

# The “beReal” project

## The firewood method

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M. Wöhler, S. Pelz

University of Applied Forest Sciences



University of Applied Forest Sciences  
Rottenburg

University of Applied Sciences



Technologie- und  
Förderzentrum



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

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

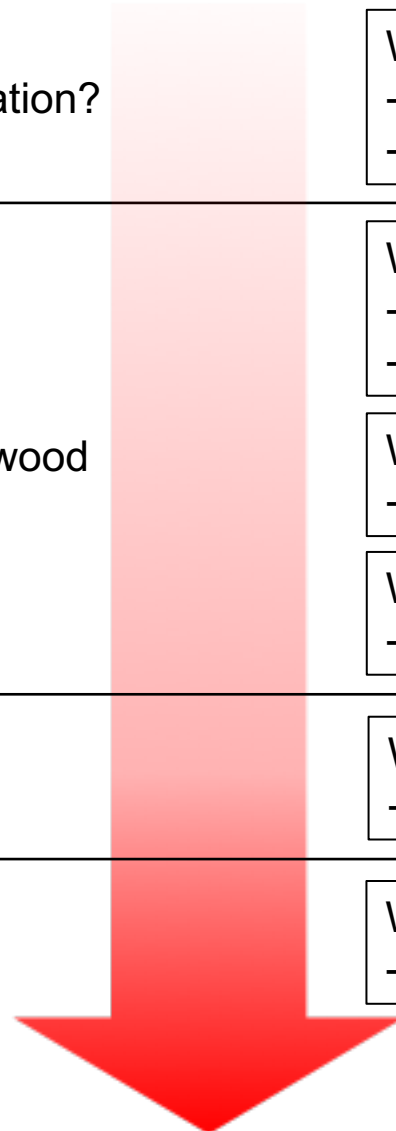
- WP 8
  - Round robin test

Demonstration

- WP 7
  - Field measurement

Output

- WP 6
  - Label development



## 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](http://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”?

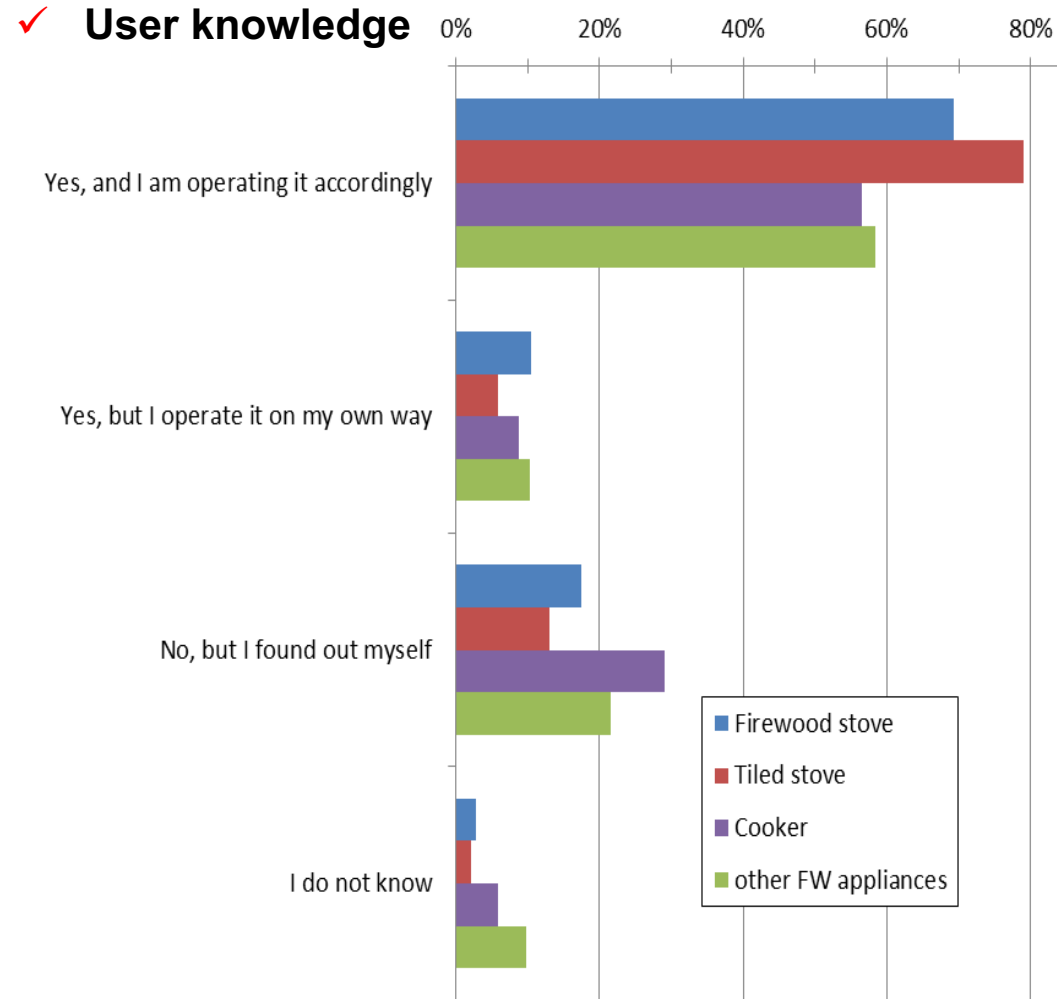
## Highlights of European online survey

### ✓ 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

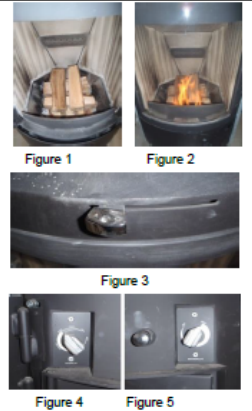


## Quick User Guide (QUG)

- ✓ 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

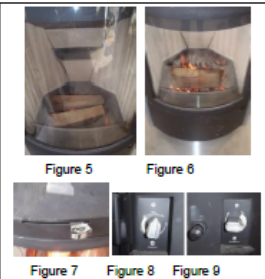
### 1. Preparation & Ignition

- Clean and open the grate and empty the ash box
- Crosswise placement of four firewood pieces (2 layers) on top of shavings(3 layers) on the grate (Bottom-up ignition) (Fig. 1 & Fig. 2)
  - Length of firewood: 25 cm
- Use only dry and natural firewood – at least 1 year stored
