Effect of co-firing of biomass on operation of fluidized bed boiler

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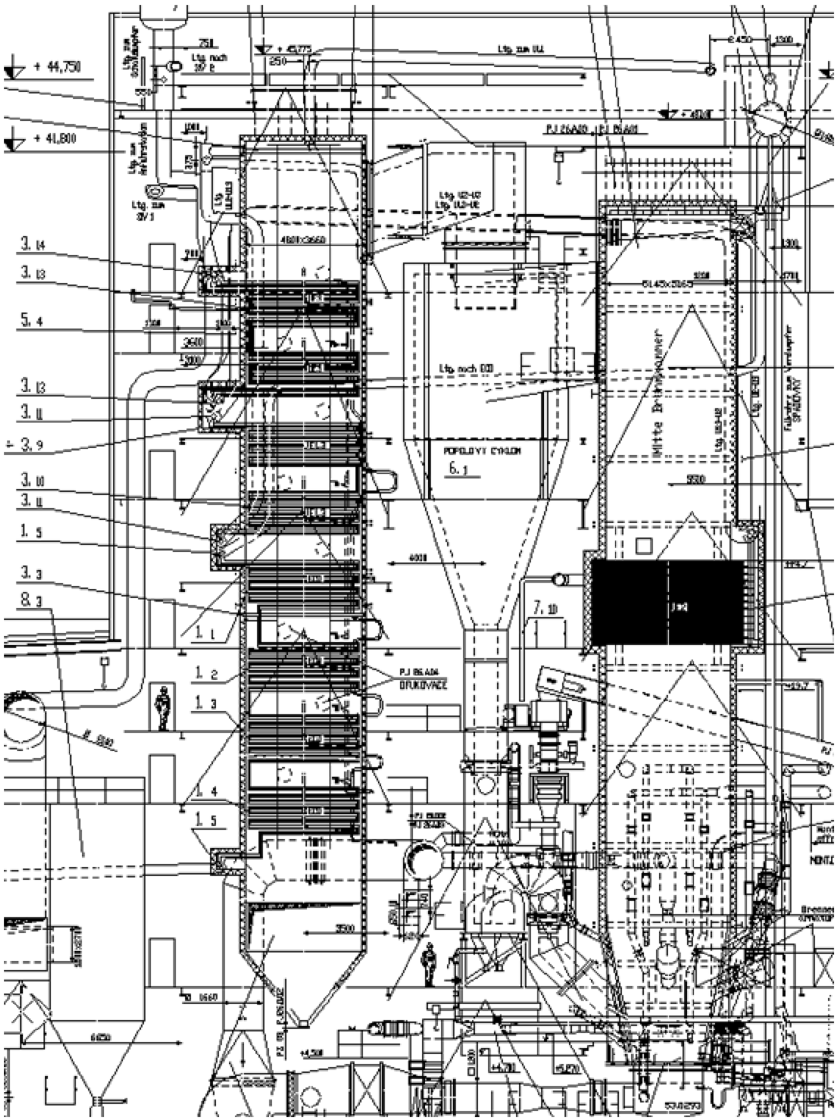
Goal of the work

Identification and quantification of the effects induced by increasing the share of biomass co-firing with coal from 15 to 30 %

CFB boiler layout and parameters



Steam power	140 t/h
S.temperature	535 °C
S. pressure	12,5 MPa
Feedwater temp.	230 °C

Fuels:

- lignite SD a.s. 18,8 MJ/kg
- Biomass – herbaceous (non-wooden) pellets 15,2 MJ/kg

Differences in the parameters of the fuels

- **Low heating value**
  – Low heating value of pellets is nearly 20% lower
- **Sulphure content**
  – Specific sulfur content in the pellets in g / MJ is 20 % of that in coal
- **Volatile combustibles**
  – high content in the biomass
  – **chlorine content**
  – can be in the non-wooden biomass more than 1%

Alkalines in ash

- pH of ash from the biomass is around 9 to 10 (Na, K)

- **Density**
  – density of the coal is 2,5 higher than biomass

Effects of biomass co-firing

positive effects:

- replacement of coal by a more environmentally friendly fuel
- decrease of CO_2 production
- energy efficient way of using the biomass

negative effects – mostly on the boiler itself, especially the following:

- more intensive formation of deposits in the boiler, resulting in a lower efficiency and a higher own consumption of the boiler;
- different way of burnout of the biomass particles resulting in an increase of temperature in the furnace
- corrosion problems caused by the increased content of chlorine and alkalis in biomass compared to coal

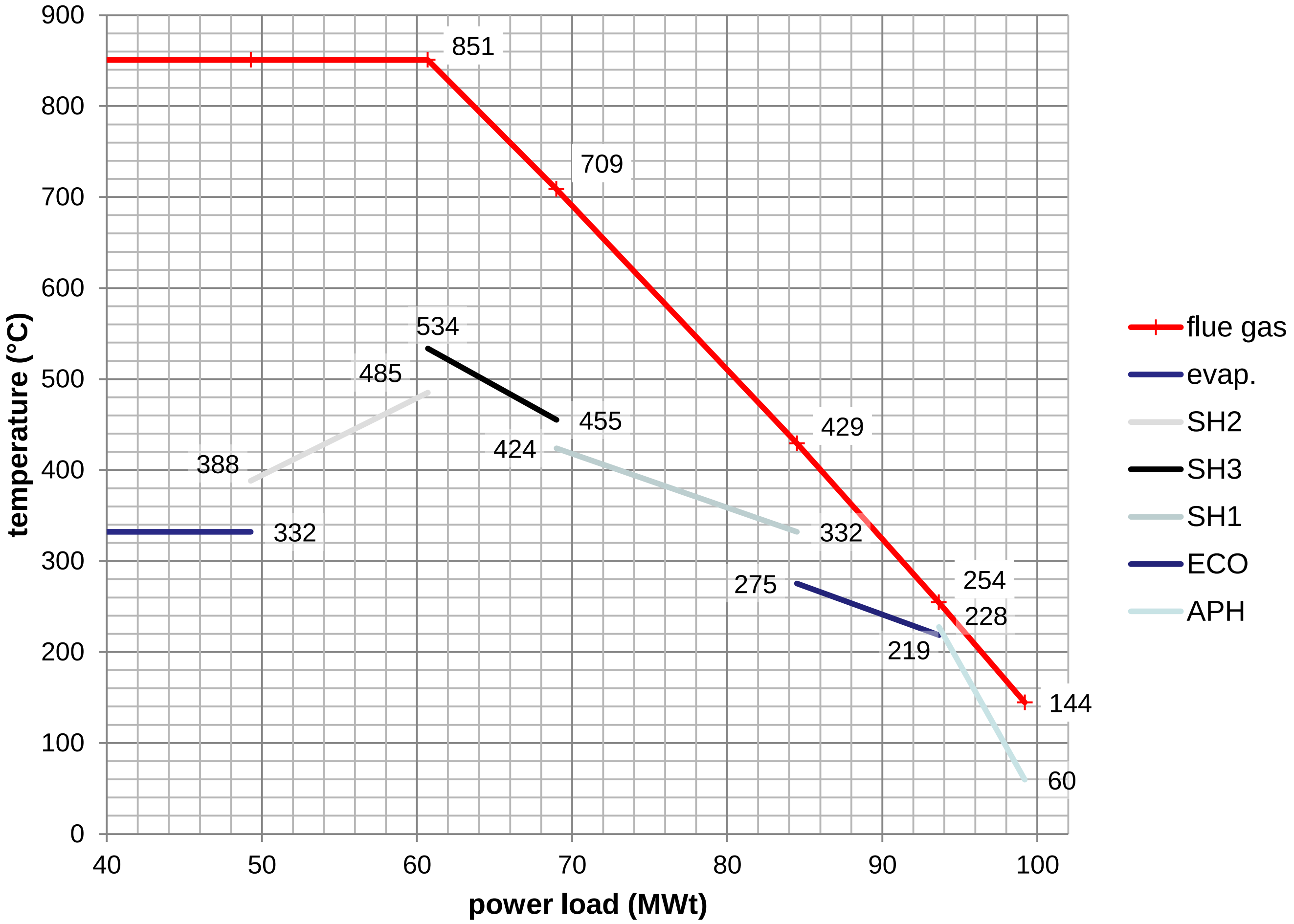
Effect of co-firing biomass in operation of fluidized bed boilers

The evaluation was performed for the boiler „K80“ using data from the archive process measurement

- from the beginning of 2013, when 15% co-firing of biomass was used
- from the 2nd half of the year, when the share of biomass increased to 30%

