BioCAT

Clean Air Technology for Biomass Combustion Systems

BioCAT – Clean air technology for small-scale combustion systems

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- Concept and Approach
- Methods
- Results
  - Catalytic material characterisation
  - Catalyst system outside the stove
  - Primary optimisation of stoves
  - Catalyst system integrated in optimised stoves
  - DemoCAT – Catalyst technology demonstrator
- Conclusions and Outlook

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Project objectives

New generation of biomass based room heating appliances

Optimising primary combustion conditions

Integration of a honeycomb type oxidation catalyst

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The BioCAT project approach

- Characterise the catalyst technology
- Develop methods to evaluate the project outcomes
- Primary optimise combustion systems and integrate catalysts
- Evaluate and demonstrate the project outcomes

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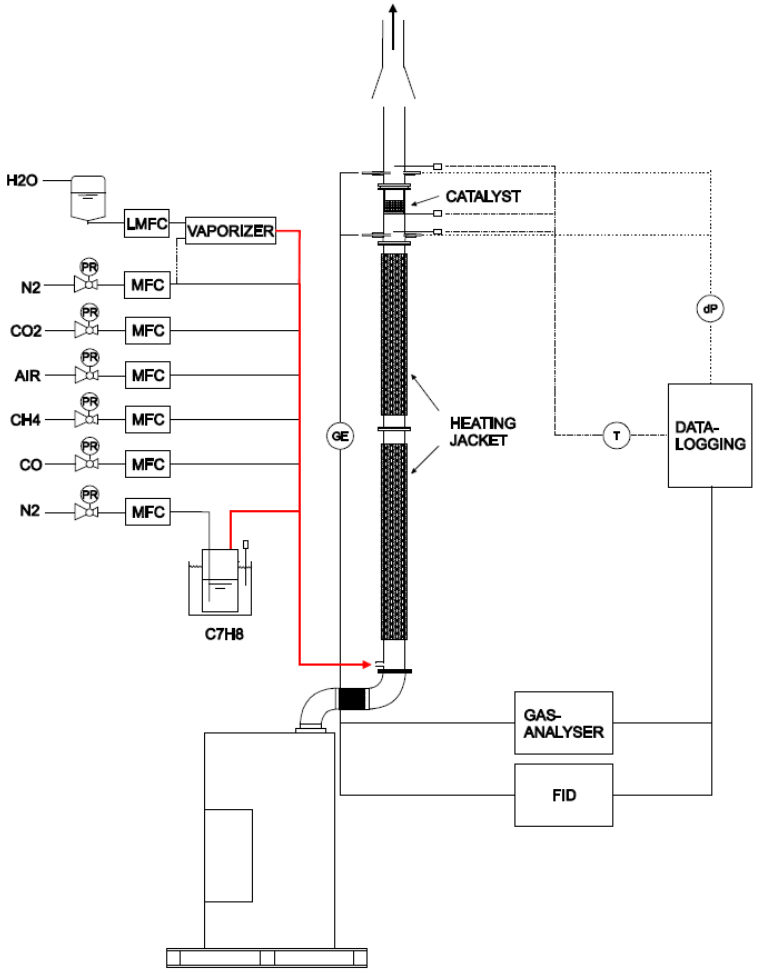
Method I: Characterisation of catalytic material

- Test Setup:
  - Synthetic flue gas:
    - CO, CH_4, C_7H_8
  - Pre-heating and mixing zone
  - Flue gas measurement up- and downstream of catalyst
  - Connection to stove for TSP loading
- Results:
  - Basic catalytic performance characteristics



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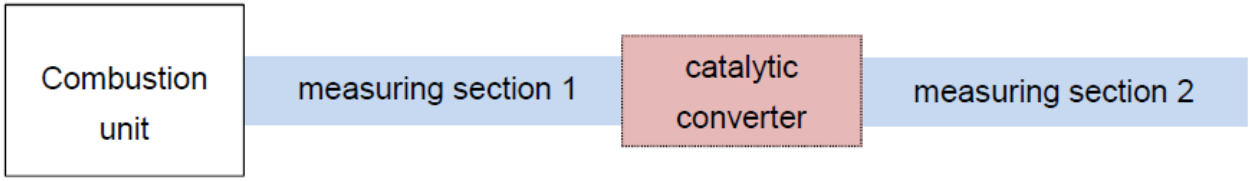
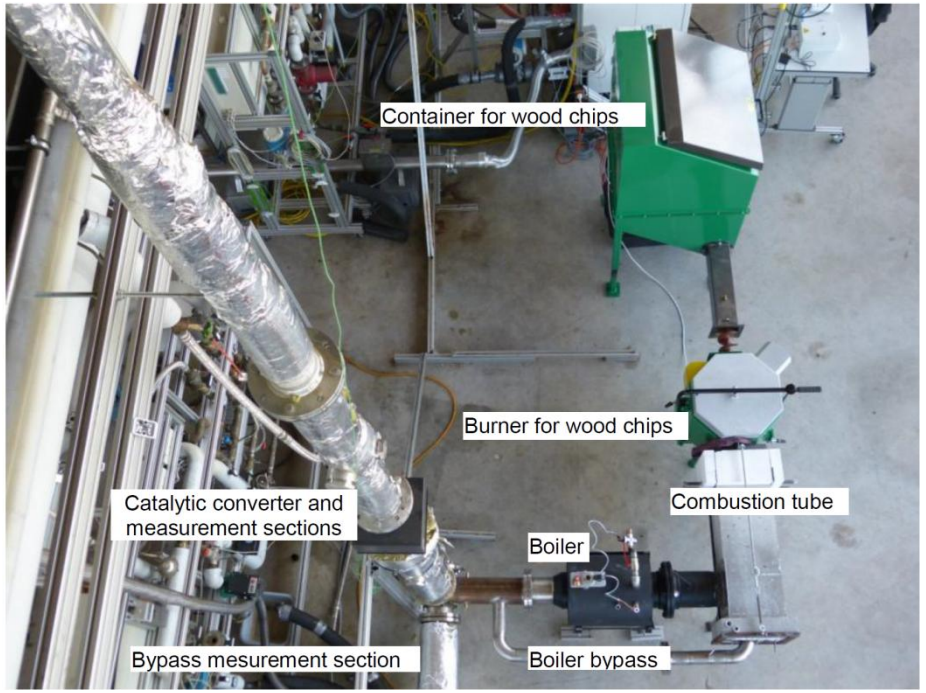
Method II: Characterisation of catalyst
(standalone/retrofit)

