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Annual efficiency of small scale biomass combustion systems

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Content

- Development of a cycle test for biomass heating systems
  - Aim and concept
  - Development of the method
- Tools for the optimization of annual efficiency (experiences from running research projects)
  - Measurements at test stands
  - Measurements in the field
  - (Simulation)
- Summary and conclusions

Load cycle test for small-scale combustion systems

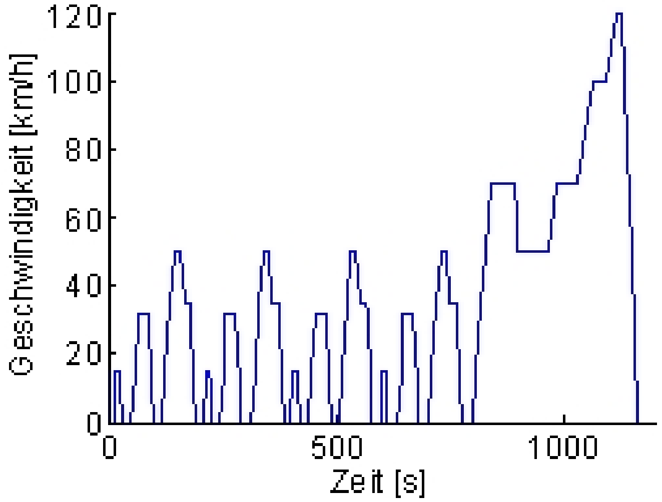
Aim:

Development of a test stand method for determination of annual efficiency and emission factors for small-scale combustion systems

New test should be possibly integrated in the current type testing procedure

Concept:

- Similar to driving cycle test:
  - Development of a load cycle test for combustion systems

