Efficiency increase of biomass combustion systems by a modular CO-λ optimization: method and results from long-term verification

Central European Biomass Conference 2023

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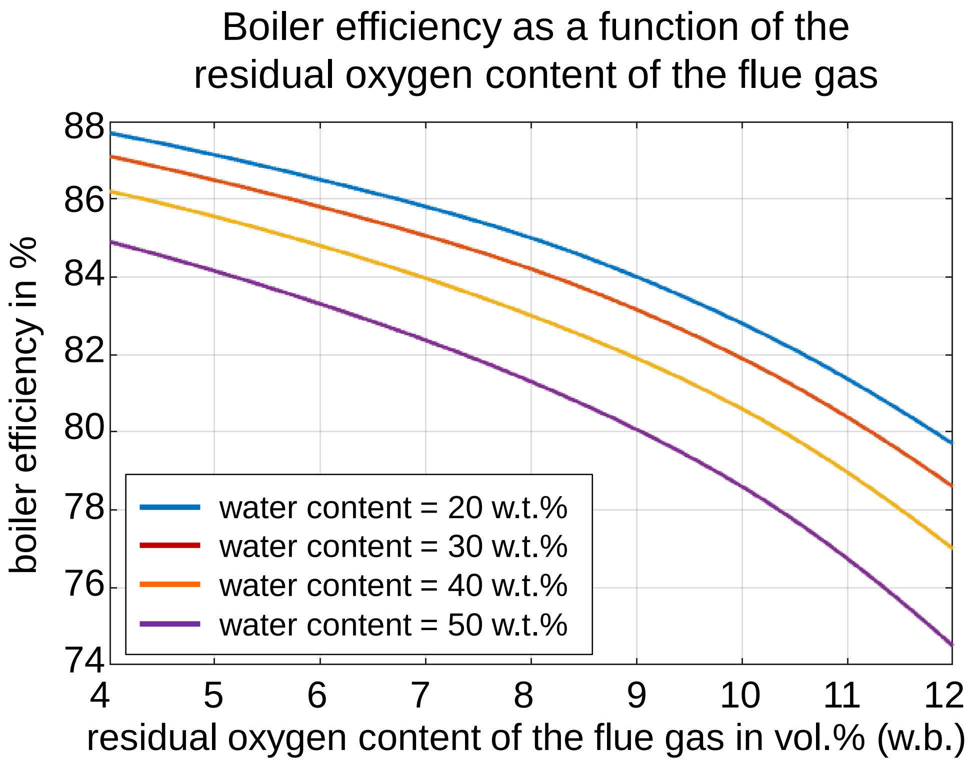
Oxygen content - boiler efficiency



A reduced residual oxygen content of the flue gas (O_2) leads to:

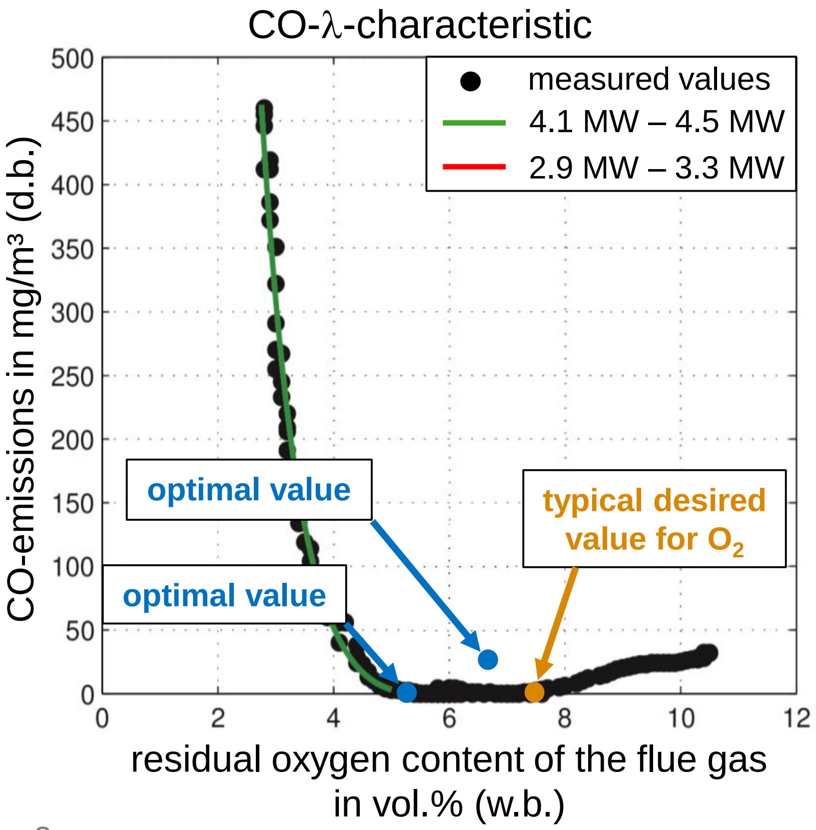
- an increased boiler efficiency
- decreased electric power consumption of the air- and flue gas fans