- Principle:



- Test Setup:
  - Wood chip burner for flue gas „production“
  - Boiler with by-pass for flue gas temperature control
  - Fuel (water content) and burner settings for flue gas composition control
- Results:
  - Actual and mean reduction of CO, OGC and TSP



Source: TFZ Straubing

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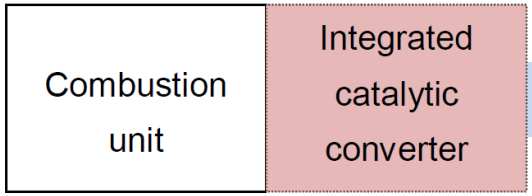
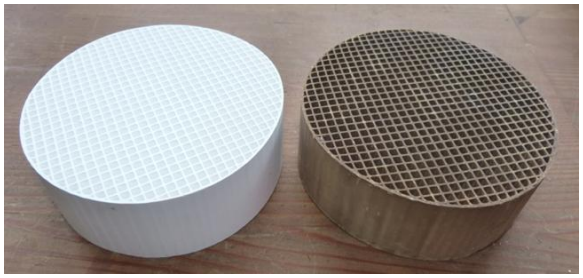
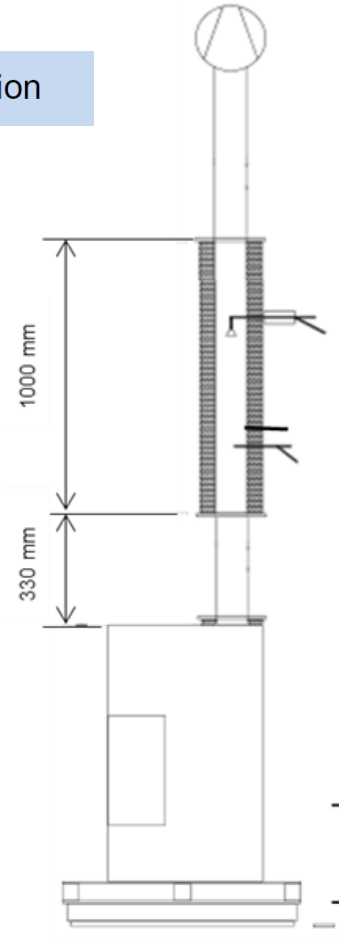
Method III: Characterisation of Stove-integrated catalysts

- Principle:
- Test setup:
  - EN13240/13229
  - Test Fuels: Beech and Spruce
  - Tests with uncoated Carrier (Dummy, n=6) and with Catalyst (n=6) for each stove







- Results:
  - Mean Reduction of CO, OGC and TSP
  - Significant Reduction at defined Level of Confidence

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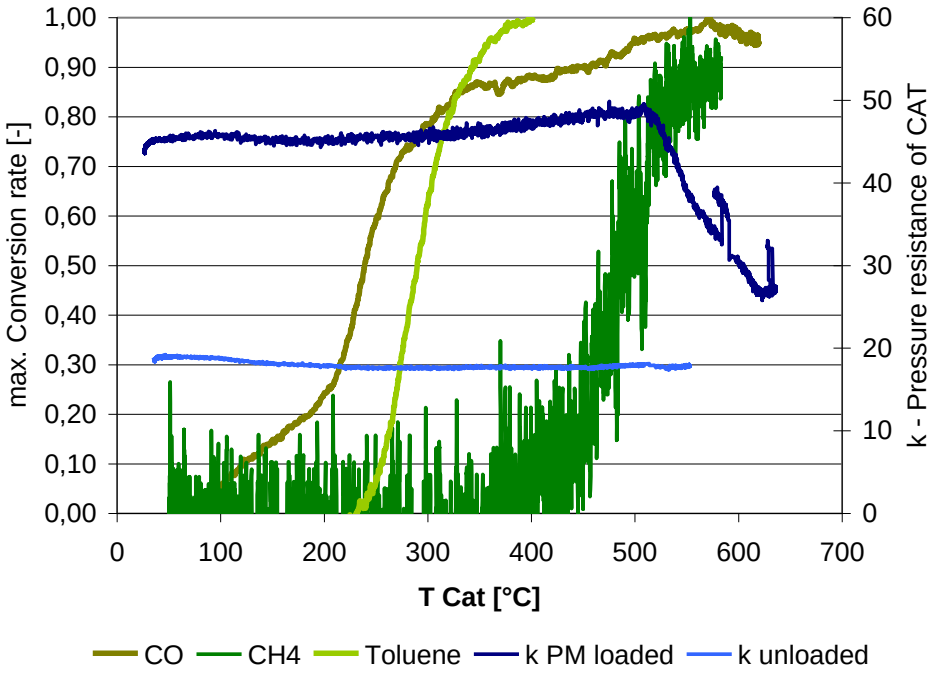
Results: Catalytic material characterisation

- Characteristic conversion temperatures for:
  - Carbon Monoxide
  - Methane
  - Toluene
- Influence on conversion:
  - Residual Oxygen
  - Water Content
  - Volume Flow
  - CO Load
- Burn-off temperatures of TSP loaded on catalyst surface



