

## The beReal-project

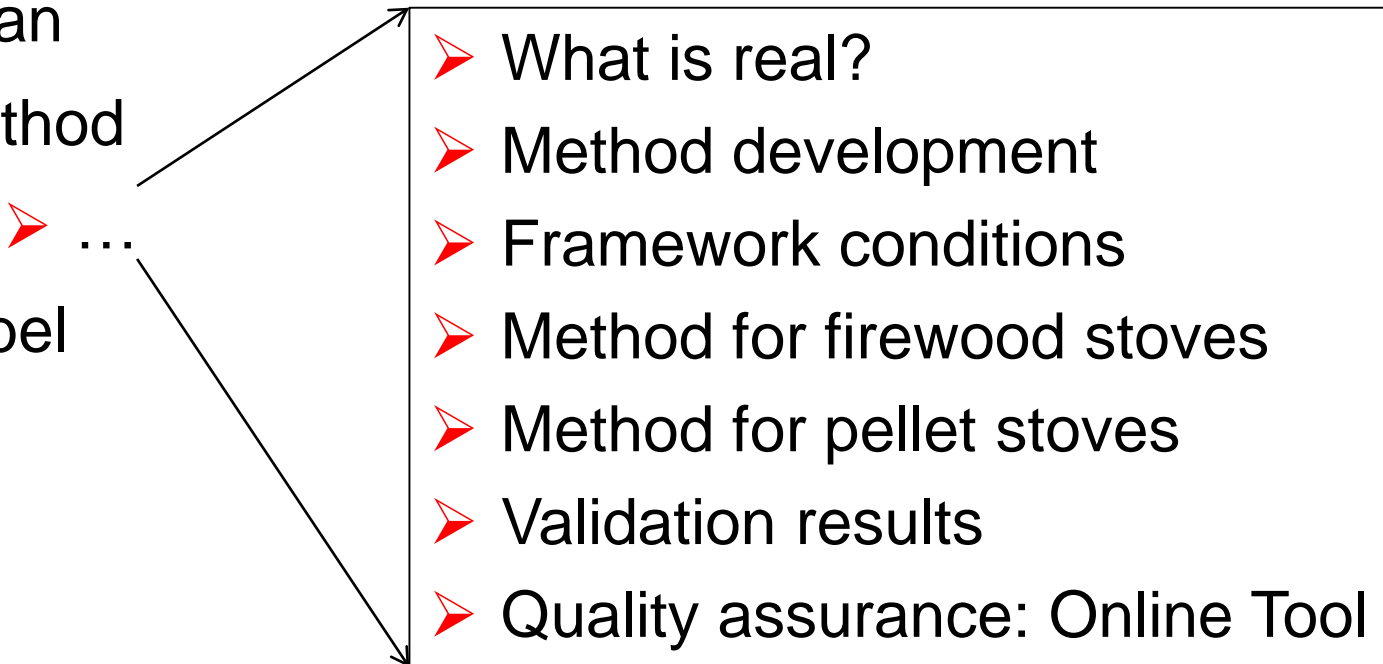
### Real life stove testing for European label development

IEA Task 32 Workshop  
Berlin  
29<sup>th</sup> October 2015

Christoph Schmidl

bioenergy2020+

- Background and Motivation
- Project Overview
- Working plan
- beReal Method
  - ...
- beReal Label
- Outlook

- 
- What is real?
  - Method development
  - Framework conditions
  - Method for firewood stoves
  - Method for pellet stoves
  - Validation results
  - Quality assurance: Online Tool

- Air quality concerns all over Europe (PM10 / PM2.5 / BaP)
  - Leading to drastic measures: e.g. ban of firewood combustion
- Often large discrepancy between performance at product certification (i.e. type testing) and in real life
- Poor link of type testing results to real life product quality in terms of efficiency and emissions
- Regulation requests more realistic testing methods that better reflect real life performance, e.g.
  - Air quality regulations bodies
  - EC Mandate to standardisation group (CEN TC 295)

- **Project Call:** FP7 – Research for the Benefit of SME-AGs (GA 606605)
- **Project coordinator:** TFZ; Straubing, Germany
- **Scientific coordinator:** Bioenergy 2020+; Wieselburg-Land, Austria
- **Project partners:**

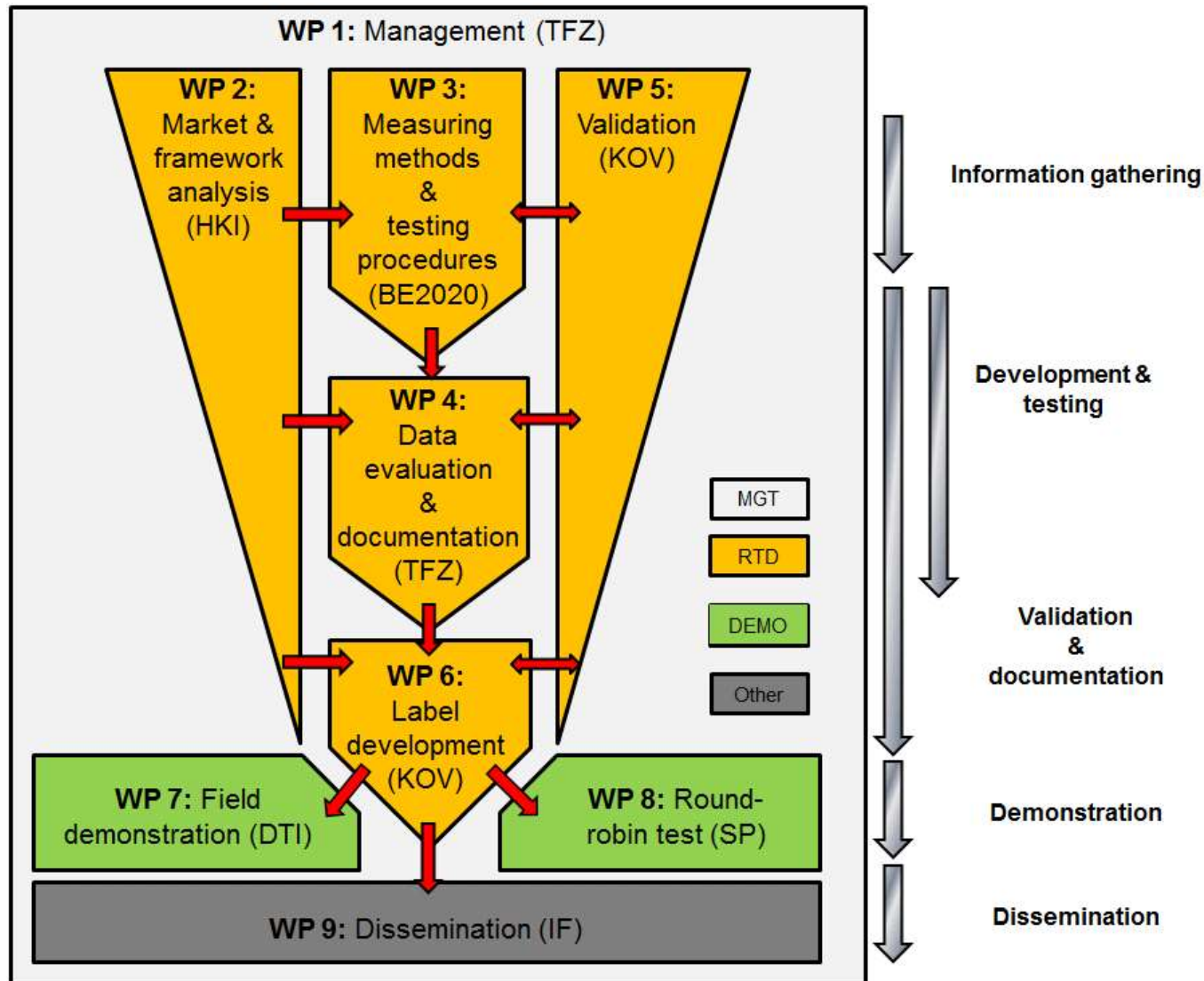
RTD	SME's	SME-AG's *
TFZ (DE)	Atech (SLO)	HKI (DE)
BE2020+ (AT)	Interfocos (NL)	KOV (AT)
DTI (DK)	Stuv (BE)	EFA (EU)
SP (SE)	HWAM (DK)	
HFR (DE)	HETAS (UK)	
	Nibe (SE)	
	Scan (DK)	