  - 3 layers shavings, crosswise placed - total: 0.6 kg
  - 1. layer 2 firewood pieces, each 0.35 kg
  - 2. layer 2 firewood pieces, each 0.35 kg
  - Whole mass of the ignition batch has to be 2.0 kg (Fig. 1)
- Air inlet flap settings for ignition:
  - Bypass foamed ceramic: fully open “A” (Fig. 3)
  - Primary air supply: fully open “Max” (Fig. 4)
  - Secondary air: fully open “Max”(Fig 5)
- Lighting of starting aid (placed on the grate) (Fig. 2)
- Closing of combustion chamber door



### 2. Recharging

- Recharge when flames are extinguishing or when no flames visible, but enough firebed is available
- After the 1<sup>st</sup> batch: (Fig. 5)
  - Firewood: 2 pieces, each 1.0 kg, Total mass 2.0 kg
- After the 5<sup>th</sup> batch: (Fig. 6)
  - Firewood: 1 piece, Total mass 1.0 kg
- Placement according to Fig. 6 – only parallel to the window
- Air inlet flap settings:
  - Bypass foamed ceramic: closed “Z” (Fig. 7)
  - Primary air supply: reduced to Min (Fig. 8)
  - Secondary air: reduced to 50 % (Fig 9)



### 3. Finishing heating operation

- When flames are extinguished and when the firebed is not glowing any more (Fig. 7)
  - Close air inlet flaps (Fig. 8) for avoidance of heat losses
  - Primary air supply: closed “Min” (Fig. 8)
  - Secondary air: closed “Min” (Fig 9)



