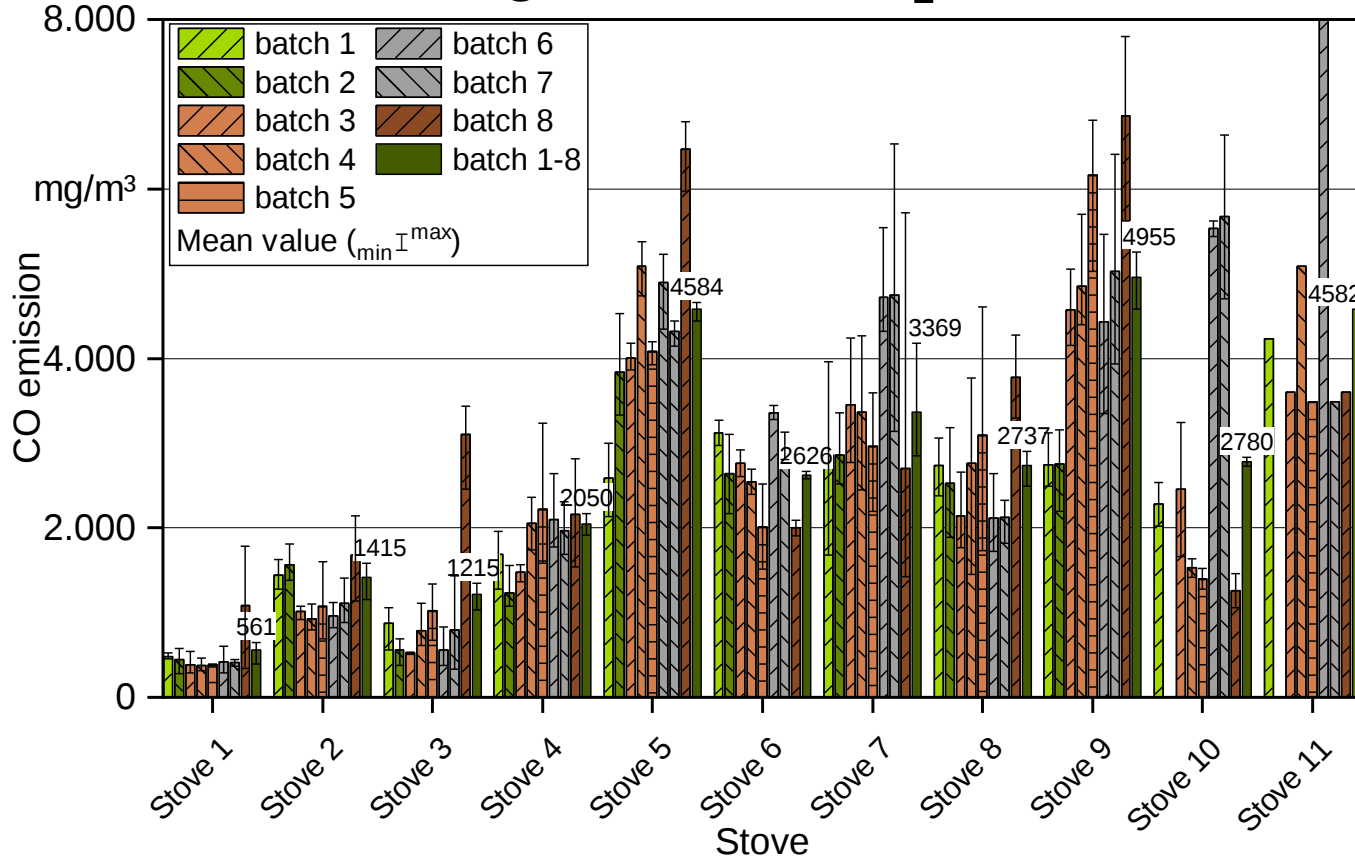
- **1st batch** at natural draught
 - Fuel mass: nominal load + 25 % kindling wood + 1 igniter
 - Ignition from top or bottom, depending on manual
- **2nd batch** at natural draught
 - Fuel mass: nominal load
- **3rd to 5th batch** at **nominal load** and forced draught of -12 Pa
- **6th and 7th batch** at **65 % partial load** and forced draught of -6 Pa, also if manufacturer only announces one heat output and no range
- **8th batch** bei **150 % overload** and forced draught of -14 Pa