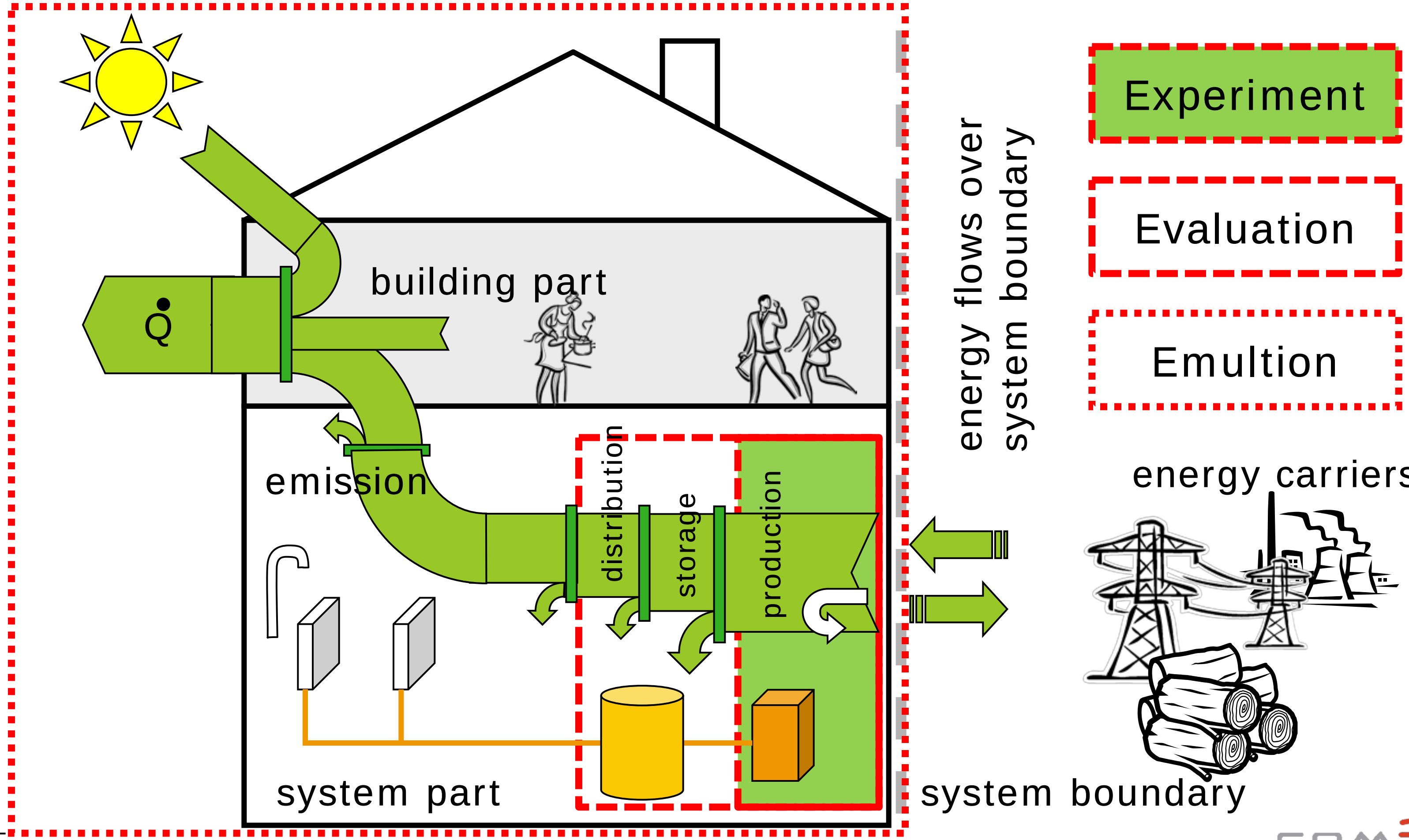


New European driving cycle test

Development steps of testing method

- Definition of system boundaries
- Definition of testing procedure
  - for automatically and manually fired systems
  - for full load / buffer and modulating operation
- Development of a simple data analysing software (VBA in MS Excel)
- Preparation of a guideline
- Experimental validation of the method

System boundaries for the testing method



Definition of the load cycle

- Analysis of different type days from literature and field measurements
- Definition of 5 type days and the respective load cycles similar to VDI 4655
- Reduction to load stages according to DIN 4702-8
- Summation of the single day cycles to a reference annual cycle
- Reduction of the 24 hour reference cycle to a 8 hour cycle (→ aim: include into type testing procedure)

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Selected results

From a new, recently tested product, P_N = 15 kW

	Nominal power test	Reference test cycle	Nominal power + heat storage	
Efficiency	89,7	83,1	77,6	[%]
CO	3,2	374,6	62,3	[kg/TJ]
NO_x	76,9	51,7	91,9	[kg/TJ]
Org. C	0,3	9,0	1,1	[kg/TJ]
PM	11,6	9,1	15,3	[kg/TJ]

Note: Data differs from paper due to improved data source and evaluation!

Tools for the optimization of the annual efficiency

- Measurements at **test stands**
  - \+ Systematic variation of requirements and configuration
  - \+ Lot of data → Optimization more efficient
  - – Average load profiles, optimal (not real) system integration
- Measurements **in the field**
  - \+ Real situation: user, building, system components
  - – Measurements difficult, variations not/limited possible

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Experiences from projects

MoreBioSystems (COMET, AT)

- Intensive evaluation on test stand (8 pellet boilers, 40 different hydraulic configurations, validation in the field)
- Development of a simulation model (Aim: model based control)

BioMaxEff (FP7–Energy, EU)

- Measurement of annual efficiency and annual emission factors
- 6 test stands, each 24 field and test stand - boilers (AT, DE, GB, GR, ES)
- Field monitoring of real operation behaviour (n = 280 / 2000)

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Test stand measurements

System configuration

Test stand Bioenergy2020+

- Heat production
  - Pellet boiler
  - Solar input (S)
- Heat storage
  - HW-boiler: 300l (B300
  - Buffer: 825l, 1000l, 1500l
- Heat dissipation
  - Variable backflow temperature
  - Variable volume flow