- QUG example -

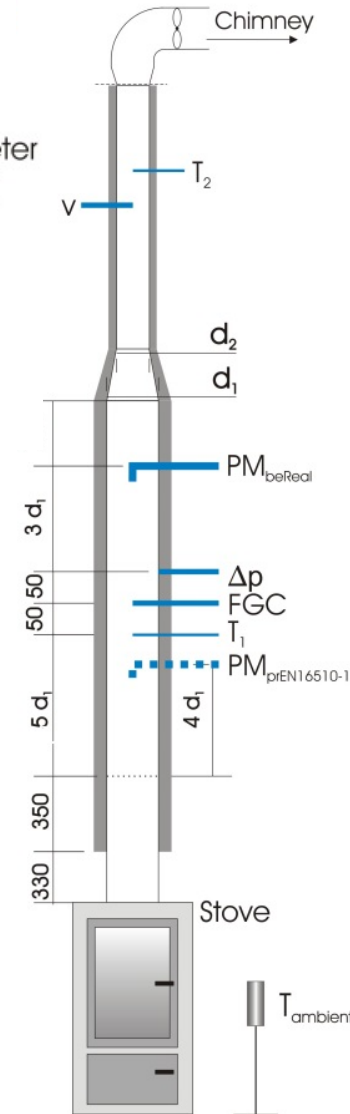
## Measurements

- ✓ Gaseous composition (FGC):  $O_2$ ,  $CO_2$ ,  $CO$ ,  $NO_x$  and OGC
- ✓ Flue gas temperature ( $T_1$ ): thermocouple, centrally located in the flue pipe
- ✓ Flue gas velocity ( $v$ ) and temperature ( $T_2$ )
- ✓ Draught measurement ( $\Delta p$ )
- ✓ Gravimetric PM measurement ( $PM_{beReal}$ )
- ✓ Measurement of ambient air temperature ( $T_{ambient}$ )
- ✓ Leakage test of appliance – before and after combustion tests (acc. to prEN 16510-1)

## Measurement section

All dimensions in [mm]

$d_{1/2}$	...	Measurement section diameter
$PM_{prEN16510-1}$	...	PM as given in prEN 16510-1
$T$	...	Flue gas temperature
FGC	...	Flue gas compounds
$\Delta p$	...	Flue gas draught
$PM_{beReal}$	...	PM measurement
$v$	...	Flue gas velocity
$T_{ambient}$	...	Ambient temperature



## Fuel

- ✓ **Type:** Beech (preferably) or birch firewood provided by testing laboratory
- ✓ **Conditions:** Water content  $15\% \pm 3\%$
- ✓ **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  $\geq 80\%$  of the nominal load mass

### **Nominal load batch:**

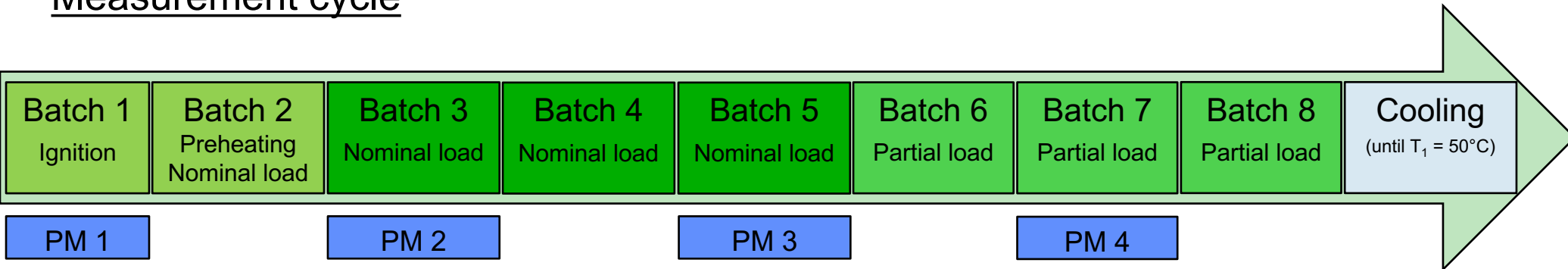
Size, number of firewood pieces and total batch mass is defined in the QUG. Only pieces with equal weight is allowed ( $\pm 10\%$ )