\* With 9 association partners: *Hark, Westfeuer, Extraflame, LaNordica, Austroflamm, RIKA, Palazzetti, ORTNER, Spartherm*

- **Subcontractor:** AIEL (IT)

- Development of **advanced testing methods** for biomass room heating appliances (firewood & pellet stoves) to better reflect **real life operation**
- Development of a **centralized standard evaluation tool** for quality assurance purposes
- **Validation of methods** at an early stage of development
- Proof of **real life impact** of advanced products by **field test demonstration**
- Proof of **reliability** and **reproducibility** of testing methods and evaluation tools in a **Round Robin test**
- Development and introduction of a **European quality label** based on the novel testing methods
- Project results are accompanied by **dissemination activities** addressing standardization bodies, SME-members of participating SME-AGs and notified bodies, including training activities for the latter two groups. The introduction of the quality label addresses end users and general public.

# Project Overview – Work Packages



# Working plan – Current status & Outlook

Project month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Month		Okt.13	Nov.13	Dez.13	Jän.14	Feb.14	Mär.14	Apr.14	Mai.14	Jun.14	Jul.14	Aug.14	Sep.14	Okt.14	Nov.14	Dez.14	Jän.15	Feb.15	Mär.15	Apr.15	Mai.15	Jun.15	Jul.15	Aug.15	Sep.15	Okt.15	Nov.15	Dez.15	Jän.16	Feb.16	Mär.16	Apr.16	Mai.16	Jun.16	Jul.16	Aug.16	Sep.16		
<b>WP</b>	<b>Gantt-Chart: beReal-project</b>																																						
2	Market and Framework																																						
3	Measuring Methods and Testing Procedures																																						
4	Data Evaluation and Documentation																																						
5	Validation																																						
6	Label Development																																						
7	Field Demonstration																																						
8	Round Robin Test																																						




- **WP2** Market & Framework: What is real life operation? → User survey, literature research & long term field tests
- **WP3** Method development: Fuel impact, draught conditions, user behavior aspects
- **WP4** Data evaluation and documentation: Quick-User-Guide, Online Tool (draft), QA concept
- **WP5** Validation: Comparison of EN & beReal, Repeatability of beReal, Viability analysis for other technologies, final method definition → validation of label classification concept ongoing
- **WP6** Label Development: Kick-Off, first concept under development → Work ongoing
- **WP7 & 8** Field demonstration and Round Robin: Planning and preparations of tests ongoing → to be performed in heating season 15/16

# What is real life?

<http://www.bereal-project.eu/survey.html>

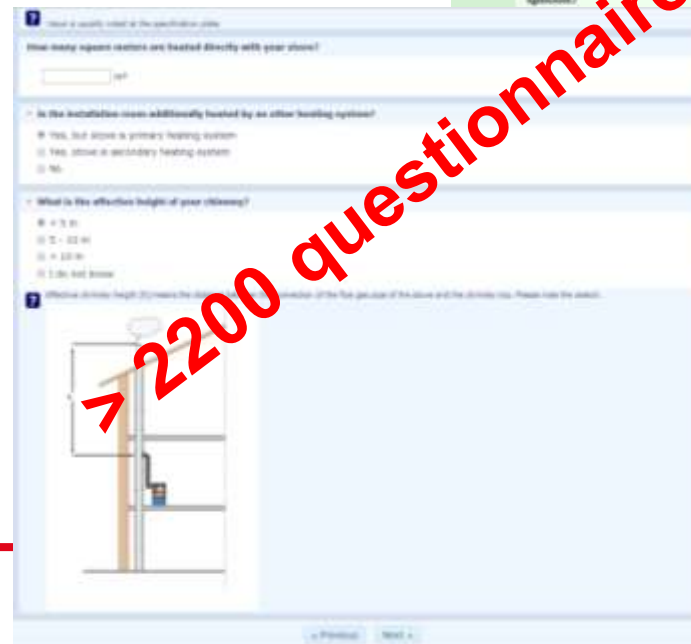
- Literature research
- Online User Survey available in 7 languages
- Long-term field measurements



