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CO-λ optimization

Operation of biomass boilers at maximum efficiency and with complete combustion

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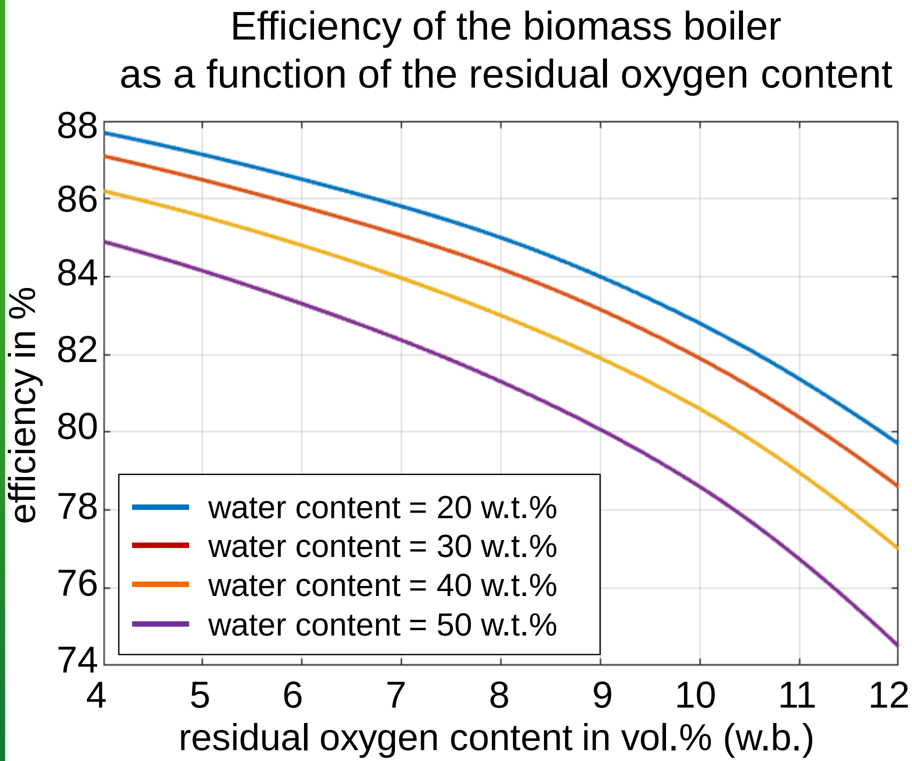
Oxygen content – efficiency



A reduction of the residual oxygen content leads to:

- increased efficiency
- reduced power consumption of the fans

Rule of thumb:

Reduction of oxygen content by 1 vol.% (w.b.) leads to an increase of efficiency by 1%.

Oxygen content – efficiency (example)

Typical biomass boiler with a nominal capacity of 2 MW (thermal output).

Fuel costs (20 EUR je m^3)

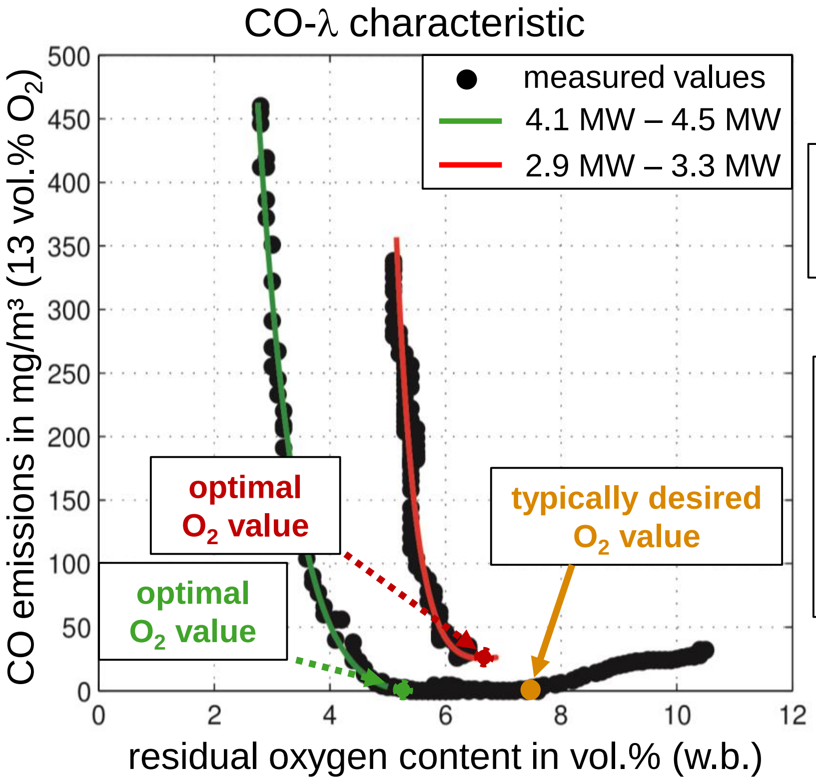
- annual heat output: 6 800 000 kWh (3400 full load hours)
- annual fuel consumption: 9 100 m^3 wood chips
- 1 – 2% fuel reduction leads to
- a cost reduction of 1 820 EUR – 3 640 EUR per year