### **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



## Measurement cycle



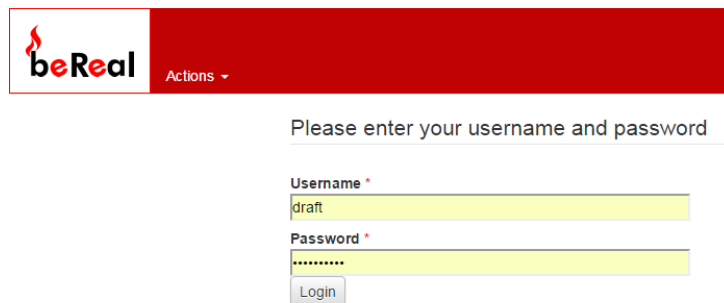
- ✓ Constant controlled flue gas draught:  $-12 \text{ Pa} \pm 2 \text{ Pa}$
- ✓ PM measurement during batch 1, 3, 5 and 7 (during the whole batch duration)
- ✓ Time of recharging:  $\text{CO}_2 < 4\%$  and  $< 25\%$  of  $\text{CO}_{2\text{max}}$  (option:  $\text{CO}_2 < 3\%$  when  $\text{CO}_{2\text{max}}$  was  $< 12\%$ )

## Combustion air settings:

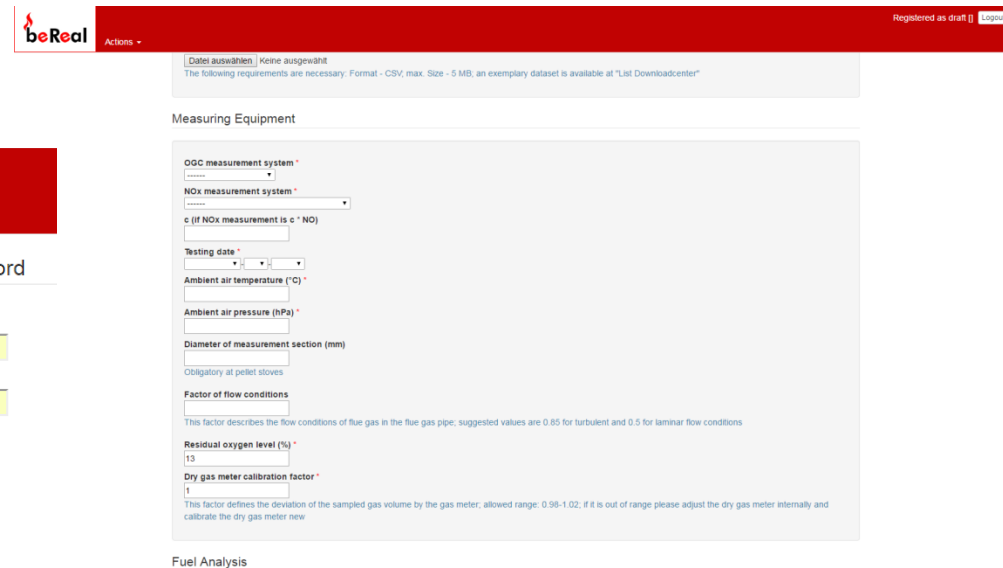
- ✓ After 1<sup>st</sup> / 2<sup>nd</sup> / 5<sup>th</sup> batch: only one manual adjustment (defined by manufacturer) is permitted
- ✓ During batches (2<sup>nd</sup> to 8<sup>th</sup>): no manual adjustments are allowed
- ✓ After 8<sup>th</sup> batch: adjustment (defined by manufacturer) is permitted
- ✓ Adjustments done by a automatic control system is allowed permanently

## 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



The screenshot shows the beReal login interface. It features a red header with the beReal logo and a navigation menu. Below the header, there is a prompt: "Please enter your username and password". The login form includes two input fields: "Username" with the text "draft" and "Password" with masked characters. A "Login" button is positioned below the password field.