 Draught measurement  
 Data logger  
 Power supply of unit

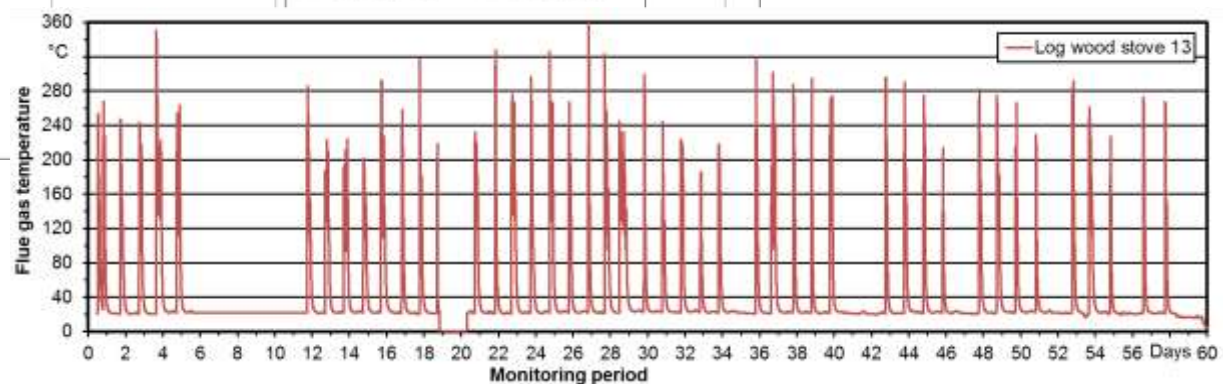
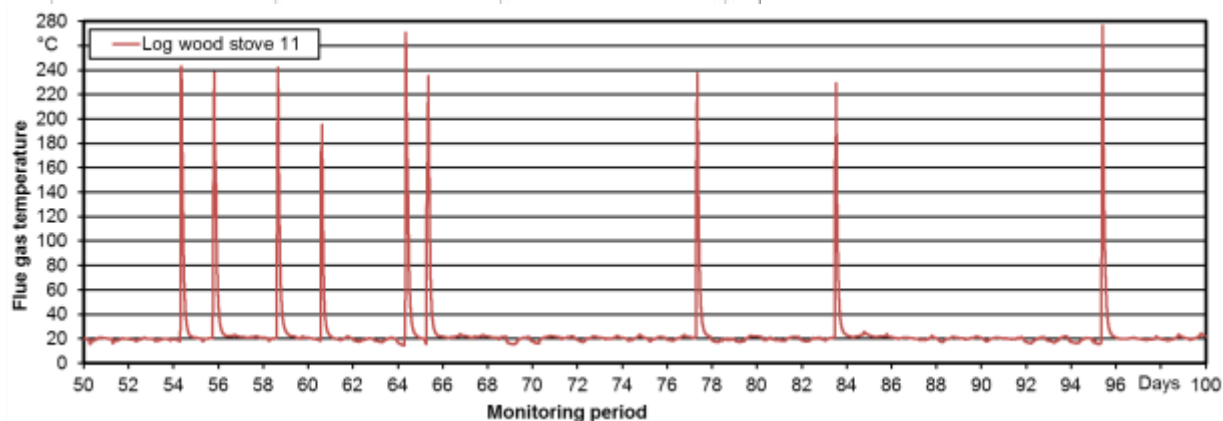
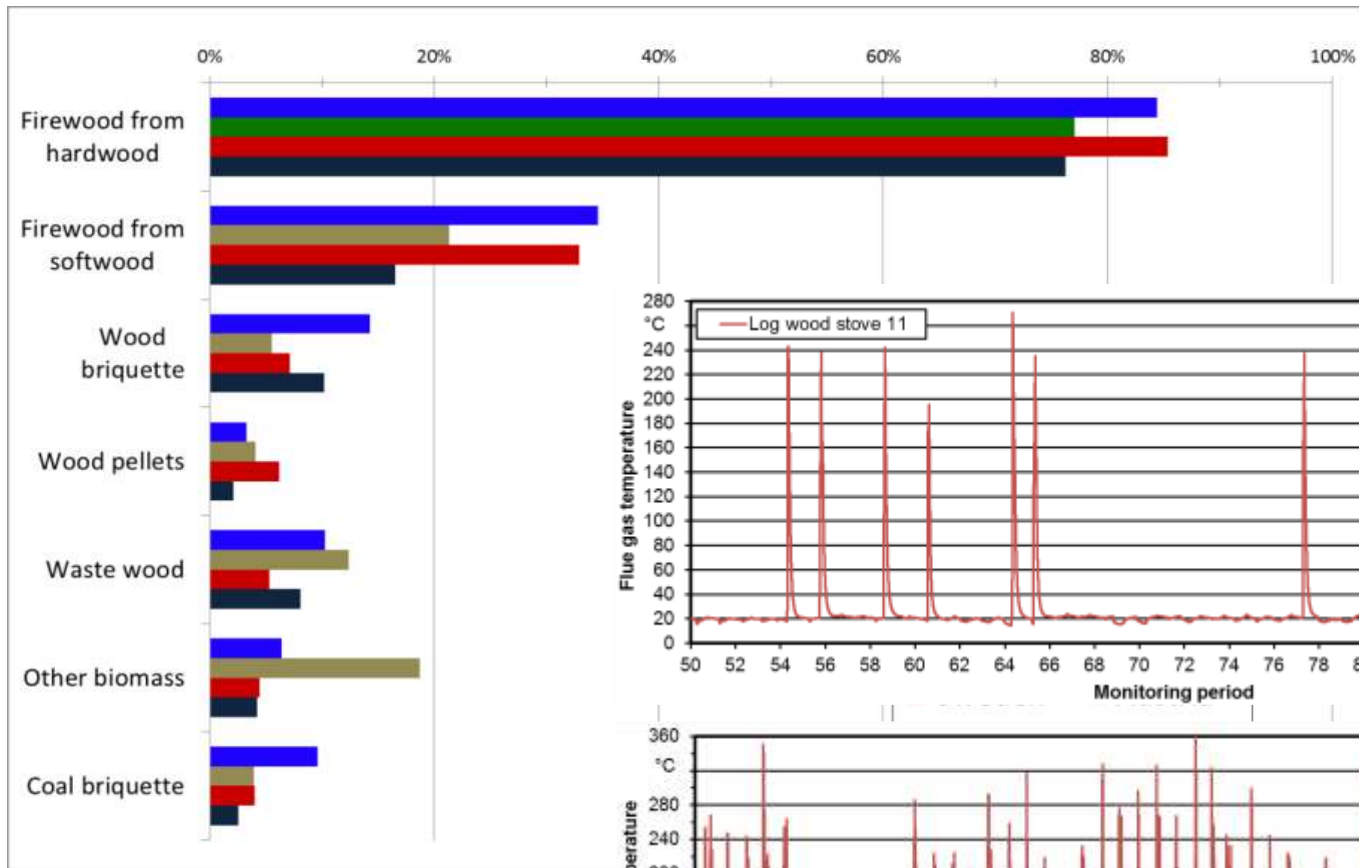


**> 2200 questionnaires completed**





# What is real life?



## Investigated parameters influencing emissions and efficiency:

- Mode of ignition (e.g. bottom-up vs. top-down)
- Refilling criterion (e.g. balance vs. CO<sub>2</sub> criterion)
- Fuel properties (e.g. wood type, water content, chemical and physical properties)
- Chimney draught (e.g. natural vs. forced draught, different draught levels)

## Measurement methods:

- Gaseous compounds (CO, OGC, NO<sub>x</sub>, CO<sub>2</sub>, O<sub>2</sub>)
- Particulate matter emissions
  - Hot vs. diluted sampling
  - Rinsing of sampling probe
- Efficiency determination
  - Indirect method (measuring all losses)
  - Direct method (calorimeter room)



## Scope - The beReal Methods can be applied for:

- Local room heating appliances according to the definitions in
  - EN13240
  - EN14785
- Water jacket appliances are **not** included in first stage of the beReal method
- Extension to other direct heating appliances will be considered in future

## Framework requirements:

- Appliances shall be **end user marketed products**.
- Testing appliances shall be **operated before the beReal Test**
- The beReal method is applied according to the **Quick User Guide (QUG)** which shall be **provided unchanged** with the product to the end customer. Any required changes in the Quick User Guide shall be approved by the testing body in advance.

All dimensions in [mm]

d ... Measurement section diameter

T ... Temperature measurement

FGC ... Flue gas compounds

p ... Flue draught measurement

PM ... PM measurement

## ■ Test facility:

Diameter of measurement section acc. EN 13240/  
prEN 16510-1

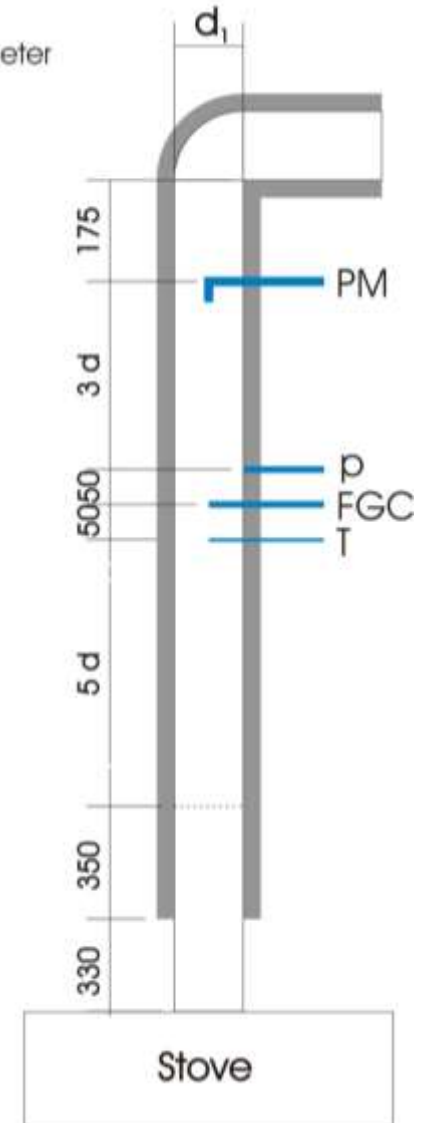
Measuring points & distances: see scheme on the  
right side:

## Important notes:

- PM measurement downstream gas analysis (different to standards)
- PM measurement flow is adjusted according to flue gas volume flow
- Flue gas temperature measured by centrally placed thermocouple

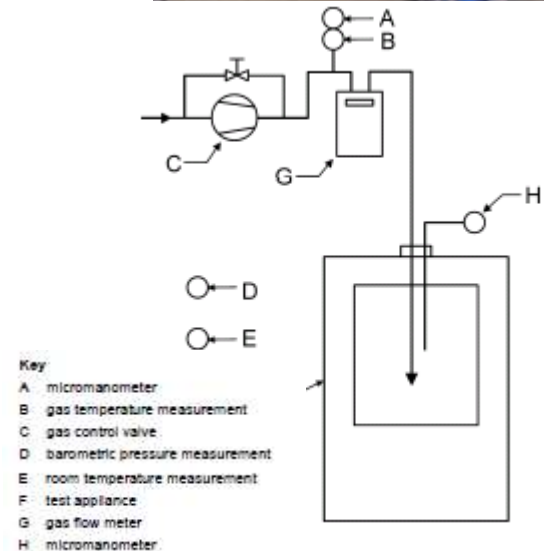
## ■ Test conditions:

Constant draught level of  $12 \pm 2$  Pa for heating operation and cooling down phase.