Real-LIFE test protocol – Fuel

- Beech wood with bark in log wood shape
- Same beech wood for stoves 1 to 5, stoves 6 to 9 and stoves 10+11
- Moisture content between 9 and 15 %
- Partial load using thinner logs
- Overload by increasing number of logs



CO emission in mg/m^3 @ 13 % O_2

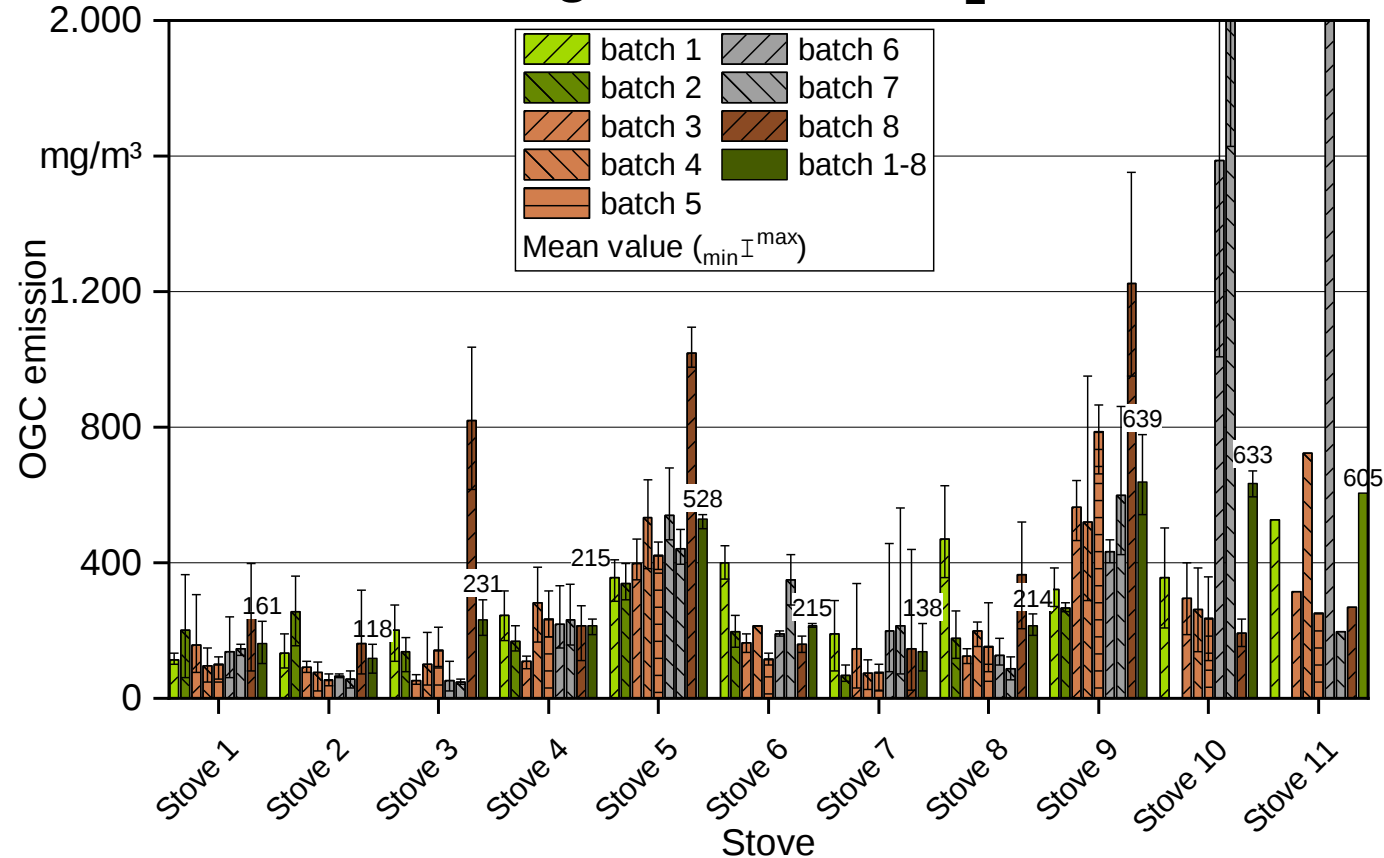


CO emissions for stove 10 and 11 would be most likely even higher, cut-off at 5000 ppm!

Stove 11 was tested on only one day → no bars.

Only 2 stoves fulfil stage 2 of BImSchV for entire test protocol
Value: $< 1250 \text{ mg/m}^3$.
3 stoves fulfil EcoDesign value
 $< 1500 \text{ mg/m}^3$