The screenshot displays the beReal data entry page. It has a red header with the beReal logo and a navigation menu. The main content area is titled "Measuring Equipment" and contains several form fields for data entry. The fields include: "Datei auswählen" (File selection), "OGC measurement system", "NOx measurement system", "c (if NOx measurement is c \* NO)", "Testing date", "Ambient air temperature (°C)", "Ambient air pressure (hPa)", "Diameter of measurement section (mm)", "Factor of flow conditions", "Residual oxygen level (%)", and "Dry gas meter calibration factor". Each field has a corresponding input box or dropdown menu. The page also includes a "Fuel Analysis" section at the bottom.

## 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

## 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

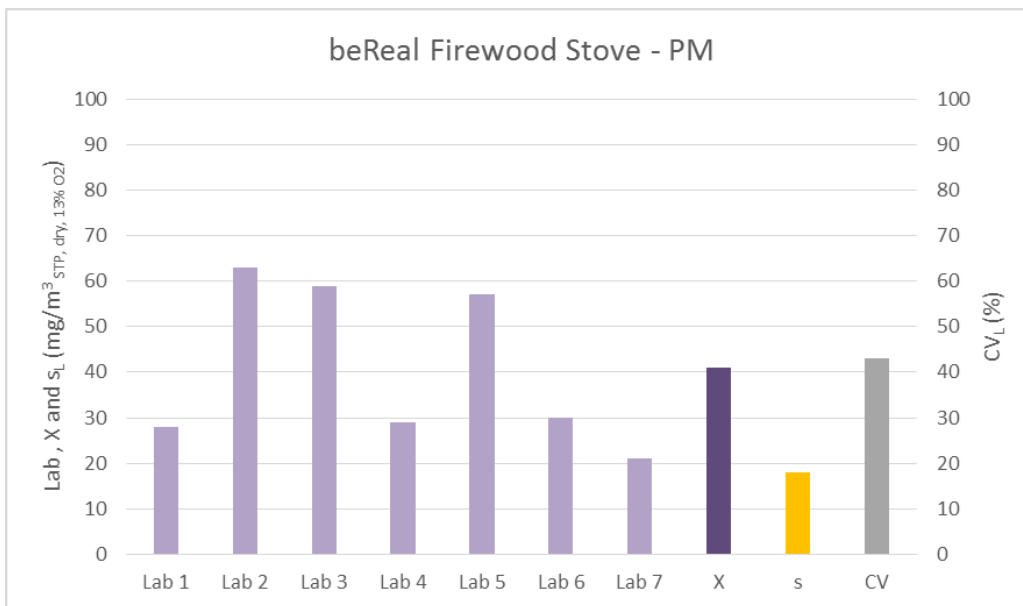
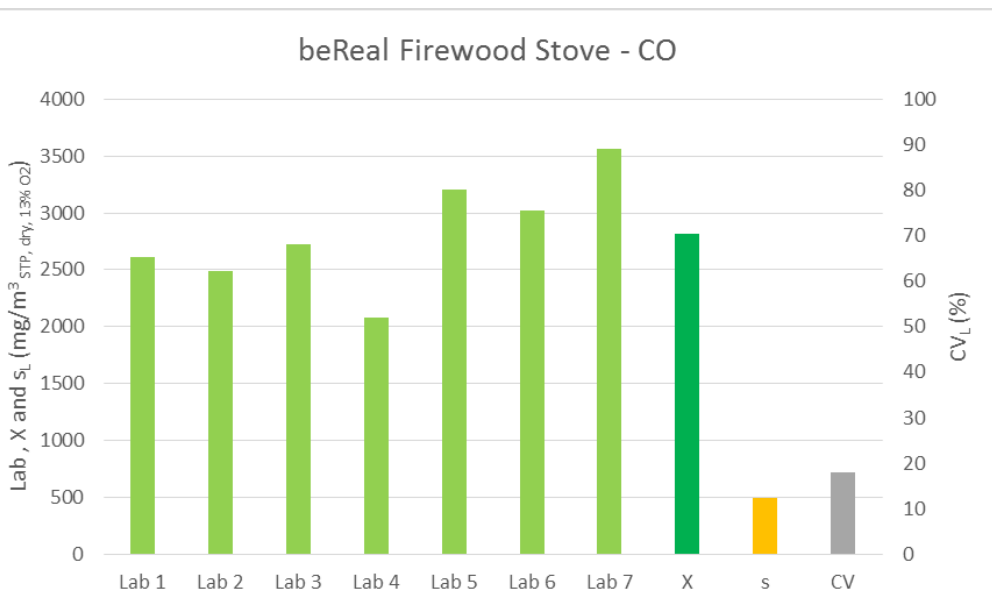
## Method:

- ✓ 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)



## Results:

- ✓ The “beReal” method can be reproduced in different laboratories
- ✓ The best reproducibility for the emissions is achieved for NO<sub>x</sub>, followed by CO, PM and OGC
- ✓ Increased reproducibility for test fuel without bark

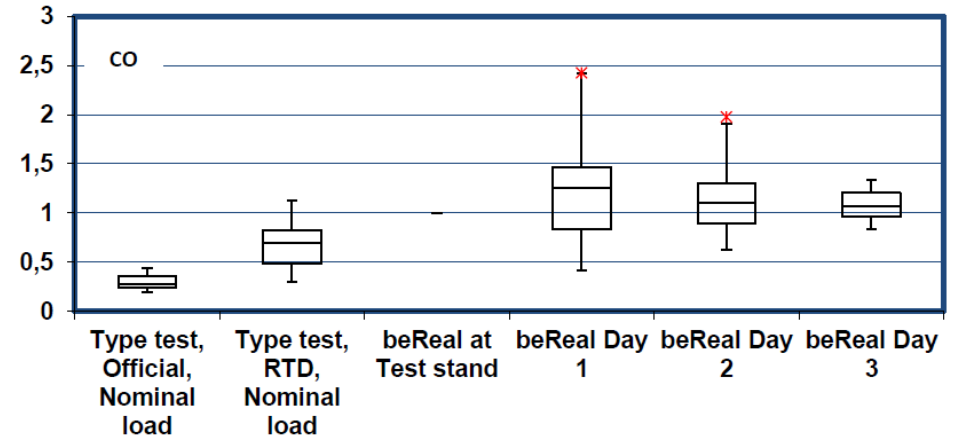
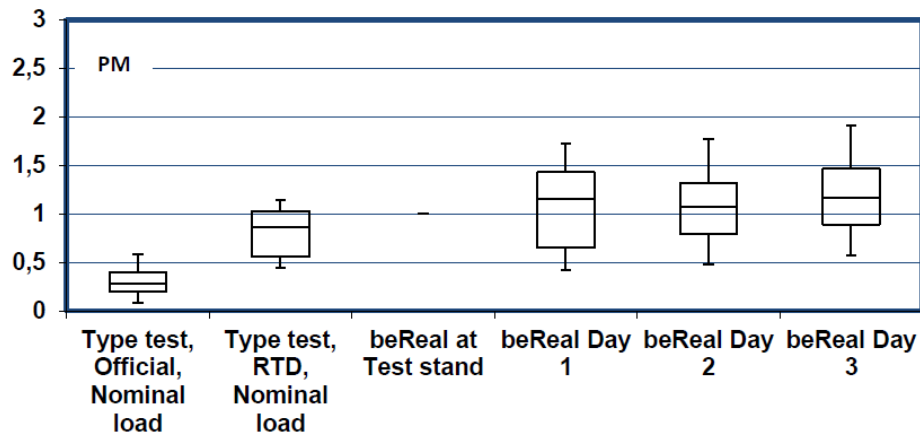


x ... mean value; s ... between-laboratory standard deviation; CV ...coefficient of variation

## 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

- ✓ 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

# The “beReal” project

## The firewood method

M. Wöhler

woehler@hs-rottenburg.de  
+49 7472 951 269

S. Pelz



University of Applied Forest Sciences  
Rottenburg

University of Applied Sciences

bioenergy2020+



Technologie- und  
Förderzentrum



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