# Determination of leakage rate

- Leakage testing shall be performed for all appliances (also for not-roomsealed appliances) for proofing quality as well as to recognize damages
  - Leakage check (as received) **before** and **after** beReal testing
  - Test shall be done according to prEN 16510-1 at defined overpressure:
    - 5 Pa (average of two repetitions)
    - 10 Pa (average of two repetitions)
    - 15 Pa (average of two repetitions)
  - Air inlet flap settings shall be closed (not taped)
- **Not absolute values are important but the relative change of leakage before and after beReal testing**



Source:  
prEN  
16510-1

## Number of test batches:

- **Eight successive batches** are performed starting from cold conditions (Ignition & preheating batch included – since they always occur in real life operation)
  - Batch 1 to 5: Batch mass represent **nominal load** (100% batch mass)
  - Batch 6 to 8: Batch mass represent **partial load** (50% batch mass)

## Mode of ignition:

- Mode of Ignition - Defined by the manufacturer (**Quick User Guide**):
  - Number of firewood pieces
  - Mass of ignition batch ( $\geq 80\%$  of the fuel mass representing nominal load)
  - Kindling material (max. 25% of total batch mass) & starting aids (only biobased fire starters allowed  $\rightarrow$  paper & liquids not allowed, max. 3% of total batch mass)
  - Mode of fuel placement of ignition batch in the combustion chamber



## Fuel requirements:

- Fuel: beech firewood (preferably) or birch firewood covered with bark
- Each wood log shall have at least one side covered with bark.
- Covered is defined as  $>80\%$  of surface area





# Quick User Guide

## Basis for operation – Quick User Guide

- The appliance is operated according to an **obligatory Quick User Guide (Text & Pictures)**
- The information of the **Quick User Guide** is **provided by the manufacturer** and defines relevant operation characteristics that are **specific** for the appliance:
  - Preparations before heating operation
  - Mode of ignition
  - Mode of refilling
  - Requirements of firewood – dimensions, number of pieces per batch
  - Adjustments of air inlet flap settings for combustion air supply (during and after heating operation)

### Quick-User-Guide Roomheater EN13240 (8 kW) –

#### 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

After the 1 batch:

- Recharge when flames are extinguishing or when no flames visible, but enough firebed is available
  - Firewood: 2 pieces, each 1.0 kg, Total mass 2.0 kg
  - Placement according to Fig. 5 – only parallel to the window
- Air inlet flap settings:
  - Bypass foamed ceramic: closed "Z" (Fig. 6)
  - Primary air supply: reduced to 20 % (Fig. 7)
  - Secondary air: reduced to 75 % (Fig 8)



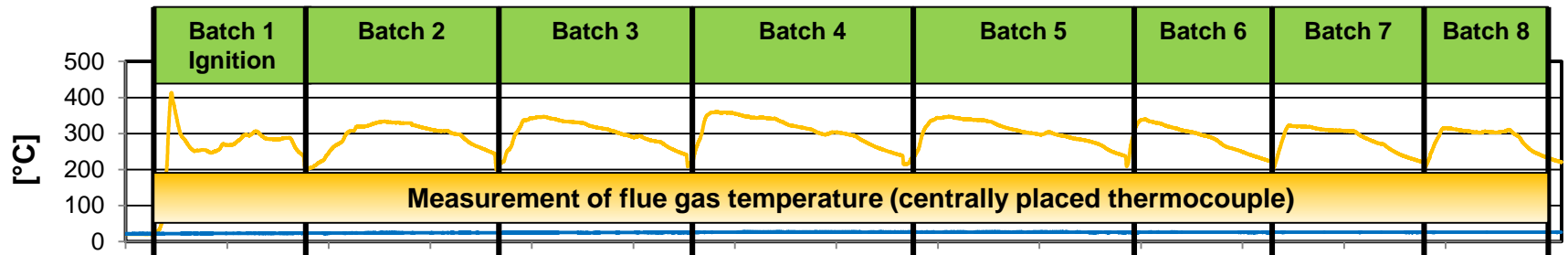
#### 3. Finishing heating operation

- 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)

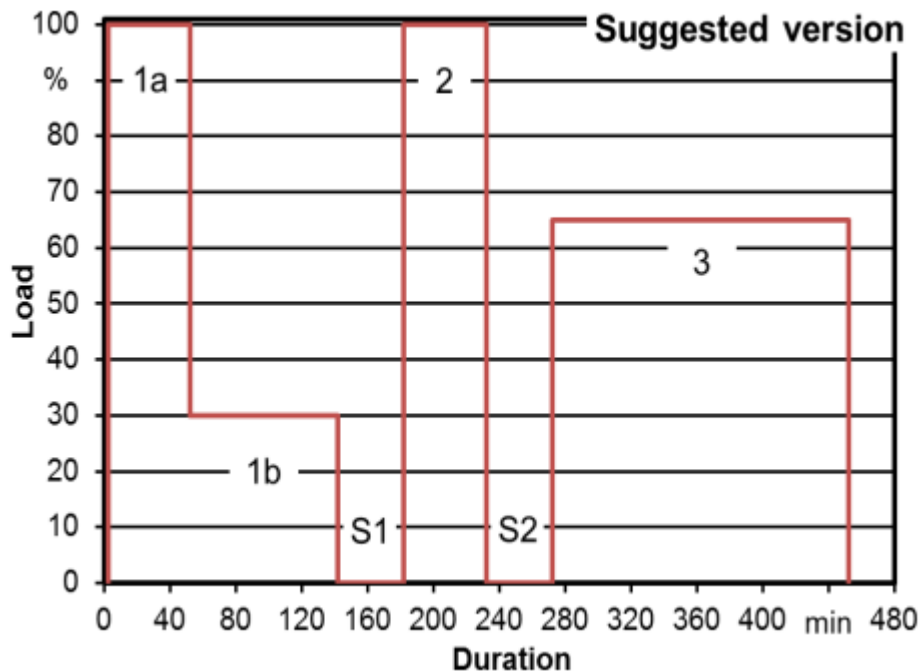


#### ATTENTION:

Divergent operation as defined by this Quick-User Guide will lead to non-optima operation. The requirements regarding emissions and efficiency cannot be achieved.







