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Biomass for Swiss Energy Future
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Development of Low Emissions Biomass Heating Systems as Demonstrated by the "Wood Gas Burner"

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Overall Competence / Motivation

Biomass as a CO_2-neutral renewable energy source will play an important role in the Swiss energy transition. In particular, high-temperature process heat is provided exclusively by combustion processes. Within the thermo-chemical conversion of biomass, the interplay of complex chemical reactions and transport provide opportunities for process optimization. In addition, processes may be adapted for the various forms of solid biomass fuels, such as logs, chips, pellets as well as dusts. FHNW is active in the development of modern low emission burner concepts, such as the retrofit wood gas burner, taking advantage of its experimental and numerical tools.

Experimental Capabilities

The gasification process of wood pellets was investigated in detail by using a single-pellet gasifier (on loan from PSI) as well as by analyzing gas samples from the burner gasification stage (see Figure 1) using FTIR (Fourier Transform Infra-Red spectroscopy). At defined fuel/air ratios the gas composition in the gasification zone was determined at different locations during cyclical burner operation. The obtained data were inputted into a numerical CFD model of the combustor, allowing optimization of the second stage.

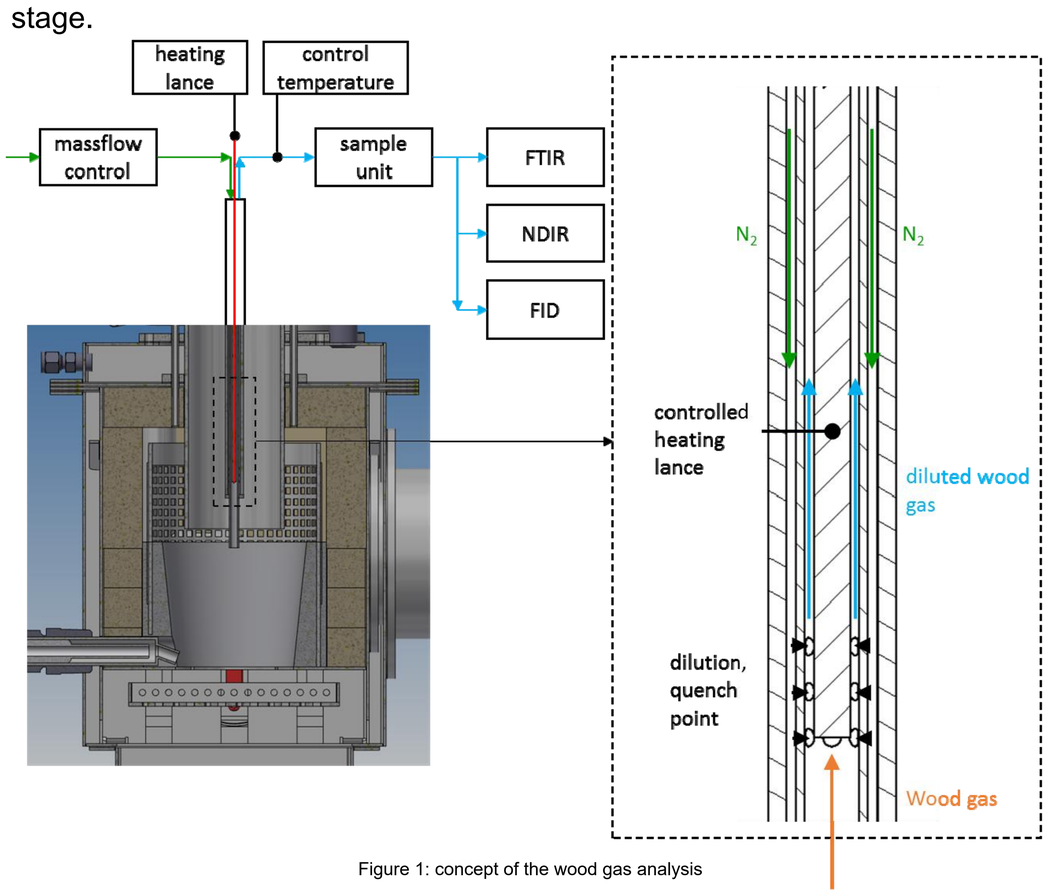