OGC emission in mg/m^3 @ 13 % O_2

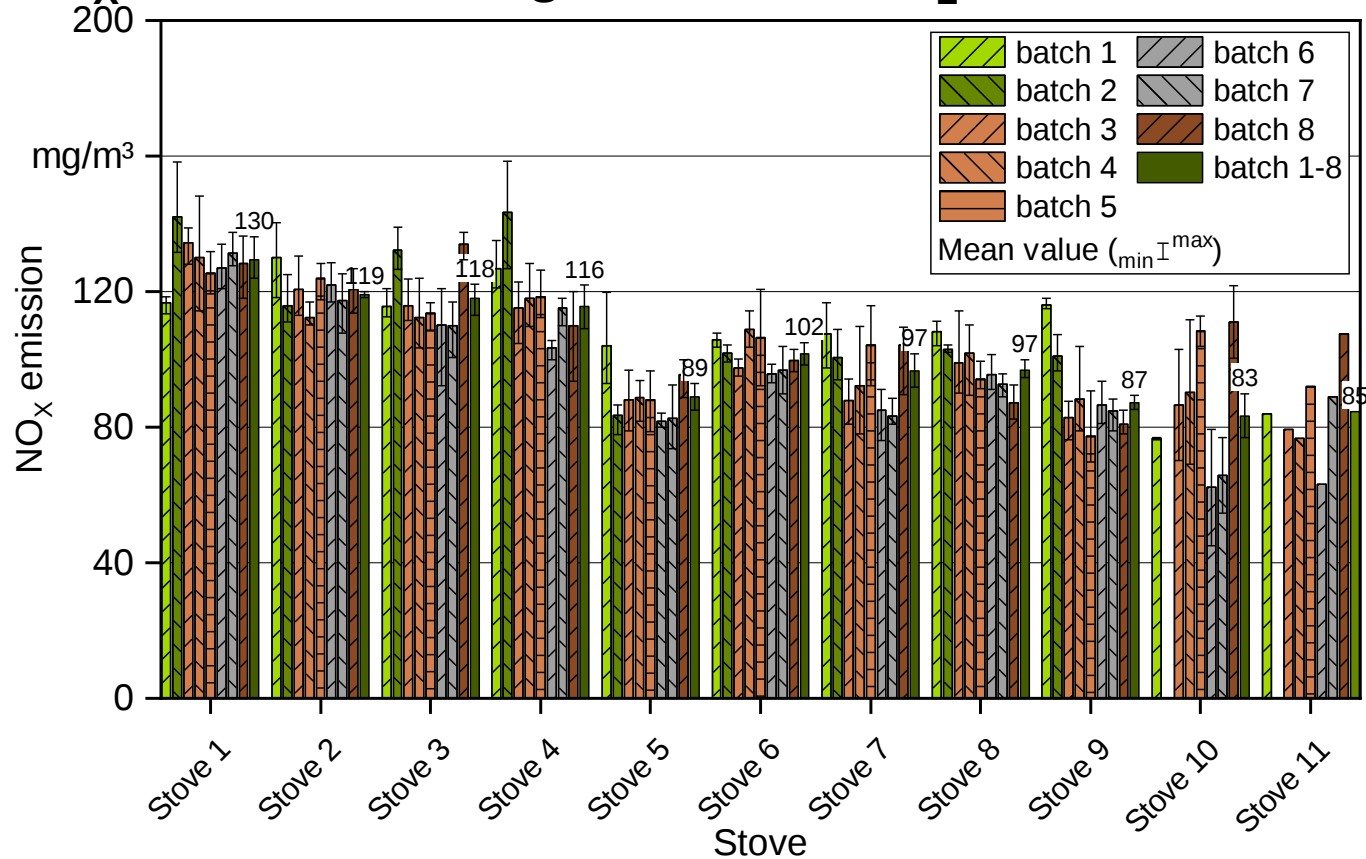


Very poor combustion for stove 10 and 11 with highest OGC emissions.