## beReal Method includes:

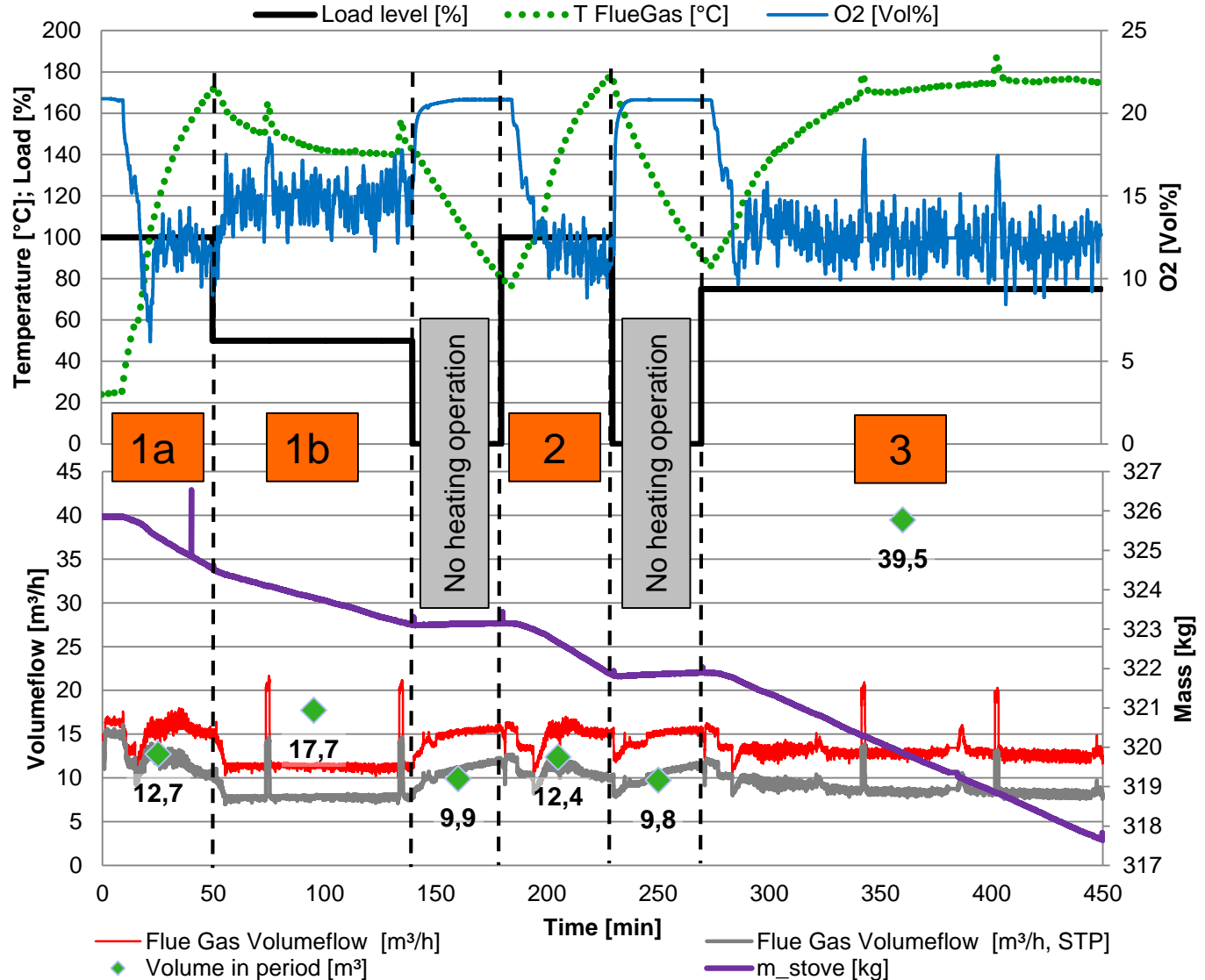
- Ignition and stop phases
- Different load levels and load changes
- Cleaning intervals (if applicable)

	Operation	Load level*	Duration
1a	Cold start	High load	50 min
1b	Load change	Low load	90 min
S1	Stand by	0%	40 min
2	Warm start	High load	50 min
S2	Stand by	0%	40 min
3	Warm start	Medium load	180 min

\*  
 „High“ → highest load to be set by user  
 „Low“ → lowest load to be set by user  
 „Medium“ → mean load between highest and lowest load

## Remarks:

- Combustion conditions vary over periods (Load level,  $T_{\text{FlueGas}}$ ,  $O_2$ )
- Different volume flows in periods and diverse durations
- ⇒ changing flue gas volumes over the periods
- ⇒ **Volume weighing also necessary for gaseous emissions**



## Repeatability

- Both methods showed good or even excellent repeatability
- Highest variabilities were observed for OGC emissions (mainly because of generally low concentrations and therefore higher measurement uncertainties)
- No advantage of current type testing method concerning repeatability

## Method related validation results

- Measurement setup might cause additional costs for testing institutes (e.g. volume flow measurement and adjustable particle sampling line)

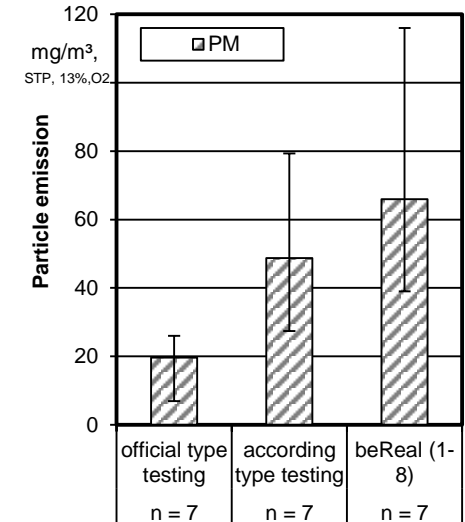
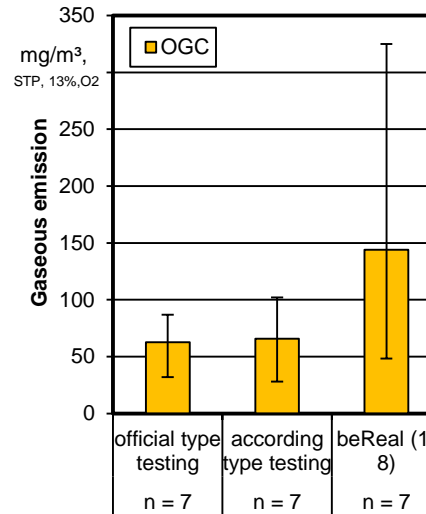
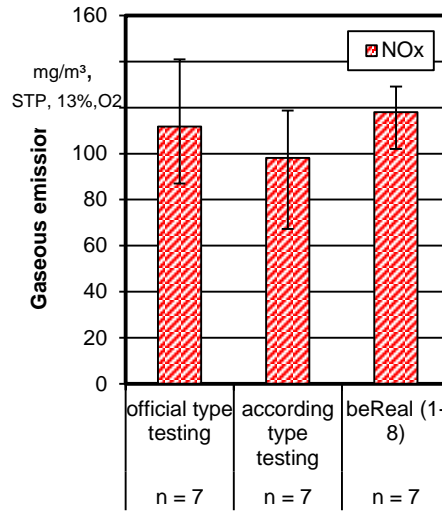
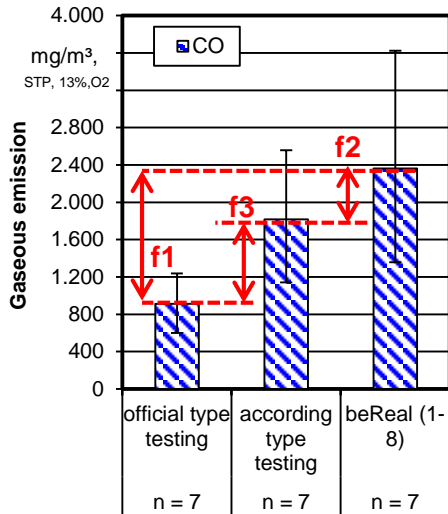
## Viability analysis:

- Adaption of beReal method for other biomass based heating appliances has been investigated and in general appears reasonable