Figure 1: concept of the wood gas analysis

In order to optimize the first stage gasification process, an elemental analysis of ash by XRF (X-Ray Fluorescence spectroscopy) was performed for potassium, magnesium, sodium, etc. In addition, thermogravimetric analysis was used to determine residual fixed carbon. These analyses were used to identify ideal process parameters (lambda, air split, fire room temperature, etc.) for both stages. The gasification process could be optimized to reduce emissions of particulate matter and improve char burnout by a factor of 5.

Within the scope of alternative fuels (torrefied biomass, bio-char, horse manure, etc.), which contain problematic components, the abovementioned analysis methods as well as determination of trace elements and ash melting behavior are also applied for the development of low emission burner systems.

Low-emission staged combustion concept

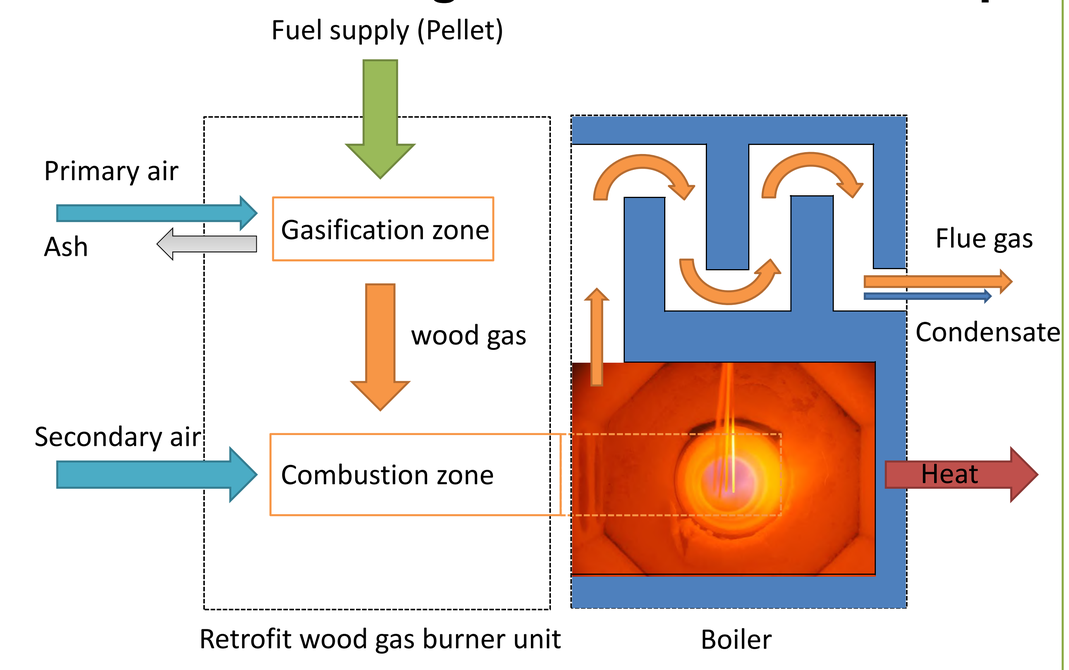


Figure 2: Process scheme of low emission staged combustion burner system

The retrofit wood gas burner, based on two stage, wood pellets combustion, is a flexible system with a high degree of power adjustment (factor 1:3, for example from 7 – 20 kW or 15 – 50 kW). In the first stage, the wood is gasified at fuel rich conditions, to produce wood gas, which is subsequently burned in the second stage in a highly turbulent, aerodynamically-stabilized flame (Figure 2). The realized staged combustion achieves high temperatures (>1'000 °C) with low CO, NO_X, UHC as well as particulate emissions.