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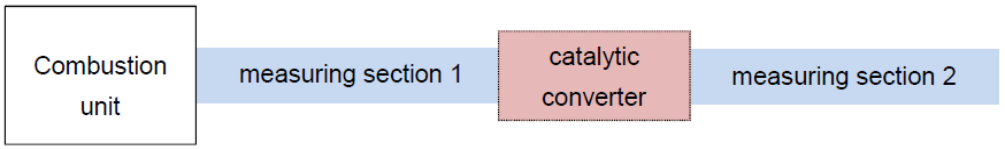
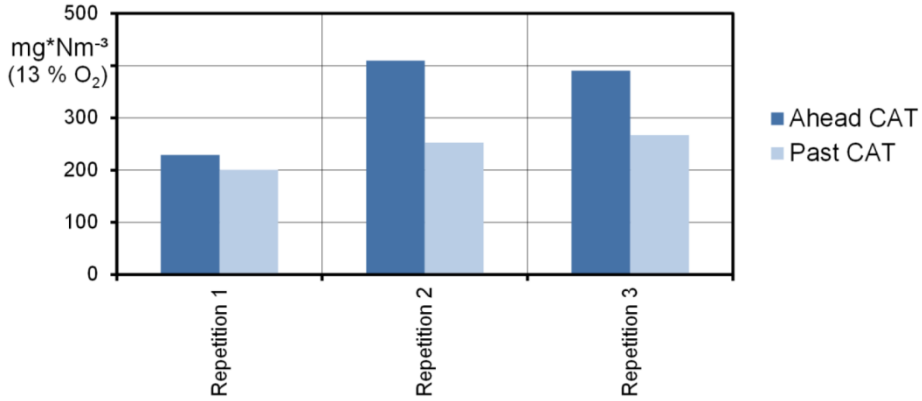
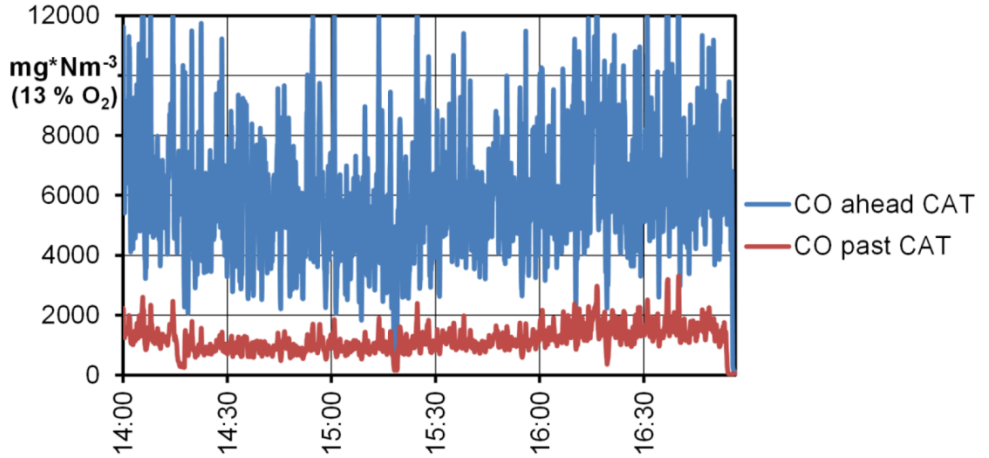
Results: Catalyst Evaluation

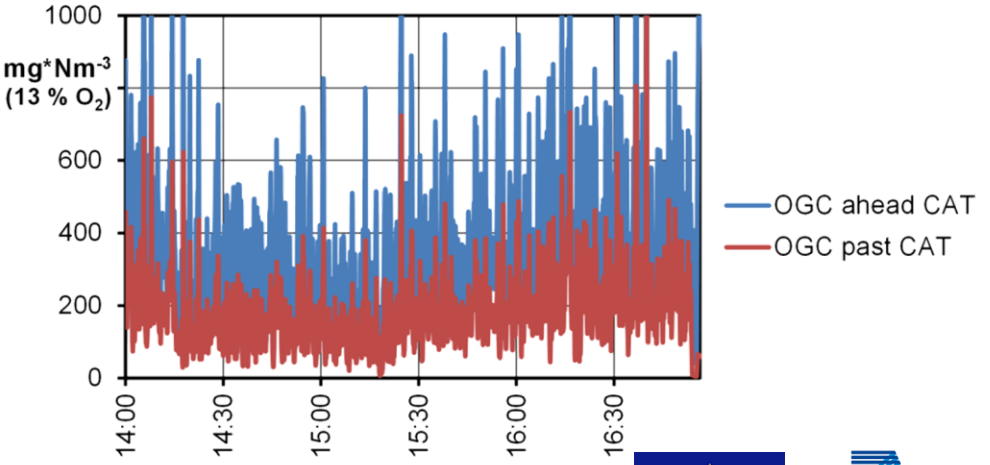
Standalone/Retrofit Cat



- Simultaneous Measurements
- Mean Reduction Rates:
  - CO: 80%
  - OGC: 48%
  - TSP: 27%







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Results: Combustion system development

Combustion optimisation by primary measures

- Avoidance of leakages (**air tightness**)
- Adapting **air supply volume**
- Implementing **air staging**
- Optimisation of **pane ventilation**
- Insulation of **combustion chamber**
- Implementation of **post combustion** chamber
- Energy management of **firebed**

Stove	A	B	C	D
Initial stoves – Optimized stoves - Test fuel spruce				
CO	- 74 %	- 63 %	- 56 %	- 44 %
OGC	- 72 %	- 40 %	- 78 %	- 47 %
TSP	n.a.	n.a.	- 38 %	- 40 %
η	+ 59 %	+ 7 %	+ 34 %	± 0 %

