The “beReal” project

The firewood method

19th of January 2017
in the frame of the 5th Central European Biomass Conference, Graz, Austria

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Outline

- Approach
- What is real life?
- Method development
- Demonstration
- Conclusion
## Approach

**What is “real-life” stove operation?**

- WP 2
  - European survey of stove users
  - Field monitoring

**Development of the new firewood stove testing method**

- WP 3
  - Method development based on WP 2
  - Constant revision during project

- WP 4
  - Web based data evaluation tool

- WP 5
  - Validation

- WP 8
  - Round robin test

**Demonstration**

- WP 7
  - Field measurement

**Output**

- WP 6
  - Label development
What is “real-life”?

Field monitoring
- Measurement of draught conditions and frequency of use in field installations
- 20 appliances (in four countries)
- ~4 months duration
- Frequency of use
- Number of batches per heating cycle
- Duration of heating cycles / batches
- Draught conditions

European online survey*
- 28 questions about heating appliance, installation conditions, user behavior and fuel
- Available in seven languages
- Online for 14 consecutive weeks
- www.bereal-project.eu
- 2205 completed questionnaires
- Good regional distribution along different climate zones in Europe
- Unique overview on user behavior on European level

What is “real-life”?  

Highlights of European online survey

- **Fuel**
  - Predominance of hardwood
  - 63% of respondents use only one fuel type (90% hardwood)
  - 26% using two fuel types (95% combinations with hardwood)

- **Batches per day**
  - 5 batches per heating session in the winter

**User knowledge**

- Yes, and I am operating it accordingly
- Yes, but I operate it on my own way
- No, but I found out myself
- I do not know
Method development

Quick User Guide (QUG)

- Basis for stove operation (testing and “real-life”)
- Provided by stove manufacturer
- Defines relevant operation procedure
  - Number of firewood pieces (incl. mass)
  - Fuel for ignition batch incl. placement in combustion chamber
  - Mass auf ignition batch
  - Recharging procedure
  - Combustion air settings

- QUG example -
Method development

Measurements

- Gaseous composition (FGC): O₂, CO₂, CO, NOₓ and OGC
- Flue gas temperature (T₁): thermocouple, centrally located in the flue pipe
- Flue gas velocity (v) and temperature (T₂)
- Draught measurement (Δp)
- Gravimetric PM measurement (PMₜₐ₇₅₂₆₈₃₈₉₅₁₀)
- Measurement of ambient air temperature (Tambient)

- Leakage test of appliance – before and after combustion tests (acc. to prEN 16510-1)
Method development

Fuel

✓ **Type**: Beech (preferably) or birch firewood provided by testing laboratory
✓ **Conditions**: Water content 15% ± 3%
✓ **Size**: As defined in the QUG
✓ **Fire starter**: Bio-based fire starter is mandatory (no paper or liquids)
✓ **Kindling material**: Spruce, beech or birch, max. 25% of ignition batch mass

Ignition batch:
Minimum batch mass (without kindling material) shall be ≥ 80% of the nominal load mass

Nominal load batch:
Size, number of firewood pieces and total batch mass is defined in the QUG. Only pieces with equal weight is allowed (± 10%)

Partial load:
Defined as 50% mass of the nominal load. Number and size of pieces and placement in the combustion chamber are defined in the QUG
Method development

Measurement cycle

- Constant controlled flue gas draught: -12 Pa ± 2 Pa
- PM measurement during batch 1, 3, 5 and 7 (during the whole batch duration)
- Time of recharging: CO₂ < 4% and < 25% of CO₂_{max} (option: CO₂ < 3% when CO₂_{max} was < 12%)

Combustion air settings:
- After 1\textsuperscript{st} / 2\textsuperscript{nd} / 5\textsuperscript{th} batch: only one manual adjustment (defined by manufacturer) is permitted
- During batches (2\textsuperscript{nd} to 8\textsuperscript{th}): no manual adjustments are allowed
- After 8\textsuperscript{th} batch: adjustment (defined by manufacturer) is permitted
- Adjustments done by a automatic control system is allowed permanently
Method development

Data evaluation

- Standardized data calculation and result reported by an online evaluation tool (developed in WP 4)
- Notified laboratories upload combustion test raw data and relevant appliance information
- Evaluation tool provide a final test report
- Data evaluation mostly based on prEN16510-1
- Results are calculated for all eight batches
Method development: Validation

Objectives:

✓ Identification of challenges in the measurement procedure and testing method
✓ Method repeatability and comparison with standard type testing
✓ Feedback loop for method development

Method:

✓ 9 stoves (acc. to EN 13240) were tested at different RTD partners (SP, DTI, HFR, TFZ, BE2020)
✓ Broad range of appliances from 4 kW to 10 kW:
  ✓ Firewood stoves in different price levels
  ✓ Firewood stoves with automatic combustion air control systems

Feedback for method development:

✓ Adjustments in the recharging criteria
✓ Modifications in the test rig (temperature measurement, PM measurement)
✓ New method showed good repeatability
Method development: Round robin test

Objectives:

✓ Provide performance data and method feedback of the new method
✓ Asses the effect of fuel quality
✓ Compare the new method with standard type testing

Method:

✓ One 5 kW stove was used for all tests
✓ Fuel was provided from HFR, in addition local fuel was used
✓ In total seven testing labs (3 with type testing accreditation)
Method development: Round robin test

Results:

- The “beReal” method can be reproduced in different laboratories
- The best reproducibility for the emissions is achieved for NOx, followed by CO, PM and OGC
- Increased reproducibility for test fuel without bark

x … mean value; s … between-laboratory standard deviation; CV … coefficient of variation
Demonstration

Field tests

Method:

- 13 firewood stoves in 4 countries
  - Day 1: End user normal operation
  - Day 2: End user operation according to QUG
  - Day 3: End user coached by RTD partner according to beReal

Results:

- The “beReal” method can reflect typical real life heating behavior
- No constant factor between standard type testing and beReal method is given
Conclusion

✓ New method was developed which considered real life stove operation

✓ Development was based on:
  ✓ Investigations on user behavior in real life stove operation (survey/field monitoring)
  ✓ Validation measurements
  ✓ Round robin tests

✓ Field tests were conducted to prove new method

✓ The new method is strongly correlated to real life stove operation

✓ High quality stoves can easier be distinguished from low quality appliances
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