Electricity costs (100 EUR / MWh)

- flue gas fan – nominal capacity (el.): 5 kW
- secondary air fan - nominal capacity (el.): 1 kW
- O_2 reduction: 1 – 2 vol.% (*from 8 vol.% to 7 – 6 vol.%*)
- ➢ cost reduction: 250 EUR – 500 EUR per year

➢ **Total cost reduction: 2 070 EUR – 4 140 EUR per year**

Oxygen content – pollutant emissions



CO emissions change with thermal output and fuel properties (e.g. water content).

Operation of the biomass boiler at constant O_2 values leads to:

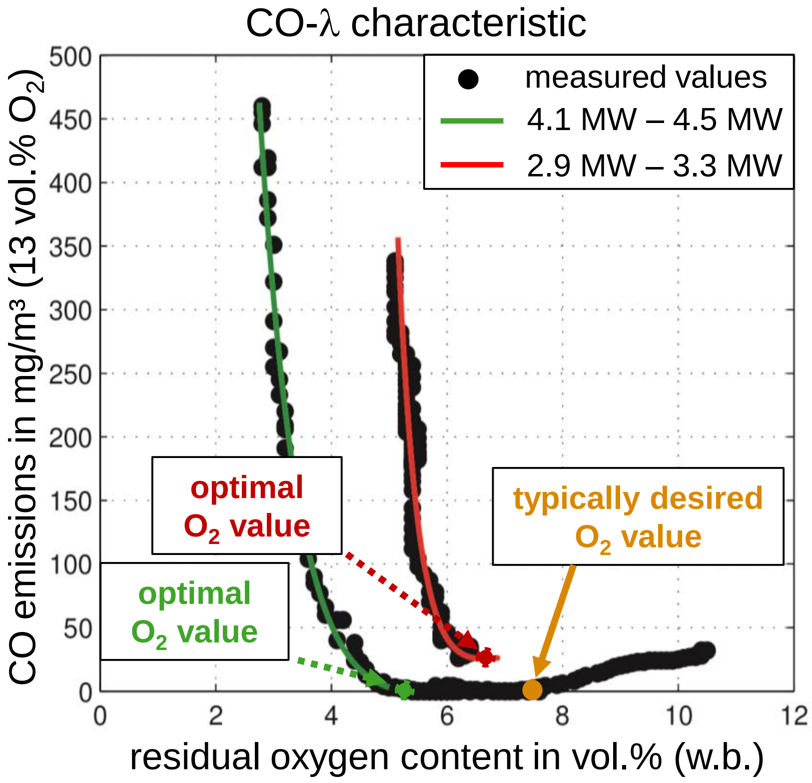
- increased CO emissions or
- reduced efficiency

Problems occuring at high CO emissions

- Legal CO limits cannot be met
- Increased emissions of particulate matter
- Tarring / fouling of the heat exchanger
  - ➢ reduced heat transfer → reduced efficiency
  - ➢ long-term fouling of the heat exhanger → expensive maintenance

CO emissions should be avoided to guarantee a stable, clean and efficient operation of the biomass boiler

Operating the biomass boiler



Choice of the residual oxygen content:

1.) as low as possible

→ increase efficiency

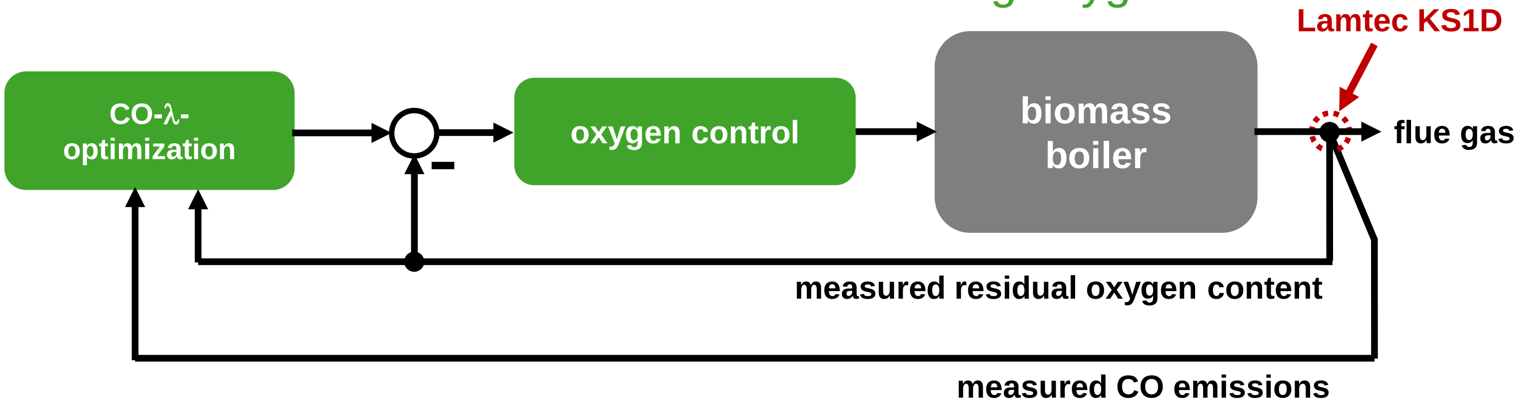
2.) avoid CO emissions

→ minimal pollutant emissions

CO-λ optimization

Functioning principle of the CO-λ optimization

The CO-λ optimization determines the optimum residual oxygen content and defines it as the desired value for the existing oxygen control.



The combined KS1D combustion sensor provided by LAMTEC simultaneously measures the oxygen content of the flue gas and the CO emissions.

Advantages of the CO-λ optimization

Only a desired value for the residual oxygen content is defined

→ the existing O2 controller is still used and remains unchanged

→ minimal effort for implementation

O_2 sensors are often faulty

→ the residual oxygen content is always adjusted precisely to achieve minimal CO emissions

→ measurement errors are automatically compensated

The biomass boilers is always operated optimally

→ independently of the boiler's thermal output

→ independently of the fuel

→ combustion is always as complete as possible

Long-term validation

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 optimization 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 validation – description

Long-term validation

- conducted over an entire heating periode (**November 2018 to March 2019**)
- alternating operation of the biomass boiler with activated and deactivated CO-λ optimization (activated for 2 days, then deactivated for 2 days, repeat)
- this ensured that comparable conditions were always ensured (e.g. thermal output and fuel water content).

Method for estimating changes in the efficiency

- measurement of the delivered thermal output (water)
- recording the number of fuel supply cycles (stoker cycles)

➢ **Efficiency: number of stoker cycles per MWh delivered heat**

Long-term validation – results

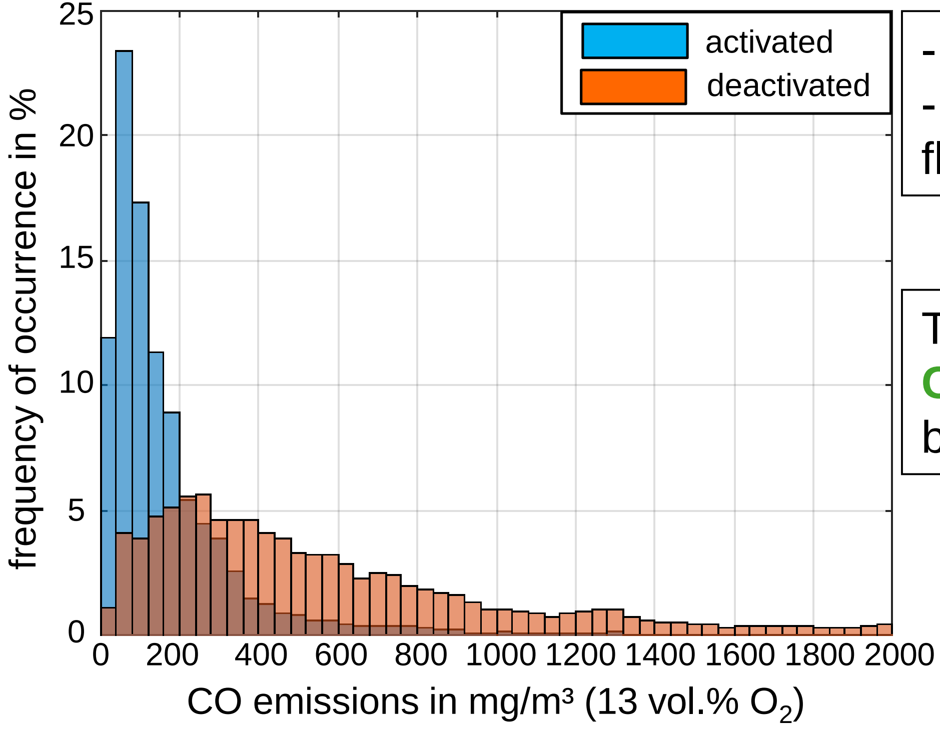
activated CO-λ optimization			
	31462	cycles	…stoker cycles
	1154.8	h	…operating hours
	2814.7	MWh	…delivered heat
	2.44	MW	…mean thermal output
	11.18	**cycles / MWh**	