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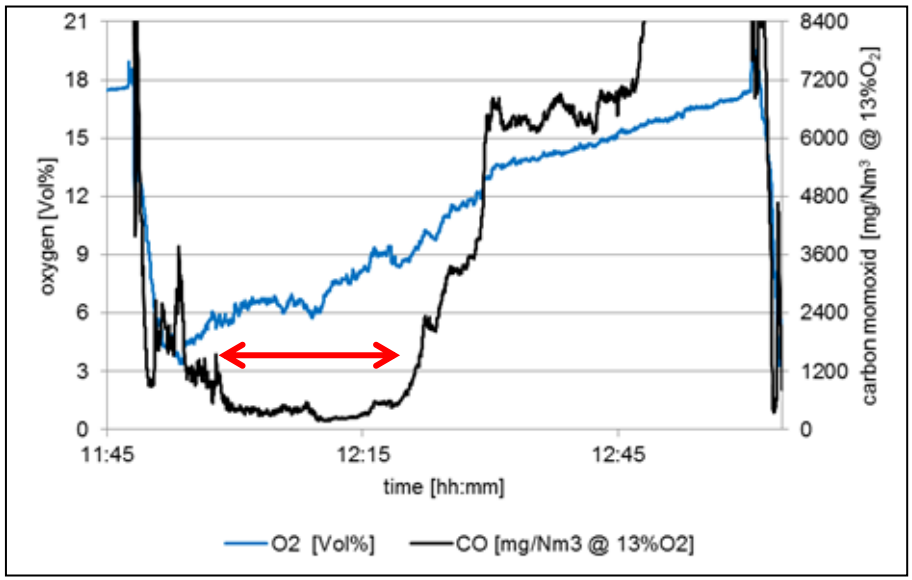
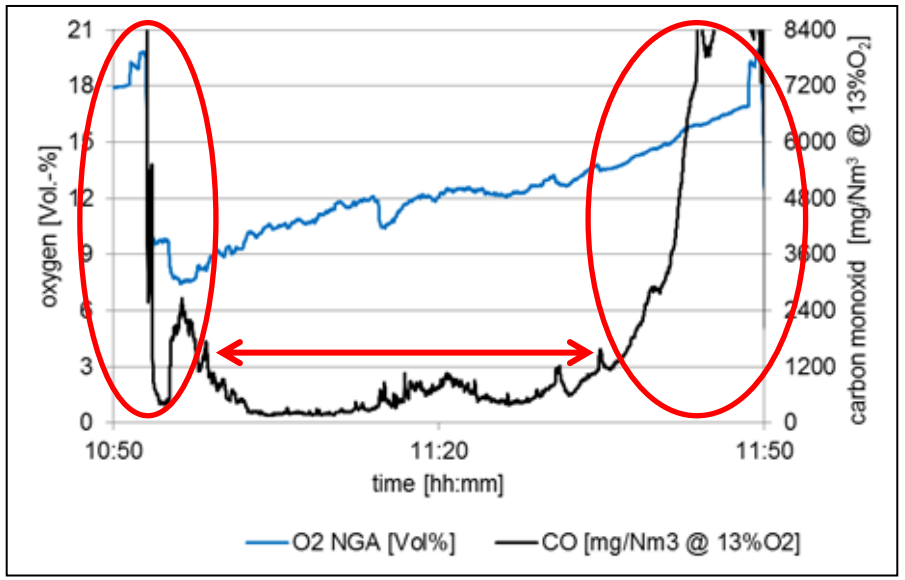
Results: Combustion system development
Primary combustion optimisation

Initial stove	Primary optimized stove





- Extension of optimum (low emission) phase
- Still need for improvement in start and burn-out phase

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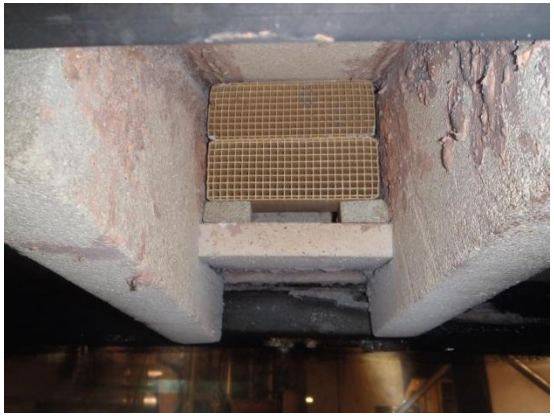
Results: Integration of Catalyst

Positioning according to measured Operation Characteristics







- **Sufficient high temperature**
- **Accessible for maintenance**

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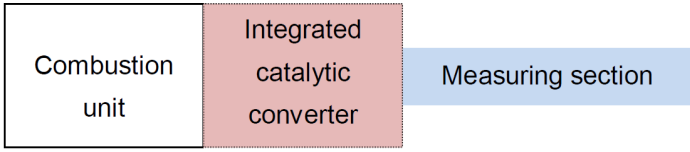
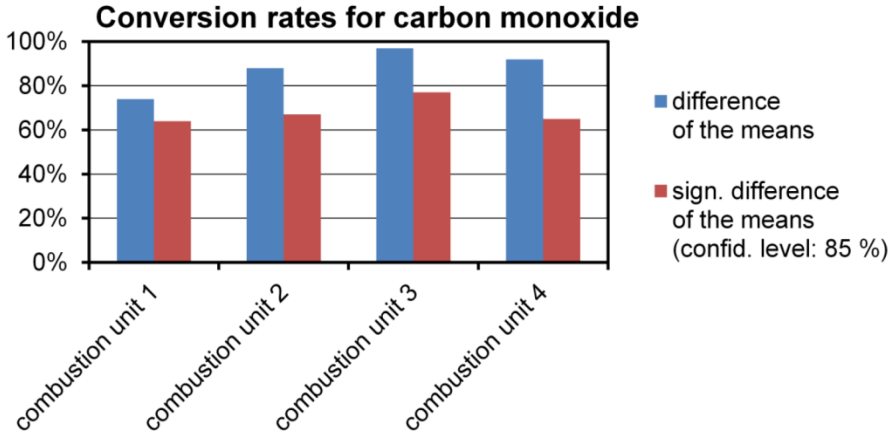
Results: Evaluation integrated Catalyst