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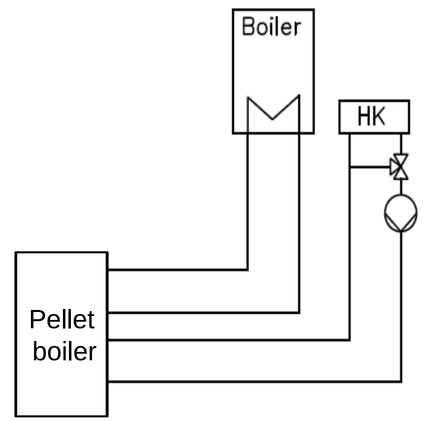
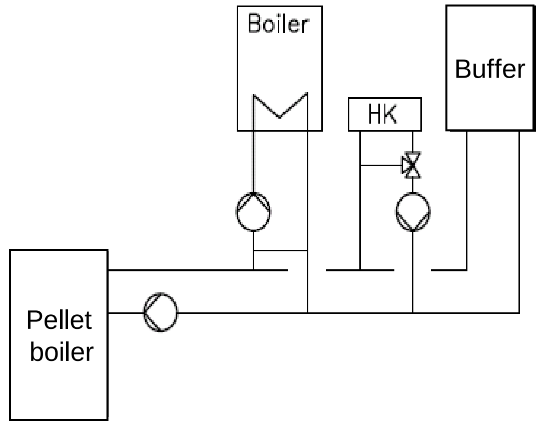
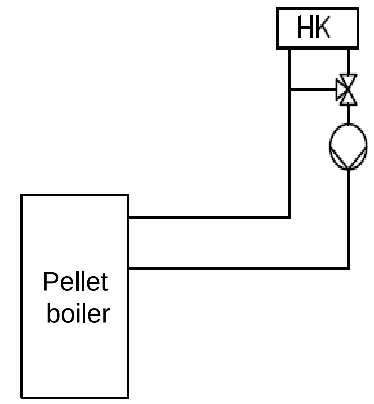
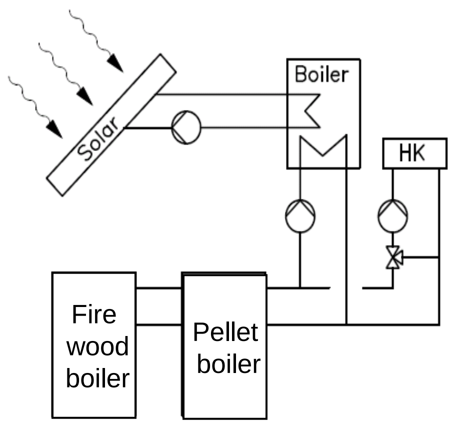
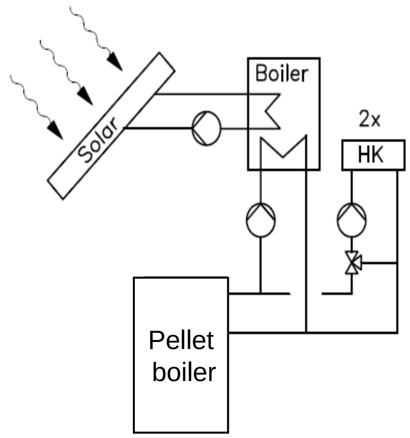
Selection of tested system configurations (test stand and field)

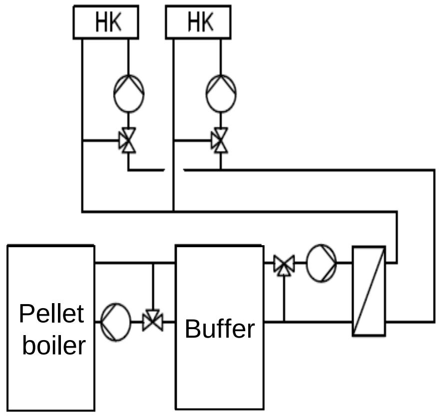












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Comparison of results for different system configurations for one boiler

- System efficiencies between 75 and 84%
- Gaps between boiler efficiency and system efficiency between 1.5 and 15% depending on
  - System design (components and implementation)
  - Use patterns
- Key loss (>4%): Missing insulation of pipes
- Hot water boiler only advantegous to buffer integration
- No relevant influence of volume return flow concept
- !Valid for investigated boiler (12 kW, top feed, 60l boiler water volume) and used components (insulation of buffer)!

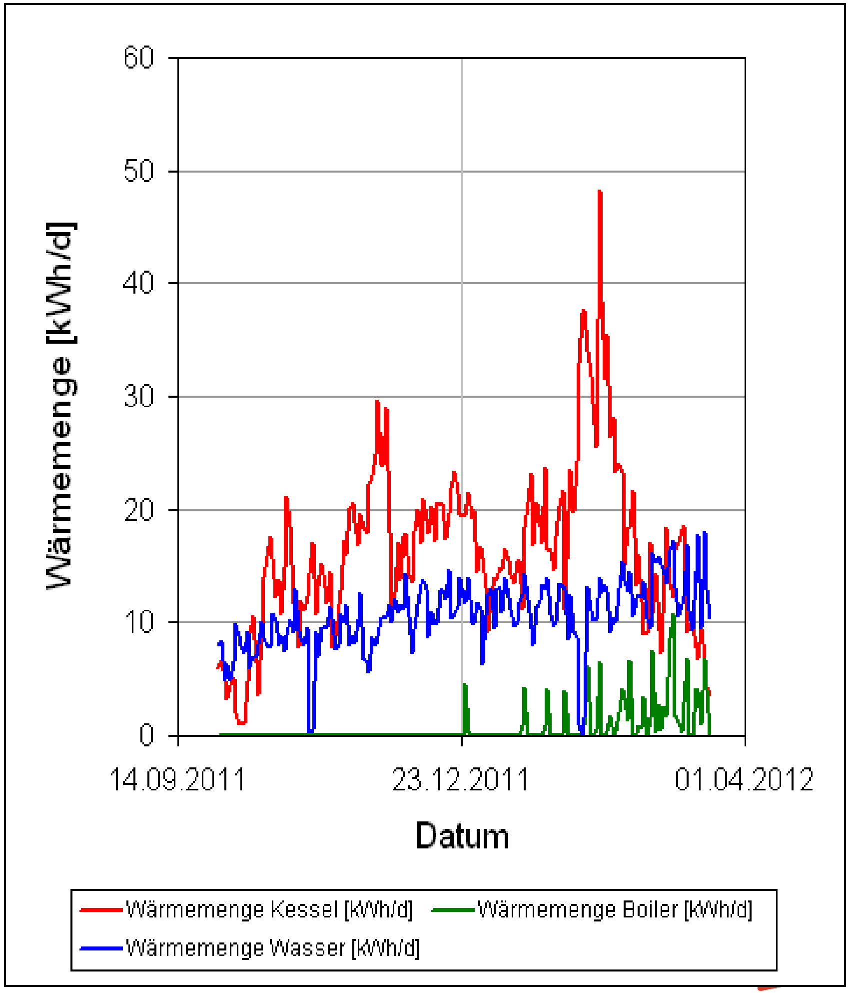
Field measurements (hardware)