<u>Example: 2.5 MW boiler</u>

O_2-decrease by 1 - 2 vol.%

€3.000 - €5.000 savings in fuel and electricity costs **per year**

Oxygen content - pollutant emissions



The CO-λ-characteristic changes with the thermal load and the fuel.

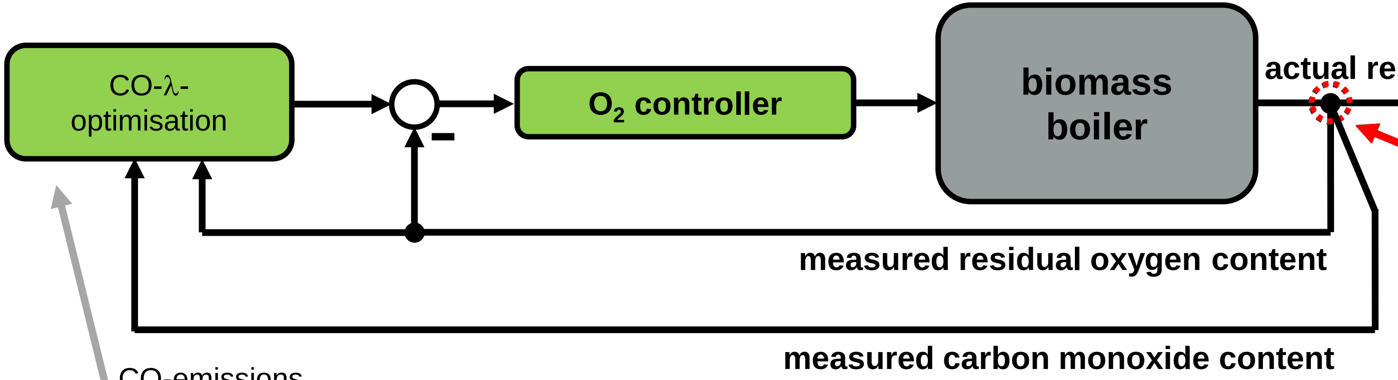
Operating the biomass boiler with a constant value for O_2 results in:

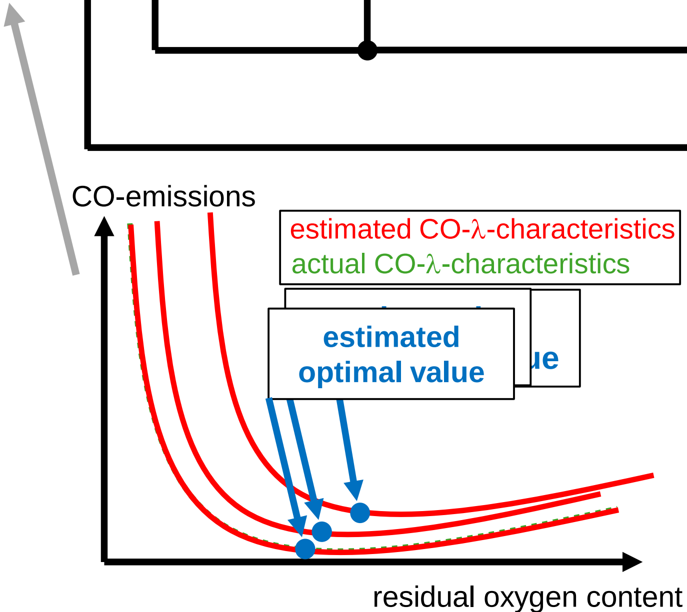
- increased CO-emissions or
- decreased boiler efficiency