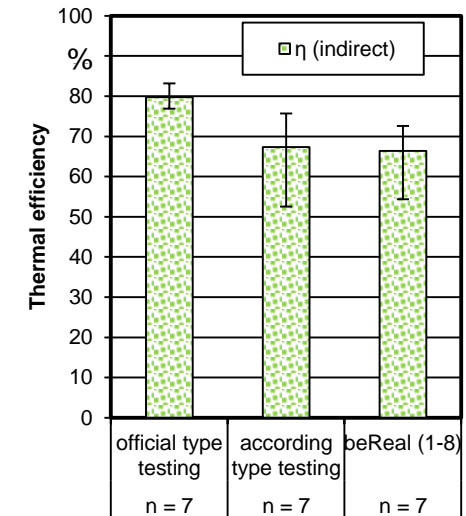
**Comparison: original type test – type test measurement by RTD partners – beReal results...** (only no.2 and 3 with same appliance)

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# beReal Validation Results Firewood



Firewood (n=7)	CO	NOx	OGC	PM	$\eta$
$f_1$ (beReal / oTT)	2.7	1.1	2.4	3.7	0.83
$f_2$ (beReal / acc. RTD TT)	1.4	1.2	2.7	1.4	0.99
$f_3$ (acc. RTD TT / oTT)	2.1	0.9	1.3	2.8	0.85



## Objective

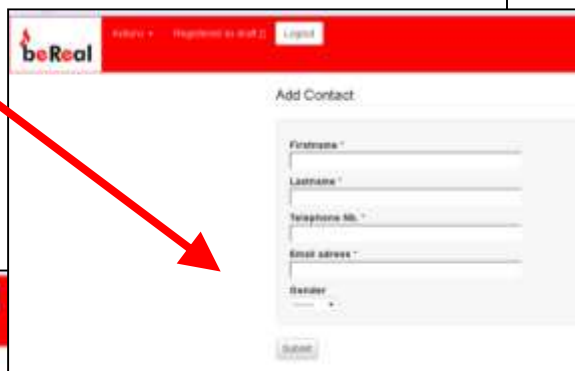
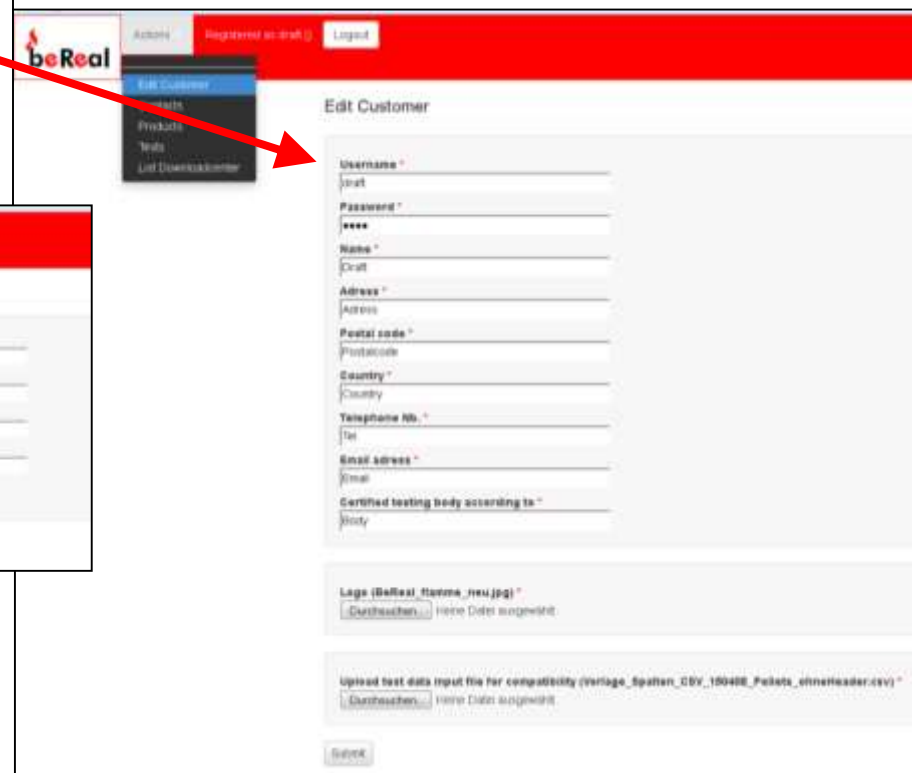

- *Development of a web-based calculation tool –*
    - **Firewood**
    - **Pellets**
- for standardized data calculation of beReal test cycles*

## Advantages of the beReal Online – Tool:

- Equal data handling for all beReal tests (avoiding any calculation mistakes)
- Quality assurance
  - Same (obligatory) information for all tested appliances
  - Automated quality checks of data are implemented
  - Any modifications (method, certification) only have to be implemented once
- Standardised form of reporting form including beReal label classification
- Comprehensive database with all beReal tested products

## Draft version already online:

- Username and password provided by the administrative authority (currently Bioenergy2020+)
- Registry of testing institute (Edit Customer)
- Submission of personal contacts



Firstname	Lastname	Telephone No.	Email address	Gender	Actions
John	Doe	000 030990	john.doe@beReal.com	male	Edit Delete

- Input of general test data
- Fuel analysis input
- Upload of raw data and QUG
- Ash analysis and PM measurements

## Edit Test

Contact <sup>\*</sup>  
Doe ▾

Product <sup>\*</sup>  
Pallet1 ▾

Operatingmode <sup>\*</sup>  
Specified Operationmode ▾

Testfuel <sup>\*</sup>  
Pellets ▾

Quick User Guide (Template\_of\_QuickUserGuide.pdf) <sup>\*</sup>  
 Keine Datei ausgewählt.  
The following requirements are necessary: Format - PDF; max. Size - 900 KB

Data Inputfile (Vorlage\_Spalten\_CSV\_150408\_Pallets\_ohneHeader.csv) <sup>\*</sup>  
 Keine Datei ausgewählt.  
The following requirements are necessary: Format - CSV; max. Size - 5 MB; an exemplary dataset is available at "List Downloadscenter"

## Measuring Equipment

DGC measurement system <sup>\*</sup>  
Methane-Equivalent ▾

NOx measurement system <sup>\*</sup>  
NOx = ox NO ▾

c (if NOx measurement is o \* NO)  
1.05 ▾

Testing date <sup>\*</sup>  
January ▾ 20 ▾ 2015 ▾

Ambient air temperature (°C) <sup>\*</sup>  
25 ▾

Ambient air pressure (hPa) <sup>\*</sup>  
1000 ▾

Diameter of measurement section (mm)  
60 ▾

Factor of flow conditions  
0.95 ▾  
This factor describes the flow conditions of flue gas in the flue gas pipe; suggested values are 0.85 for turbulent and 0.5 for laminar flow conditions

Residual oxygen level (%) <sup>\*</sup>  
13 ▾

Dry gas meter calibration factor <sup>\*</sup>  
1 ▾  
This factor defines the deviation of the sampled gas volume by the gas meter; allowed range: 0.99-1.02; if it is out of range please adjust the dry gas meter internally and calibrate the dry gas meter new

## Fuel Analysis

C (wt-% d.b.) <sup>\*</sup>  
47.10 ▾

H (wt-% d.b.) <sup>\*</sup>  
6.10 ▾

N (wt-% d.b.) <sup>\*</sup>  
0.1 ▾

O (wt-% d.b.) <sup>\*</sup>  
46.69 ▾

S (wt-% d.b.)  
0.01 ▾

Cl (wt-% d.b.)  
▾

Ash (wt-% d.b.) <sup>\*</sup>  
0.06 ▾

H2O (wt-% w.b.) <sup>\*</sup>  
14 ▾

Testing institute  
▾

Certification number  
▾

## Ash Analysis

A template of the ash analysis is available at "List Downloadscenter!"