- Sensors
  - Heat meters
  - Net analyser (electric power)
  - Room temperature sensors
  - Boiler parameters
  - Fuel input
- Logger
  - Computer with storage
  - Modem
  - Signal converter
  - Gateways

Example I: Monitoring results
Energy balance

- Building has very low heating demand
- Hot water is almost exclusively produced by an exhaust air heat pump

	Heating kWh	San.water kWh	Fuel kWh
Fall	848	0	1316
Winter	1786	67	2267
Spring	204	57	366



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Example II: Important improvement potential obtained from field measurements

- **Observation:**

  Extremely variable heating demand

- **Reason:**

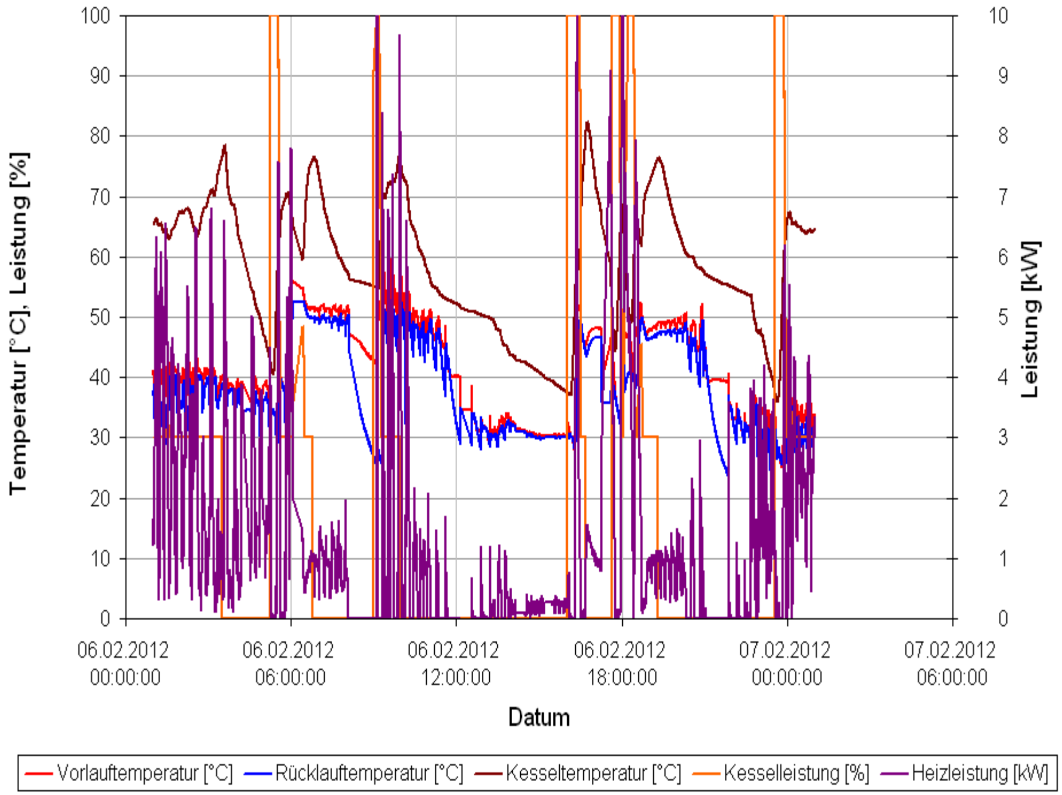
  Single room control of floor heating with 2-point controler

- **Potential Improvements:**

  Hysteresis room control

  Regulating valves

  Buffer tank



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Summary and conclusions

- Measurement of load cycles reveals different results of boilers and systems respectively compared to EN303-5

  → **Load cycle test and variation of system configurations as basis of technological development of biomass boilers**

  → **Specific boilers require specific system configuration for optimum performance**

- Field measurements can be used for validation of test stand measurements and...

  → **Errors in the system integration can only be revealed by field measurments**

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Thank you!

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