No bars for stove 11. Highest OGC value with 6816 mg/m^3 for one batch!

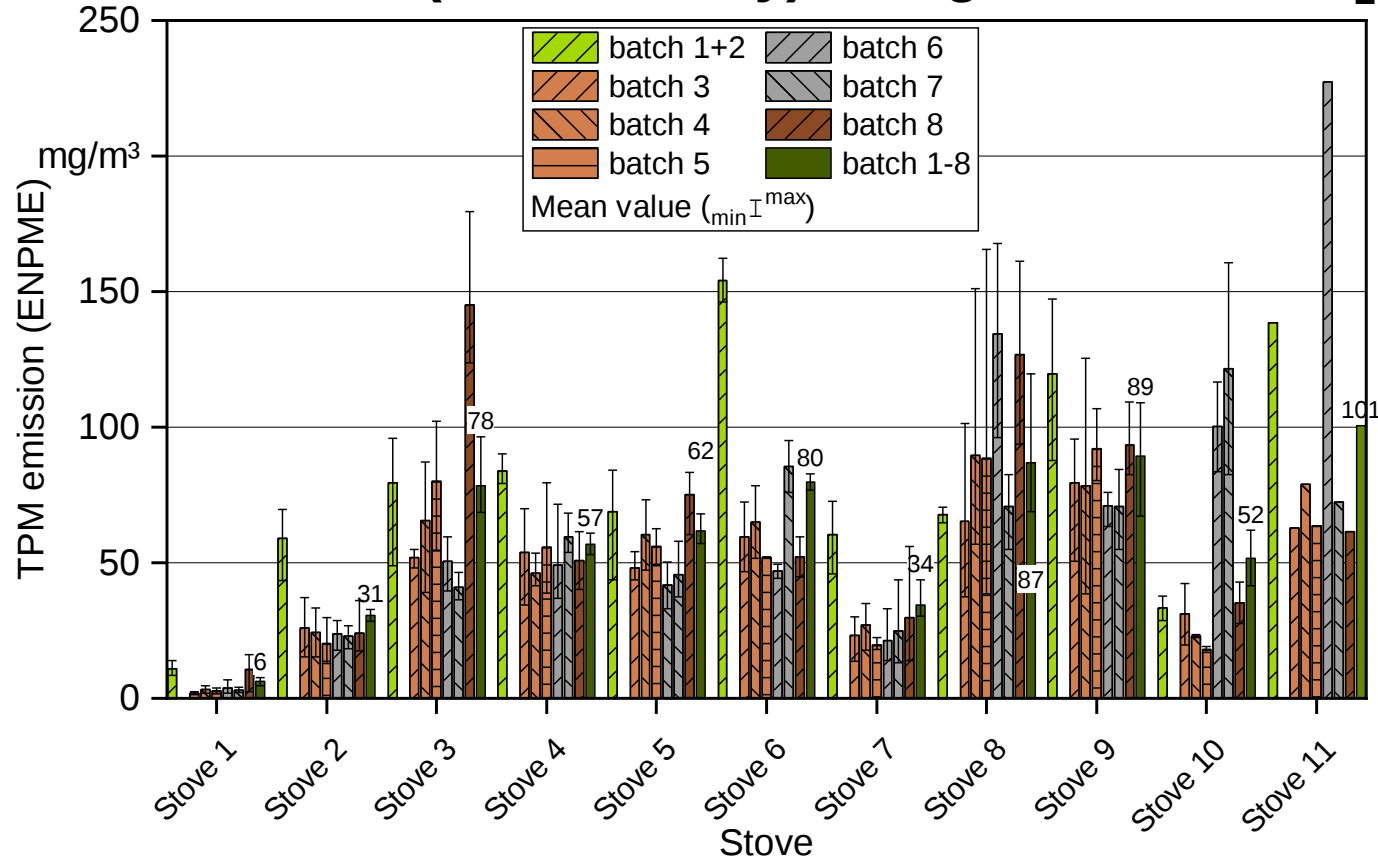
EcoDesign value $< 120 \text{ mg/m}^3$ fulfilled only by stove 2.