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

The CO-λ optimization **reduced the fuel consumption by 3.8%.**

Long-term validation – CO emissions

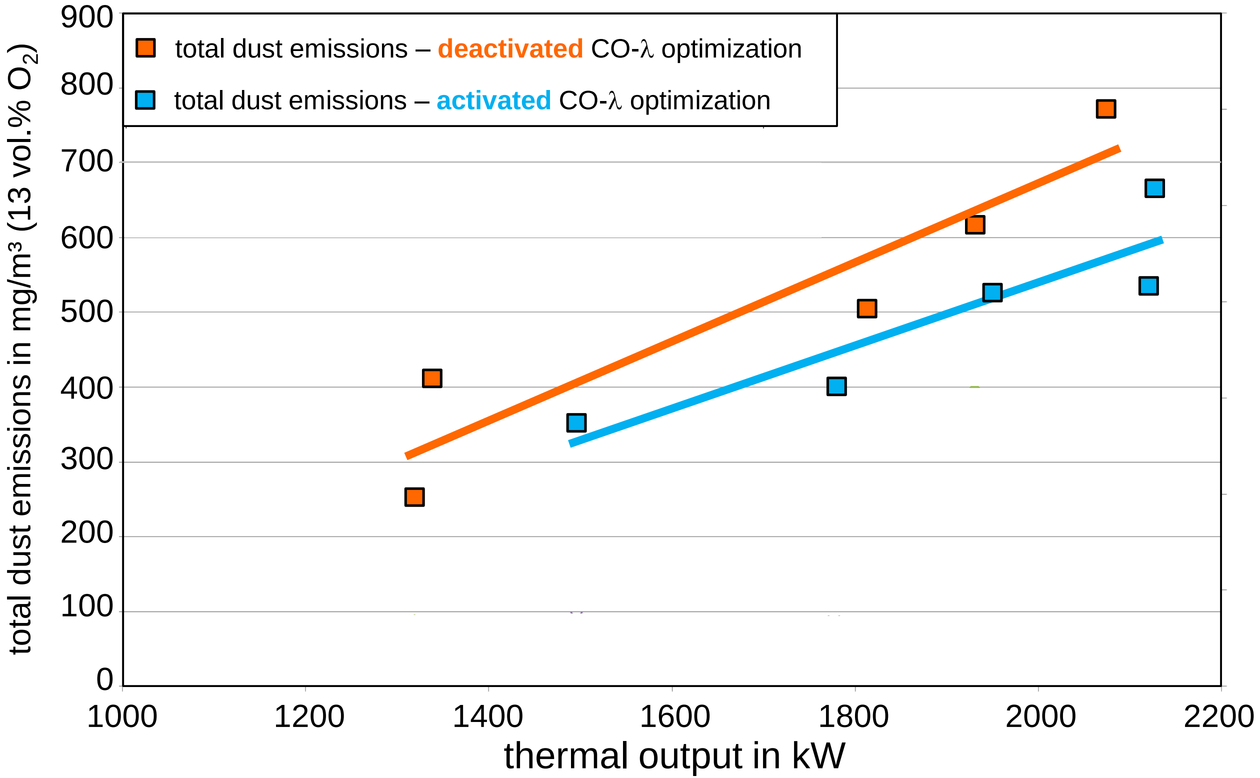
Distribution of the CO emissions with
activated and deactivated CO-λ optimization



- Observation period: one week
- Comparative measurements with a flue gas analyzer (ABB)

The CO-λ optimization **reduced the CO emissions** on average (median) by **200 mg/m³**.

Long-term validation – total dust emissions



The CO-λ optimization **reduced the total dust emissions by 19.5%**.

Long-term validation – summary

The long-term validataion of the CO-λ optimization in the biomass boiler in Fuschl am See led to the following results:

- reduction of fuel consumption **(-3.8%)**
- reduction of mean CO emissions **(-200 mg/m³ (13 vol.-% O2))**
- reduction of the mean total dust emissions **(-19.5%)**

The CO-λ optimization simultaneously improved the biomass boiler's efficiency and the pollutant emissions.

Summary

CO-λ optimization automatically operates the biomass boiler with the optimal residual oxygen content

→ independently of the boiler's thermal output

→ independently of the fuel

→ combustion is always as complete as possible

As a result, CO-λ optimization improves the combustion process

→ operation with minimum pollutant emissions

→ operation with maximum combustion efficiency

→ savings in electricity costs

→ oxygen measurement errors are automatically compensated

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