CO-λ-optimisation: Operation of the biomass boiler with a value for O_2 which

- maximises the boiler efficiency and simultaneously
- minimises the CO-emissions

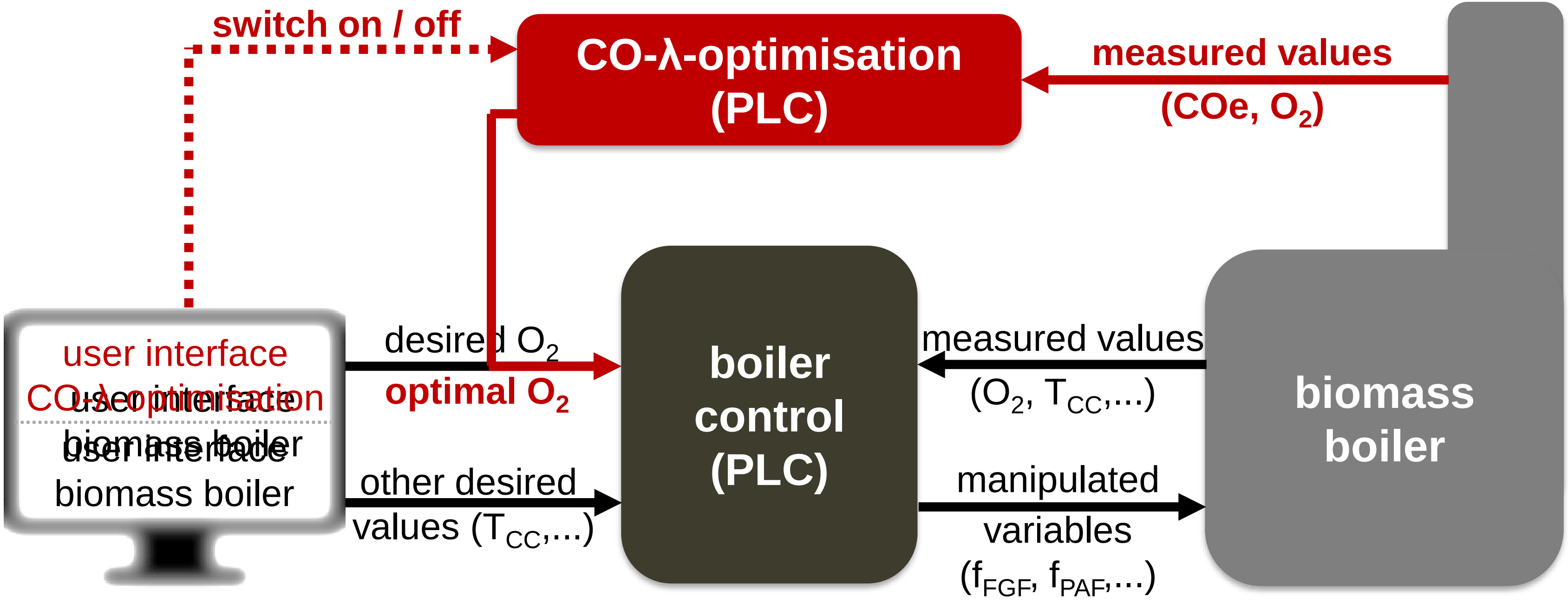
CO-λ-optimisation - method





Method: estimation of the shape of the real CO-λ-characteristics using an extended Kalman Filter.

CO-λ-optimisation - implementation



The CO-λ-optimisation can be implemented at all biomass boilers with existing O_2-controller → It is a **modular method**.