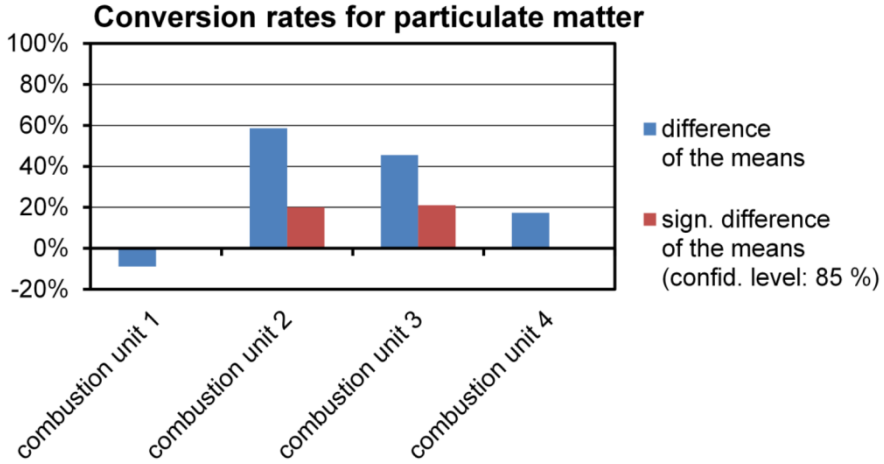
Reduction of Catalyst vs. Dummy

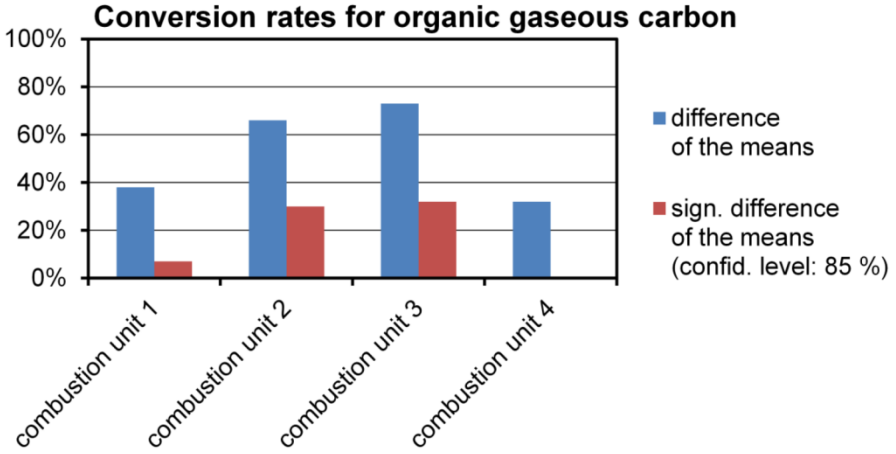


Reduction in %*	Mean	Significant (85% confid.)
CO	74-97	64-77
OGC	32-73	0-32
TSP	0-59	0-21

* Test fuel: Spruce







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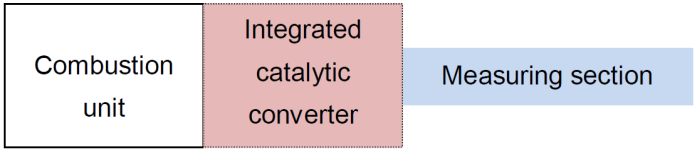
Results: Combustion System Development

Final Evaluation of Cat-integrated Stoves



Stove	A	B	C	D
Advanced prototype – without catalyst: Test fuel beech				
CO (mg/Nm³)	823	1109	825	1003
OGC (mg/Nm³)	48	43	62	64
TSP (mg/Nm³)	106	31	26	21
η (%)	74	81	80	76
Optimized stoves – with catalyst: Test fuel beech				
CO (mg/Nm³)	267	200	64	184
OGC (mg/Nm³)	n.a.	37	51	47
TSP (mg/Nm³)	n.a.	14	8	22
η (%)	74	83	80	81

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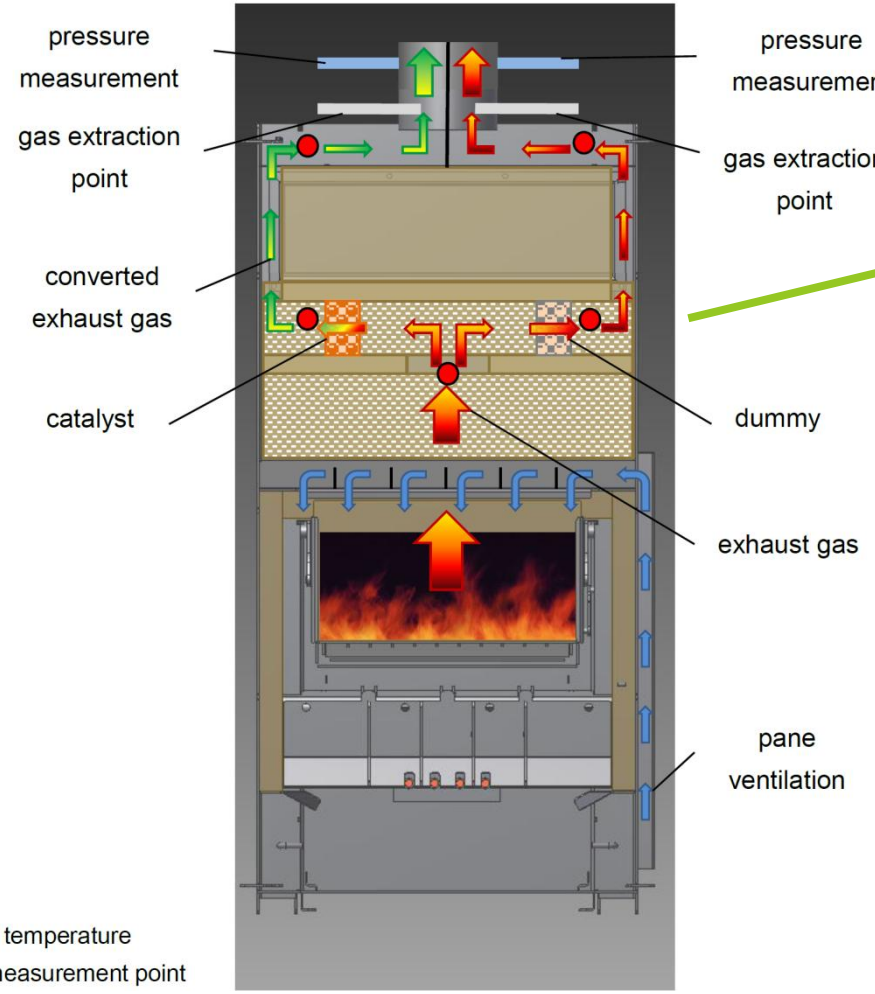
Results: DemoCAT – modified Briquette Stove