NO_x emission in mg/m³ @ 13 % O₂



EcoDesign limit no problem for all stoves being below 200 mg/m³ @ 13% O₂.

TPM emission (ENPME only) in mg/m³ @ 13 % O₂



EcoDesign limit of 40 mg/m³ only fulfilled by 3 stoves.

Stove 2 fulfils EcoDesign while applying the Real-LIFE test protocol 😊.

→ We can stick to the limiting values from EcoDesign while requiring the Real-LIFE test protocol for the best stoves.

Does measurement procedure change ranking of stoves?

- Comparison/ranking using heat maps made for:
 - Official type test results
 - Best 3 batches at nominal load
 - Batch 1+2 (ignition phase)
 - All nominal loads (3 to 9 values)
 - All partial loads (2 to 6 values)
 - Overloads (1 to 3 values)
 - Batch 1-7 (Blue Angel without overload)
 - Batch 1-8 (Real-LIFE test protocol)

Heat Maps – CO emission in mg/m³ and ranking

CO emission mg/m³ @ 13% O ₂	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	---	---	---	---	---	---	n. a.	---	---	---	n. a.
best 3 batches at NL	306	837	594	1485	3989	1848	2472	1650	4462	1754	4061
batch 1+2	467	1512	643	1441	3582	2943	2658	2632	2756	2849	4228
all nominal loads	379	1006	812	1953	4532	2260	3289	2665	5197	2240	4061
all partial loads	414	1037	676	2033	4606	3164	4456	2120	4729	6899	5826
overloads	1087	1682	3106	2161	6473	2000	2949	3773	6865	1572	3598
batch 1-7	431	1312	788	1996	4192	2724	3367	2486	4523	3792	4252
batch 1-8	561	1415	1215	2067	4584	2626	3369	2737	4955	3641	4582

CO emission	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	1	3	2	8	7	9	n. a.	6	5	4	n. a.
best 3 batches at NL	1	3	2	4	9	7	8	5	11	6	10
batch 1+2	1	3	2	4	10	6	6	5	7	8	11
all nominal loads	1	3	2	4	10	6	8	7	11	5	9
all partial loads	1	3	2	4	8	6	7	5	9	11	10
overloads	1	3	7	5	10	4	6	9	11	2	8
batch 1-7	1	3	2	4	10	6	7	5	11	8	9
batch 1-8	1	3	2	4	10	5	7	6	11	8	9