Collected mass of unburnt residues (g w.b.) <sup>\*</sup>  
80 ▾

Share of combustible in residues (wt-%) <sup>\*</sup>  
20 ▾

## PM measurement

Number of used filters  
4 ▾

Number of measurement devices <sup>\*</sup>  
2 ▾

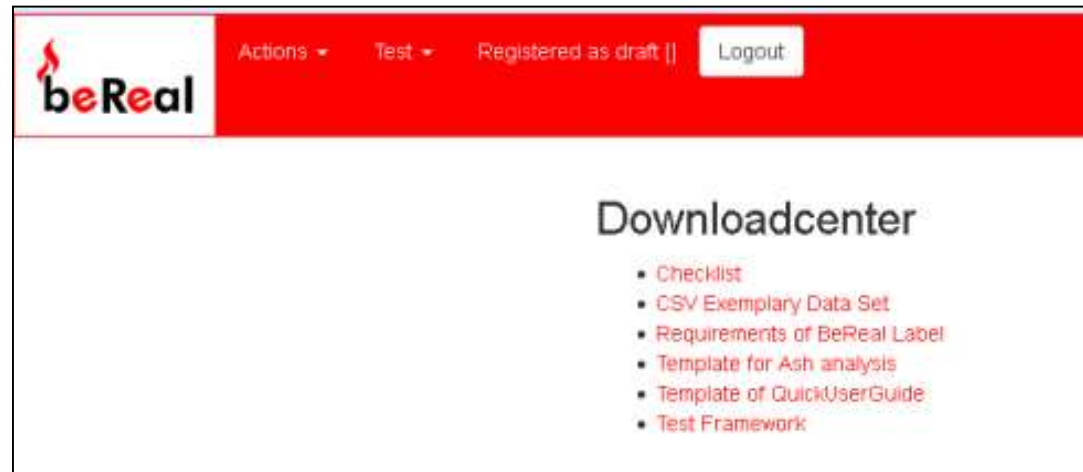
Rinsing of measurement device 1 tars (g) <sup>\*</sup>  
24.20438 ▾

Rinsing of measurement device 2 tars (g)  
24.04507 ▾

Rinsing of measurement device 1 clogged (g) <sup>\*</sup>  
24.20922 ▾

Rinsing of measurement device 2 clogged (g)  
24.04601 ▾

- Helpful information is provided for download:
  - Checklist for using the web-tool
  - CSV as an exemplary dataset
  - Requirements of the beReal Label
  - Test framework (firewood and pellets)
  - (Ash analysis)





## Report of results includes

- Main information about testing institute
- General appliance and test properties
- Results for emissions, efficiency and temperature
- Illustration of raw data, measurement intervals and test pictures \*



### Testing institute

Name: XXX Testing institute  
Address: Unknown Street 1  
Postal code: 1111 City  
Country: Austria  
Certified testing body acc. to: 123456789  
Contact: John Doe  
Tel. nb.: 123456789  
Email address: john.doe@xxxinstitute.com

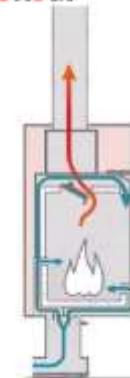
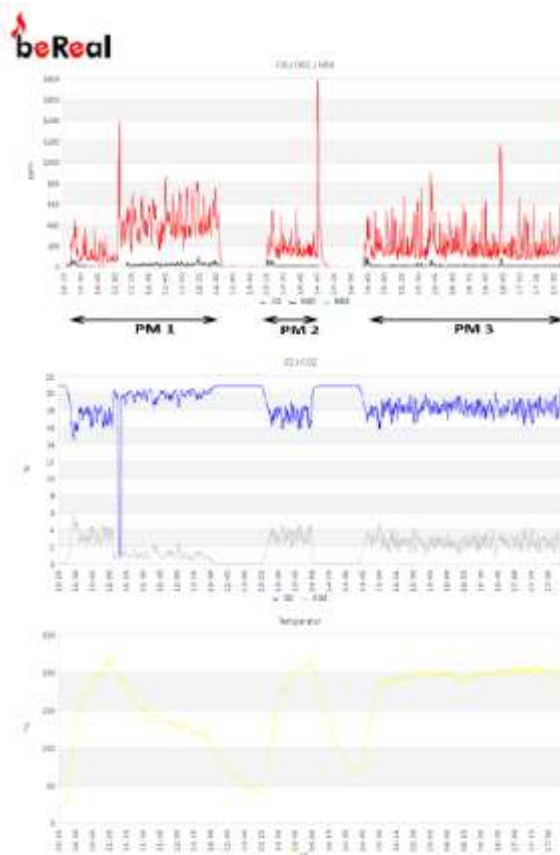
### Test

Producttype: Pelletstove  
Manufacturer: Manufacturer 1  
Name: Pellet 1  
Year of construction: 2015  
Operating mode: specified operation mode  
Nominal thermal heat output: 7 kW  
Roomsealed appliance: True  
Leakage at 5 Pa: 1 m<sup>3</sup>/h  
Leakage at 10 Pa: 1,2 m<sup>3</sup>/h  
Leakage at 15 Pa: 1,5 m<sup>3</sup>/h

Testing date: 2015-05-05  
Ambient air temperature: 25 °C  
Ambient air pressure: 980 hPa

### Results:

CO: 600 mg/m<sup>3</sup>, STP, 13% O<sub>2</sub>  
OGC: 20 mg/m<sup>3</sup>, STP, 13% O<sub>2</sub>  
NOx: 80 mg/m<sup>3</sup>, STP, 13% O<sub>2</sub>  
PM: 40 mg/m<sup>3</sup>, STP, 13% O<sub>2</sub>  
Efficiency: 80 %  
Temperature: 200 °C



\* and the beReal Label (once available)

## Technical Framework (under development):

- Requirements for gaseous and particulate emissions as well as efficiency will be included
  - Concept: Using emission factors rather than emission concentrations
- Documentation requirements (e.g. obligatory quick user guide)

## Administrative Framework (under development):

- Legal form and structure of labeling body
- Requirements for testing institutes performing beReal tests
- Market surveillance (retesting of beReal labelled appliances from market)

## Label Design (under development):

- Design contest has been performed, decision for label design upcoming

## Field demonstration:

- Field measurements at pellet and firewood sites in heating season 15/16
  - 1<sup>st</sup> day: Usual user operation without any influence by testing personal
  - 2<sup>nd</sup> day: The quick user guide is provided to the user, the user operates the appliance without further support
  - 3<sup>rd</sup> day: Operation according to the beReal method by the user, with assistance testing personal
- Comparison of lab testing results with field performance

## Round robin test:

- Performed with one pellet and one firewood stove
- Participating partners from Austria, Germany, Sweden, Denmark

## Establishment of beReal Label

- Start planned for 2016

*Thank you for your kind attention!*

[www.bereal-project.eu](http://www.bereal-project.eu)