Parallel measurement of coated and non-coated catalysts



coated catalyst

non-coated carrier

	CAT	Dummy	Differenz [$\%_{rel}$]
CO [mg/Nm³]13%O_2	116	1.631	-93
O_2 [%]	12.3	12.6	
T [°C]	581	585	
p [pa]	16 (+/-1)	18 (+/-1)	

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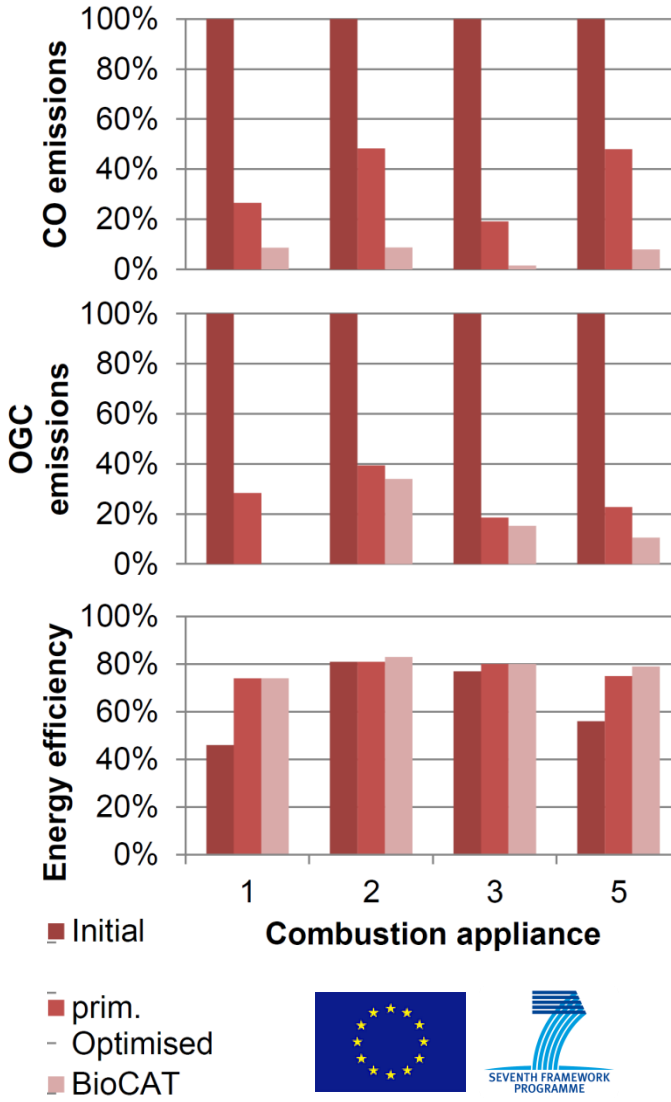
Summary and Conclusions

- Primary optimisation of firewood stoves has shown high potential
  - Reduction ~ 40-80% for CO, OGC, TSP
  - Significant increase of efficiency
- Catalysts can further reduce emissions especially in start and burn-out phase
  - 80-90% CO, 40-70% OGC, 0-50% TSP
- Integration has important advantages compared to retrofit solutions
  - Higher temperatures
  - Primary effects of catalyst are considered
- Catalyst integrated prototypes perform close to pellet stoves in terms of emissions



Outlook

- Long-term testing of catalyst integrated stoves
  - Deactivation of catalyst
    - Reactivation measures (washing)
    - Time interval for replacement
  - Influence of different use patterns
    - Safety aspects (blogging of catalysts in case of maloperation?)
- BioCAT Demonstrator 2.0
  - Operated with firewood
  - Including TSP measurement section

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Acknowledgements

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RIKA

STAFFIERI AG

Scientific and supporting Partners:

Technologie- und Förderzentrum

CLARIANT

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Thank you very much for your attention

