The beReal-project
Real life stove testing for European label development

IEA Task 32 Workshop
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beReal

- What is real?
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- Method for firewood stoves
- Method for pellet stoves
- Validation results
- Quality assurance: Online Tool
Background and Motivation

- 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 Overview – Framework

- **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:**

<table>
<thead>
<tr>
<th>RTD</th>
<th>SME’s</th>
<th>SME-AG’s *</th>
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<td>TFZ (DE)</td>
<td>Atech (SLO)</td>
<td>HKI (DE)</td>
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<td>BE2020+ (AT)</td>
<td>Interfocos (NL)</td>
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<td>Scan (DK)</td>
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* With 9 association partners: Hark, Westfeuer, Extraflame, LaNordica, Austroflamm, RIKA, Palazzetti, ORTNER, Spartherm

- **Subcontractor:** AIEL (IT)
Project Overview – Objectives

- 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

WP 1: Management (TFZ)
- WP 2: Market & framework analysis (HKI)
- WP 3: Measuring methods & testing procedures (BE2020)
- WP 4: Data evaluation & documentation (TFZ)
- WP 5: Validation (KOV)
- WP 6: Label development (KOV)
- WP 7: Field demonstration (DTI)
- WP 8: Round-robin test (SP)
- WP 9: Dissemination (IF)

Information gathering
Development & testing
Validation & documentation
Demonstration
Dissemination
### Working plan – Current status & Outlook

<table>
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<tr>
<th>WP</th>
<th>Gantt-Chart: beReal-project</th>
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<td>Measuring Methods and Testing Procedures</td>
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<td>Label Development</td>
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<td>Field Demonstration</td>
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<td>8</td>
<td>Round Robin Test</td>
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</tbody>
</table>

- **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?

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

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

> 2200 questionnaires completed
What is real life?
Method development

Investigated parameters influencing emissions and efficiency:

- Mode of ignition (e.g. bottom-up vs. top-down)
- Refilling criterion (e.g. balance vs. CO₂ 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, NOₓ, CO₂, O₂)
- Particulate matter emissions
  - Hot vs. diluted sampling
  - Rinsing of sampling probe
- Efficiency determination
  - Indirect method (measuring all losses)
  - Direct method (calorimeter room)
beReal Method – Framework Conditions

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.
Test Facility & Test Conditions

- **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 $12 \pm 2 \text{ Pa}$ 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
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 (≥ 80% of the fuel mass representing nominal load)
  - Kindling material (max. 25% of total batch mass) & starting aids (only biobased fire starters allowed → 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)

### 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, oven 0.36 kg
  - 2. layer 2 firewood pieces, each 0.36 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 firewood 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 29 % (Fig. 7)
  - Secondary air: reduced to 75 % (Fig. 8)

### 3. Finishing heating operation

- When flames are extinguished and when the firewood 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-optimal operation. The requirements regarding emissions and efficiency cannot be achieved.
beReal Test-Run Firewood

Measurement of flue gas temperature (centrally placed thermocouple)
beReal method for pellet stoves

beReal Method includes:

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Load level*</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Cold start</td>
<td>High load</td>
<td>50 min</td>
</tr>
<tr>
<td>1b Load change</td>
<td>Low load</td>
<td>90 min</td>
</tr>
<tr>
<td>S1 Stand by</td>
<td>0%</td>
<td>40 min</td>
</tr>
<tr>
<td>2 Warm start</td>
<td>High load</td>
<td>50 min</td>
</tr>
<tr>
<td>S2 Stand by</td>
<td>0%</td>
<td>40 min</td>
</tr>
<tr>
<td>3 Warm start</td>
<td>Medium load</td>
<td>180 min</td>
</tr>
</tbody>
</table>

* "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_{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)
beReal Validation Results Firewood

### Gaseous Emission

- **CO (mg/m³, STP, 13%, O₂):**
  - Official Type Testing: 0
  - According Type Testing: 0
  - beReal (1-8): 0

- **NOx (mg/m³, STP, 13%, O₂):**
  - Official Type Testing: 0
  - According Type Testing: 0
  - beReal (1-8): 0

- **OGC (mg/m³, STP, 13%, O₂):**
  - Official Type Testing: 0
  - According Type Testing: 0
  - beReal (1-8): 0

### Particle Emission

- **PM (mg/m³):**
  - Official Type Testing: 0
  - According Type Testing: 0
  - beReal (1-8): 0

### Thermal Efficiency

- **η (indirect):**
  - Official Type Testing: 0
  - According Type Testing: 0
  - beReal (1-8): 0

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### Firewood (n=7)

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>NOx</th>
<th>OGC</th>
<th>PM</th>
<th>η</th>
</tr>
</thead>
<tbody>
<tr>
<td>f₁</td>
<td>2.7</td>
<td>1.1</td>
<td>2.4</td>
<td>3.7</td>
<td>0.83</td>
</tr>
<tr>
<td>(beReal / oTT)</td>
<td></td>
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</tr>
<tr>
<td>f₂</td>
<td>1.4</td>
<td>1.2</td>
<td>2.7</td>
<td>1.4</td>
<td>0.99</td>
</tr>
<tr>
<td>(beReal / acc. RTD TT)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>f₃</td>
<td>2.1</td>
<td>0.9</td>
<td>1.3</td>
<td>2.8</td>
<td>0.85</td>
</tr>
<tr>
<td>(acc. RTD TT / oTT)</td>
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beReal Online – Tool

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
beReal Online-Tool: Registry

Draft version already online:

- Username and password provided by the administrative authority (currently Bioenergy2020+)
- Registry of testing institute (Edit Customer)
- Submission of personal contacts
beReal Online-Tool: Data Input

- Input of general test data
- Upload of raw data and QUG
- Fuel analysis input
- Ash analysis and PM measurements
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)
beReal Online-Tool: Reporting

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 *

* and the beReal Label (once available)
The beReal Label

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
beReal Outlook

Field demonstration:
- Field measurements at pellet and firewood sites in heating season 15/16
  - 1\textsuperscript{st} day: Usual user operation without any influence by testing personal
  - 2\textsuperscript{nd} day: The quick user guide is provided to the user, the user operates the appliance without further support
  - 3\textsuperscript{rd} 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

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**beReal Validation Results Pellet (Nominal Load)**

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

- 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)

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