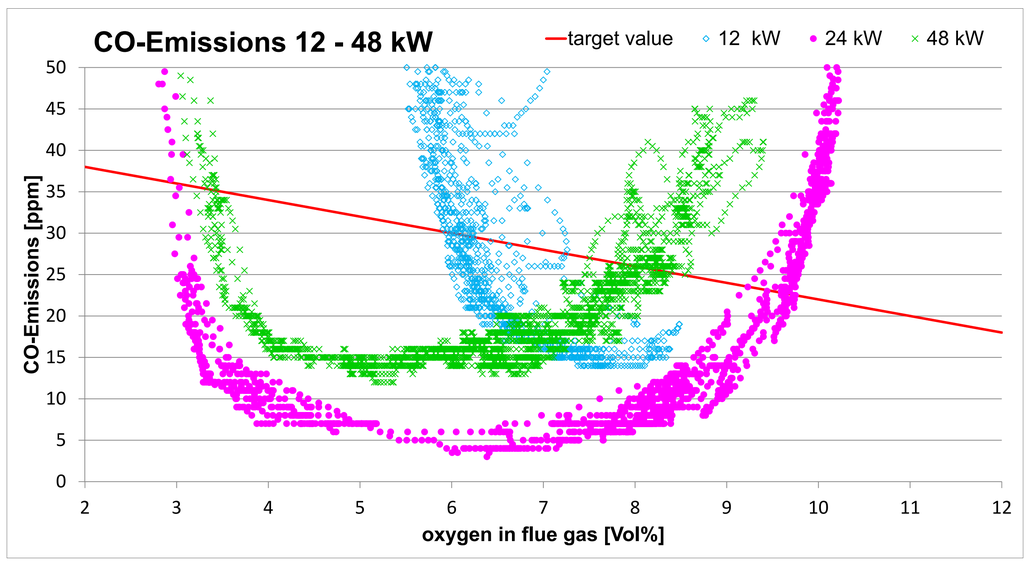
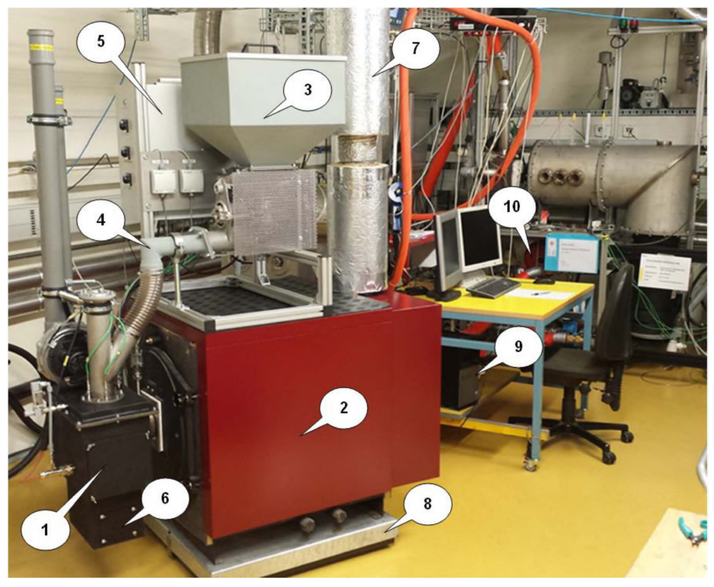


Figure 3: CO-Emissions as function of the oxygen in flue gas for different power



1. Wood gas burner (7 - 50 kW)
2. Liebi oil boiler LAX 30 (36 - 60 kW)
3. Pellet tank
4. Pellet conveying
5. Switch cabinet
6. Ash tank
7. Chimney
8. Floor scale
9. Measurement PC
10. Cooling system

Figure 4: Retrofit wood gas burner (black) attached to standard fossil boiler (red)