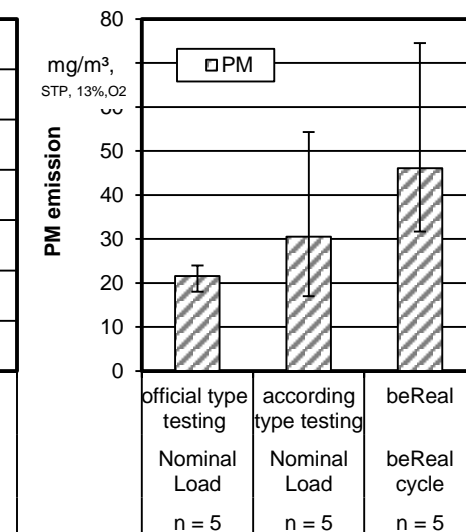
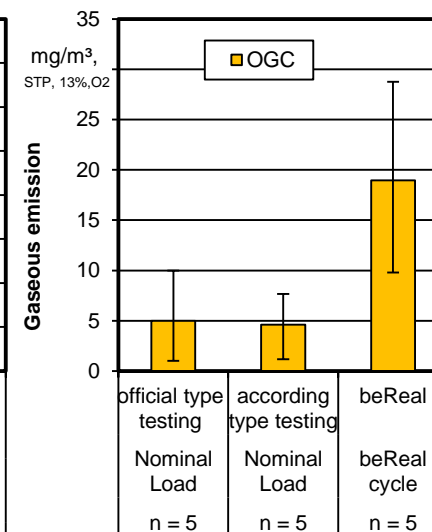
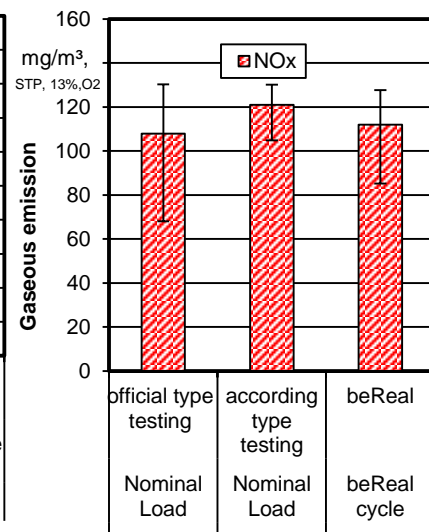
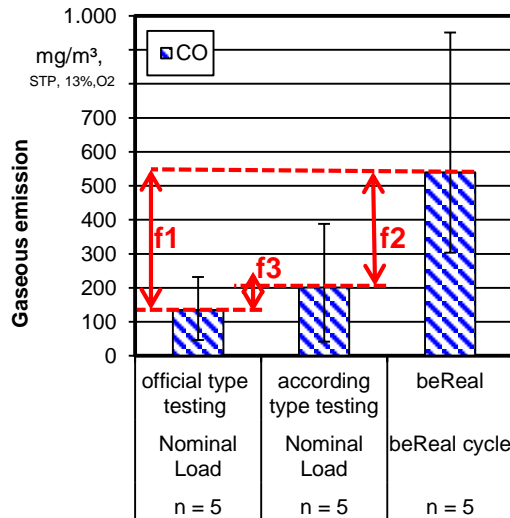
Contact:

Dr. Christoph Schmidl  
BIOENERGY 2020+ GmbH  
Gewerbepark Haag 3, 3250 Wieselburg-Land, Austria  
[Christoph.schmidl@bioenergy2020.eu](mailto:Christoph.schmidl@bioenergy2020.eu)  
[www.bioenergy2020.eu](http://www.bioenergy2020.eu)



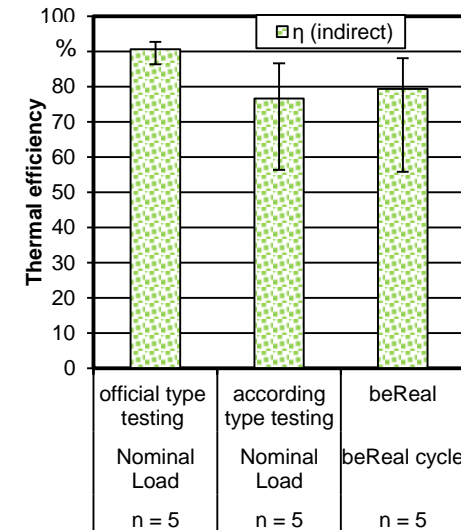
*BeReal Consortium*

# beReal Validation Results Pellet (Nominal Load)

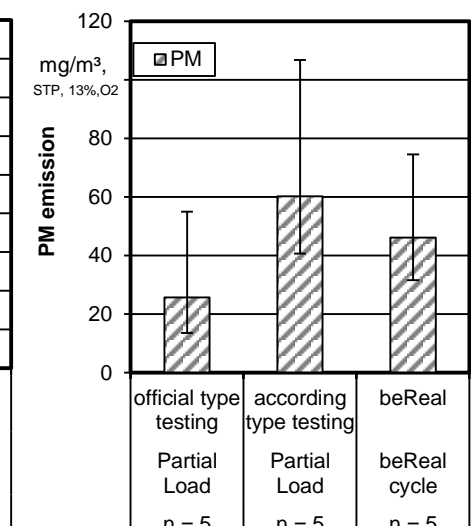
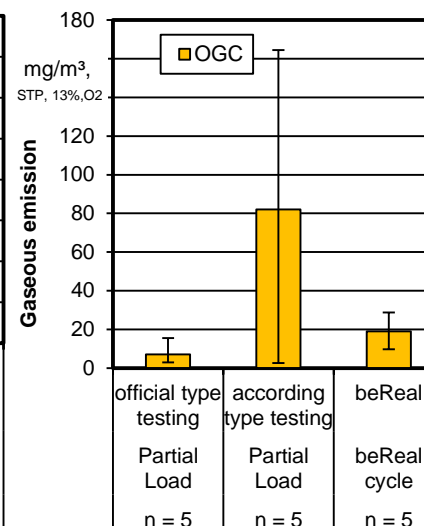
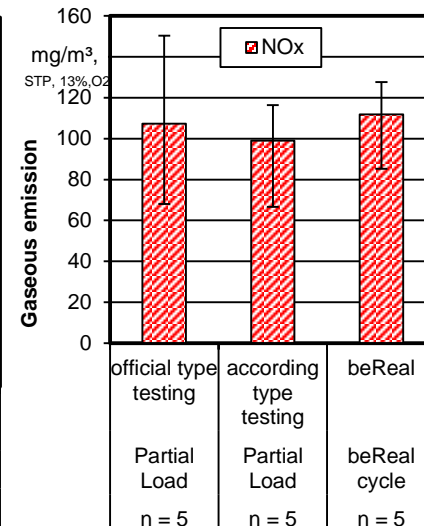
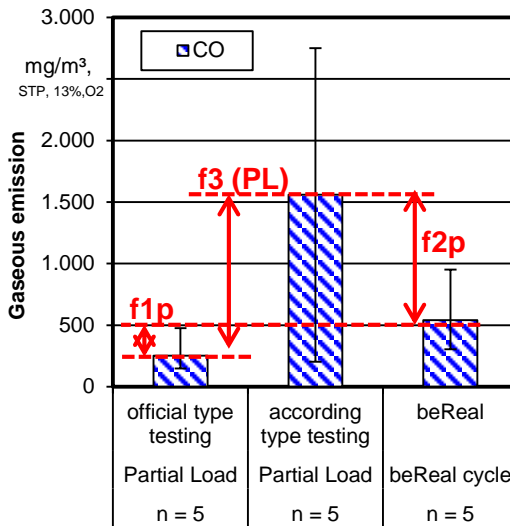


Pellets (n=5)	CO	NOx	OGC	PM	Efficiency
$f_1$ (beReal/ oTT)	4.5	1.1	7.3	2.2	0.87
$f_2$ (beReal/ aTT)	4.8	0.9	6.7	1.6	1.04
$f_3$ (NL) (aTT/ oTT)	2.3	1.2	2.0	1.5	0.85

- Level differences varied between parameters and different test methods clearly (highest differences for CO & OGC between beReal and oTT)



# beReal Validation Results Pellet (Part Load)



Pellets (n=5)	CO	NOx	OGC	PM	$\eta$
$f_{1p}$ (beReal/ oTT)	2.4	1.1	3.6	2.2	0.86
$f_{2p}$ (beReal/ aTT)	0.6	1.2	0.9	0.9	1.22
$f_{3(PL)}$ (aTT/ oTT)	7.1	1.0	15.8	2.8	0.75

- Level differences varied between parameters and different test methods clearly (highest differences for CO & OGC between aTT & OTT)