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Supplemental Material

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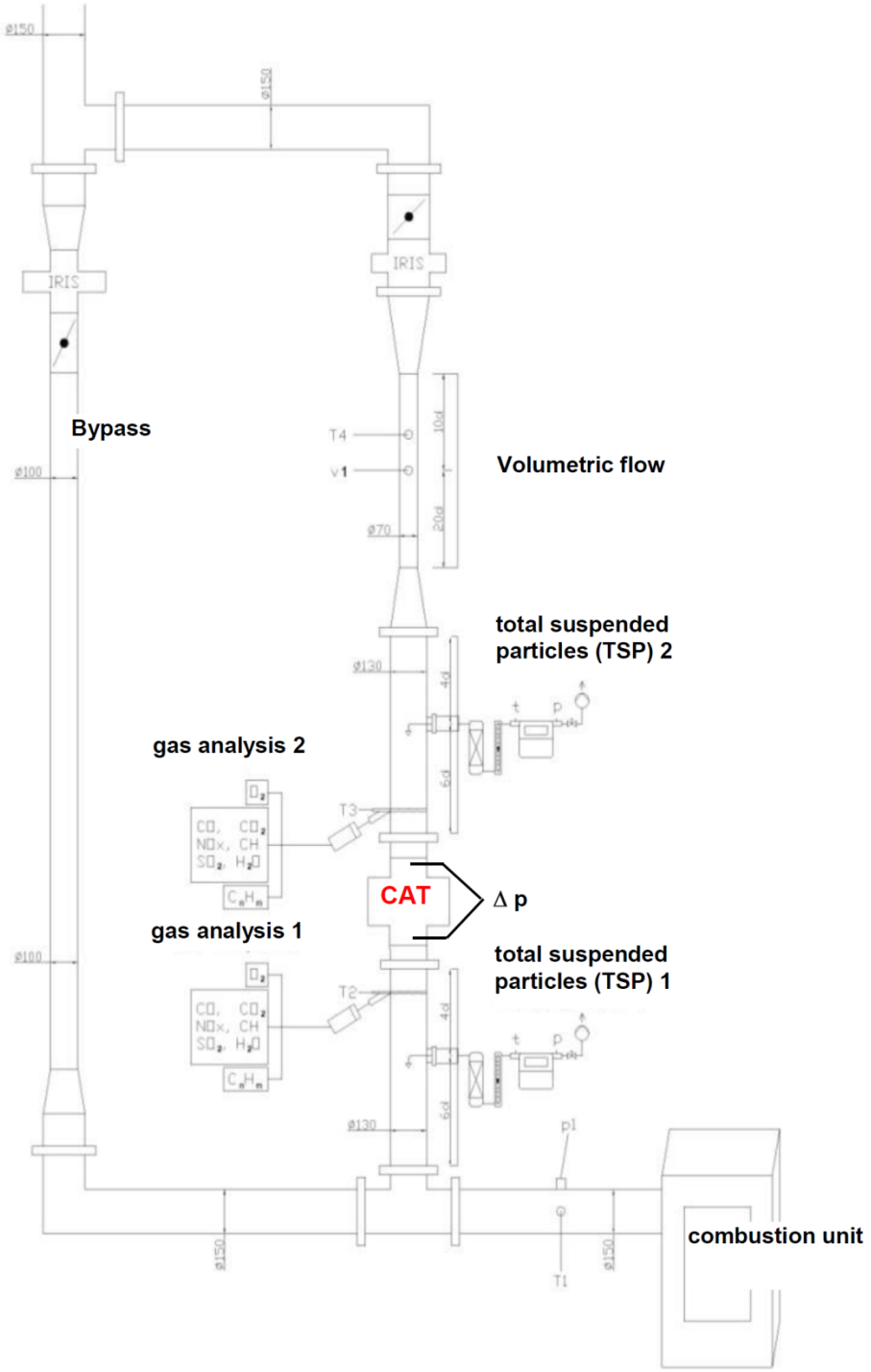
Measurement section catalyst evaluation



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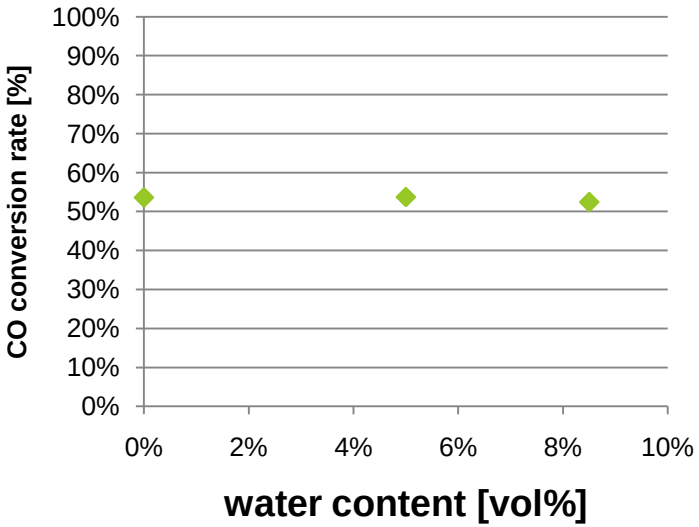
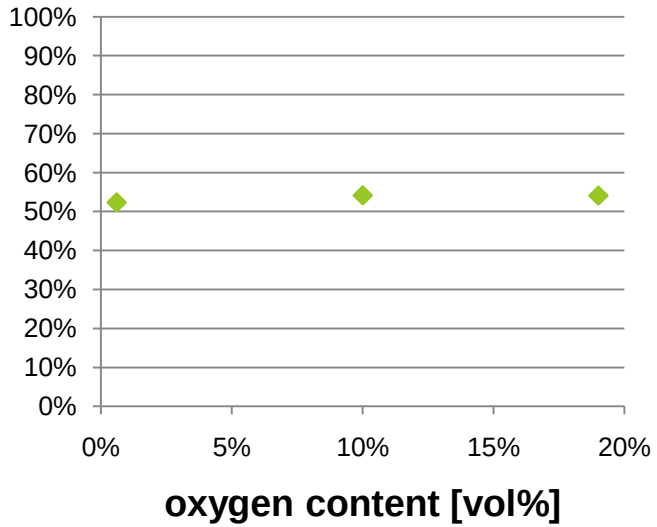
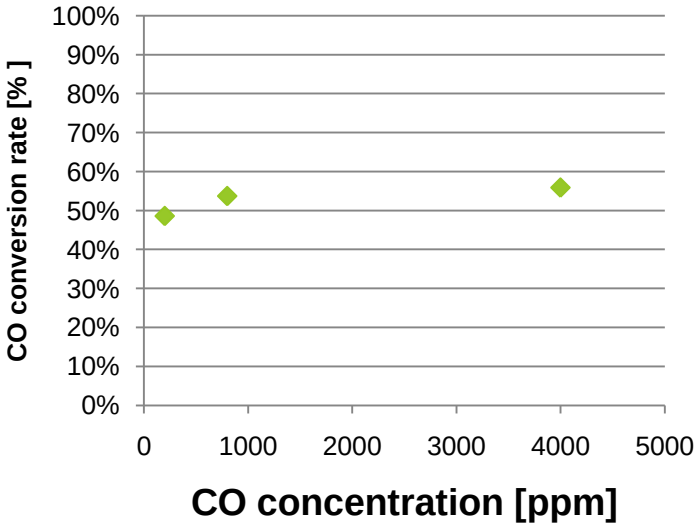
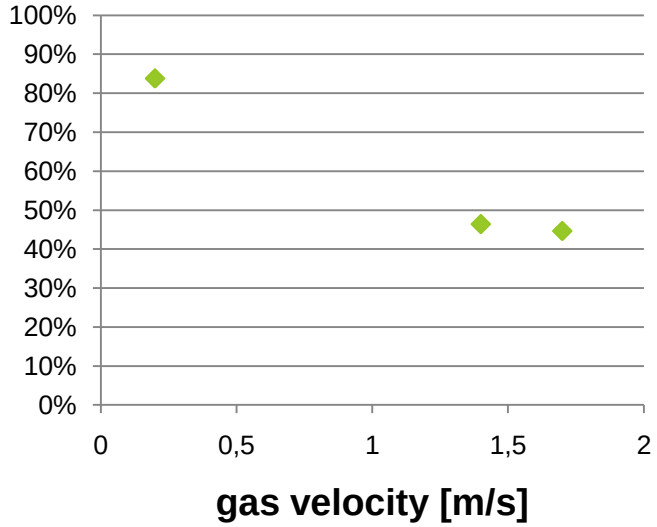
Catalyst characterisation