Long-term verification


Heating plant in Fuschl am See.

Heating plant:

- management: s.nahwaerme.at Energiecontracting GmbH
- 2 biomass boilers
  - 1 MW and 2.5 MW
- annual heat output: 16000 MWh
- customers: ~175

The CO-λ-optimisation has been implemented at one of the biomass boilers

- nominal capacity: 2.5 MW
- fuel: wood chips (water content: 30-50 w.t.%)

Long-term verification - description

Procedure for the long-term verification:

- time period: November 2018 to March 2019 (5 months)
- The modular CO-λ-optimisation was repeatedly **activated for 2 days** and subsequently **deactivated for 2 days** to ensure comparable conditions.

Method of calculating the boiler efficiency

- The boiler's thermal output was measured and from it the total delivered heat was calculated for activated and deactivated CO-λ-optimisation.
- The number of stoker cycles was recorded for activated and deactivated CO-λ-optimisation.

➢ **The boiler efficiency is calculated as total delivered heat per stoker cycle for activated and deactivated CO-λ-optimisation.**

Long-term verification - result overview

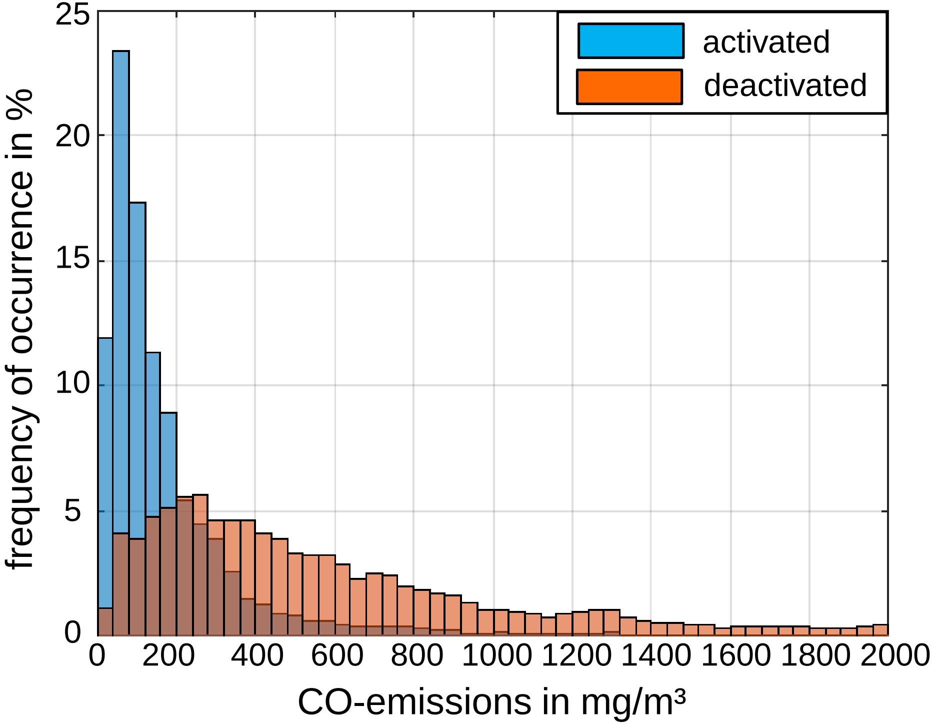
activated CO-λ-optimisation	31462	cycles	…stoker cycles
	1154.8	h	…operating hours
	2814.7	MWh	…total delivered heat
	2.44	MW	…mean thermal output
	11.18	**cycles / MWh**	

deactivated CO-λ-optimisation	36651	cycles	…stoker cycles
	1310.6	h	…operating hours
	3154.0	MWh	…total delivered heat
	2.41	MW	…mean thermal output
	11.62	**cycles / MWh**	

The modular CO-λ-optimisation reduced the fuel consumption by 3.8%.