Heat Maps – OGC emission in mg/m³ and ranking

OGC emission mg/m³ @ 13% O ₂	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	---	---	---	---	---	---	n. a.	---	n. a.	---	n. a.
best 3 batches at NL	71	37	58	131	396	111	65	126	397	203	431
batch 1+2	165	203	138	172	378	323	124	317	291	356	528
all nominal loads	118	74	105	213	474	159	103	159	624	264	431
all partial loads	143	61	51	225	491	270	164	107	516	1887	3507
overloads	256	162	819	215	1019	160	170	366	1223	193	269
batch 1-7	135	106	101	214	428	232	131	199	507	760	760
batch 1-8	161	118	231	223	528	215	138	214	639	633	605

OGC emission	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	2	1	7	5	3	8	n. a.	4	n. a.	6	n. a.
best 3 batches at NL	4	1	2	7	9	5	3	6	10	8	11
batch 1+2	3	5	2	4	10	8	1	7	6	9	11
all nominal loads	4	1	3	7	10	5	2	6	11	8	9
all partial loads	4	2	1	6	8	7	5	3	9	10	11
overloads	6	2	9	5	10	1	3	8	11	4	7
batch 1-7	4	1	2	6	8	7	3	5	9	11	10
batch 1-8	3	1	7	6	8	5	2	4	11	10	9

Heat Maps – NO_x emission in mg/m³

NO _x emission mg/m ³ @ 13% O ₂	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	-.-.-.	-.-.-.	n. a.	-.-.-.	-.-.-.	-.-.-.	n. a.	-.-.-.	n. a.	-.-.-.	n. a.
best 3 batches at NL	126	118	119	122	88	104	98	108	91	109	83
batch 1+2	130	122	122	124	92	104	105	107	106	77	84
all nominal loads	130	119	112	117	87	104	91	98	83	95	83
all partial loads	129	120	110	109	82	96	84	94	86	64	76
overloads	128	121	134	110	95	100	103	87	81	111	108
batch 1-7	130	119	115	117	88	102	94	99	89	81	83
batch 1-8	130	119	118	116	89	102	97	97	87	83	85

Heat Maps – TPM emission in mg/m³ and ranking

TPM emission mg/m³ @ 13% O ₂	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	---	---	---	---	---	---	n. a.	---	n. a.	---	n. a.
best 3 batches at NL	2	19	53	44	46	50	22	46	54	20	68
batch 1+2	11	59	80	84	69	94	33	32	54	33	138
all nominal loads	3	24	66	48	53	59	25	81	83	24	68
all partial loads	3	23	46	54	44	66	21	103	71	111	150
overloads	11	24	145	51	75	52	35	127	93	35	62
batch 1-7	5	28	54	60	59	84	35	80	90	52	98
batch 1-8	6	31	78	61	62	80	34	87	89	49	92

TPM emission	Stove 1	Stove 2	Stove 3	Stove 4	Stove 5	Stove 6	Stove 7	Stove 8	Stove 9	Stove 10	Stove 11
Official Type Test	3	6	2	4	7	8	n. a.	5	n. a.	1	n. a.
best 3 batches at NL	1	2	9	5	7	8	4	6	10	3	11
batch 1+2	1	6	8	9	7	10	3	2	5	4	11
all nominal loads	1	2	8	5	6	7	4	10	11	3	9
all partial loads	1	3	5	6	4	7	2	9	8	10	11
overloads	1	2	11	5	8	6	3	10	9	4	7
batch 1-7	1	2	5	7	6	9	3	8	10	4	11
batch 1-8	1	2	7	5	6	8	3	9	10	4	11

Summary and conclusion

- Stoves of different ages with different properties were tested.
- One to three repetitions were performed applying Real-LIFE test protocol.
- Real-LIFE test protocol was not always followed (e. g. longer breaks between batches).
- Only one stove (stove 2) fulfilled requirements of EcoDesign if we consider the entire Real-LIFE test protocol.
- Order of stoves regarding emissions changed if Real-LIFE test protocol is applied compared to type test results.
- Database should be further extended.

Thank you for your attention!



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