Influence analysis on conversion rate









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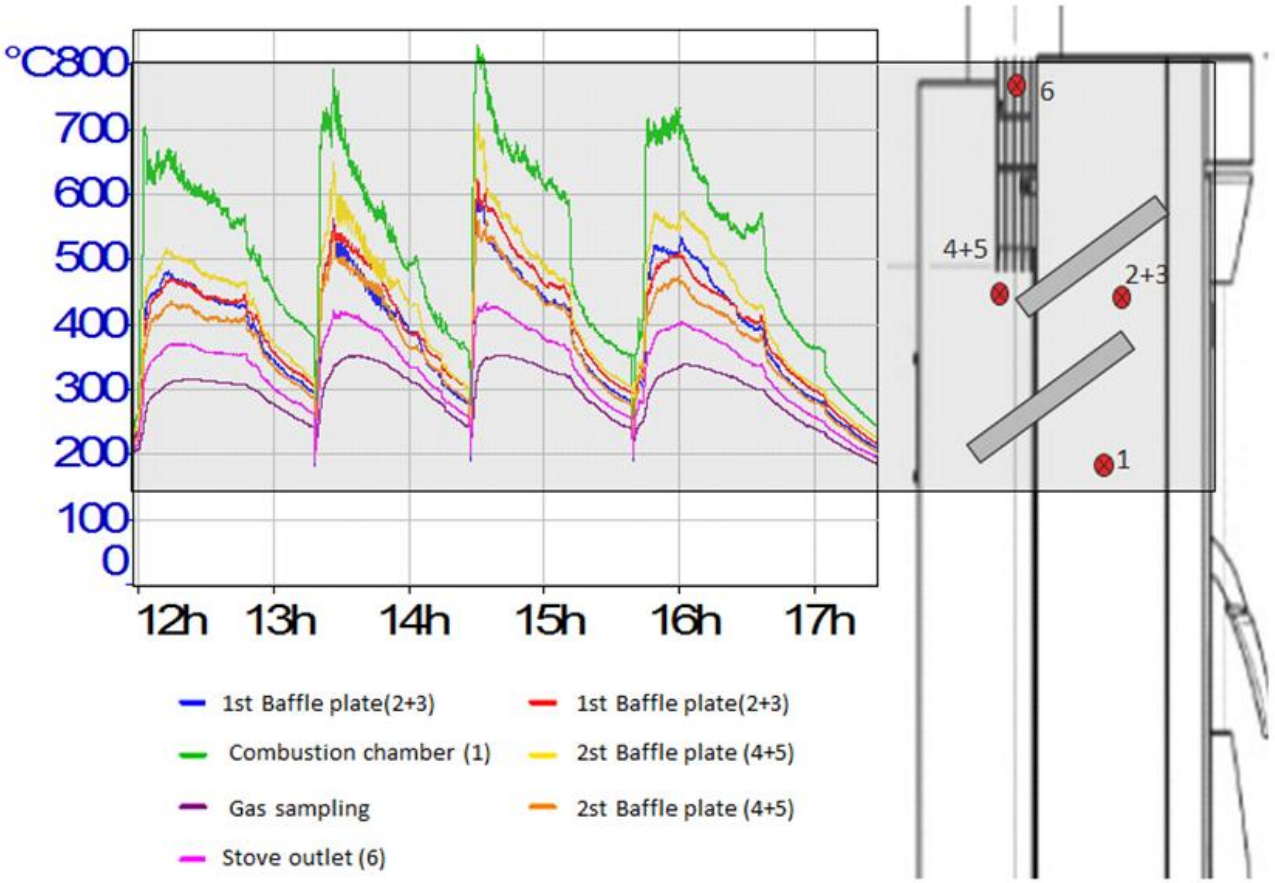
Results: Combustion system development

Temperature profiles of optimised stoves

- Temperature Profiles of potential integration positions:
- Basis for the integration of catalysts



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