Long-term verification - CO-emissions

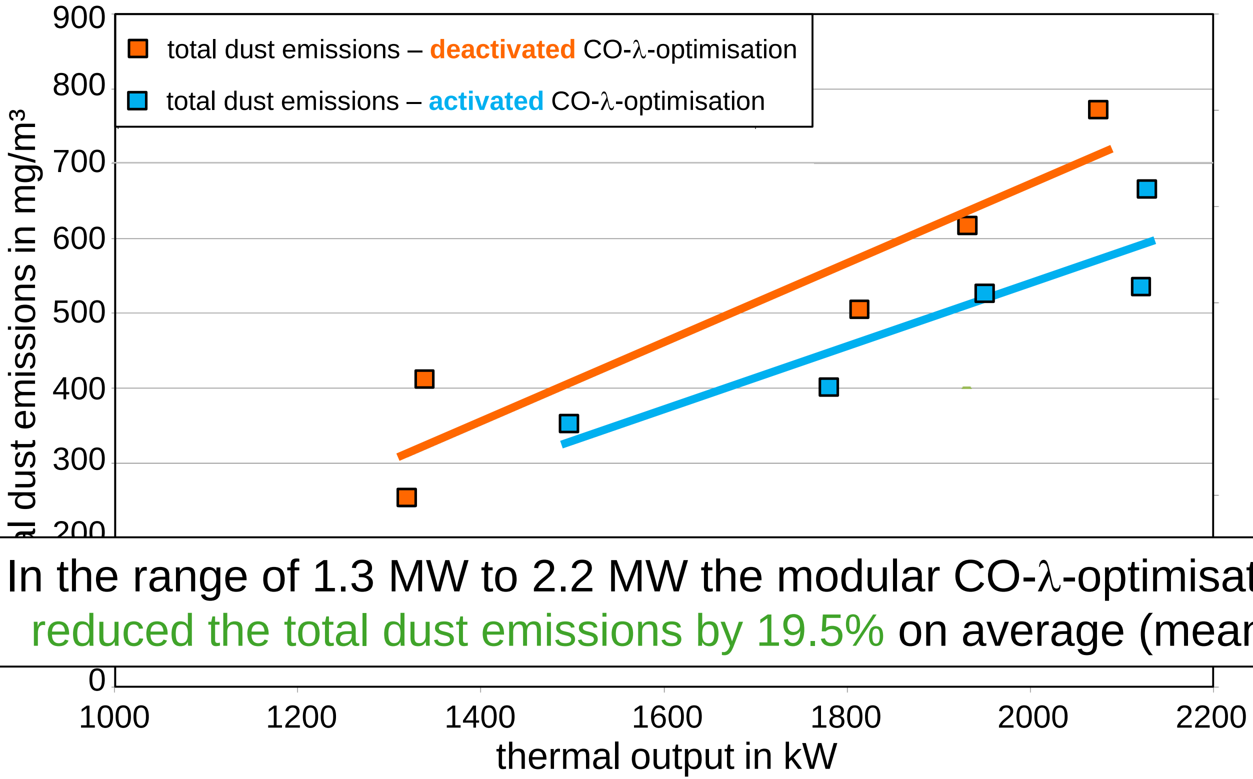
Distribution of the CO-emissions with
activated und deactivated CO-λ-optimisation



- period of consideration: one week
- comparative measurement with a flue gas analyser (ABB)

On average (median) the modular CO-λ-optimisation reduced the CO-emissions by 200 mg/m³ (standard conditions, 13 vol.% O_2).

Long-term verification - dust emissions (before electrostatic precipitator)



In the range of 1.3 MW to 2.2 MW the modular CO-λ-optimisation reduced the total dust emissions by 19.5% on average (mean).

Summary and conclusions

The modular CO-λ-optimisation

- defines an optimal desired value for the O_2-controller of the biomass boiler.
- can be applied at all biomass boilers with existing O_2-controller.

During the long-term verification the modular CO-λ-optimisation

- reduced the fuel consumption by -3.8%
- reduced the average CO-emissions by -200 mg/m³
- reduced the total dust emissions on average by -19.5%

The modular CO-λ-optimisation improves the boiler's efficiency while simultaneously decreasing pollutant emissions.

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