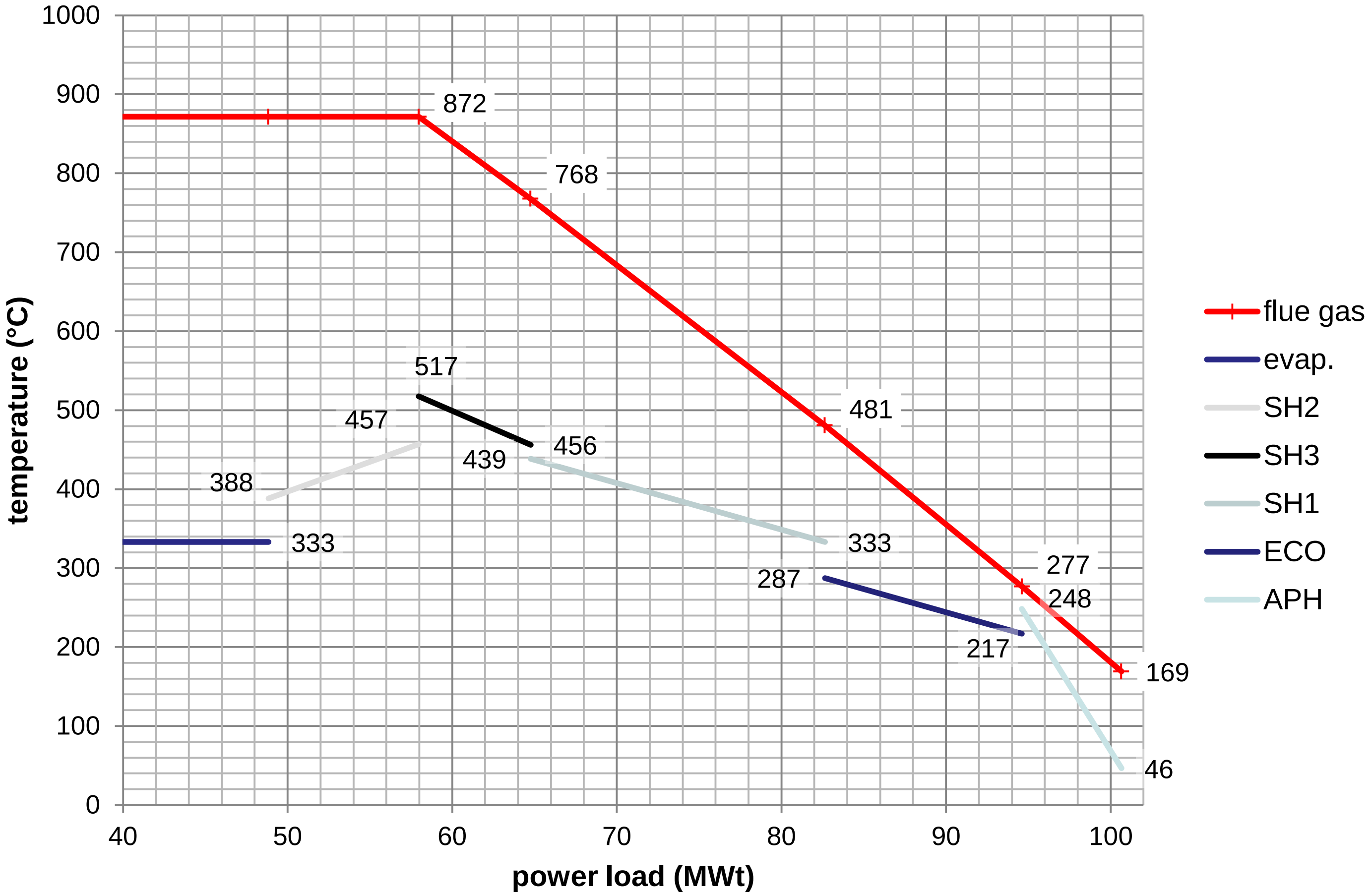
Effect of co-firing biomass on boiler efficiency

- Q -T diagram for the boiler, combustion of 15% biomass share



Effect of co-firing biomass on boiler efficiency

- Q -T diagram for the boiler, combustion of 30 % biomass share



Effect of biomass co-firing on boiler efficiency

The results of performance evaluation at 30 % biomass share:

- increased deposits of ash in the furnace
- The average temperature measured in the fluidized bed increased by 17 ° C
- about 20 ° C higher flue gas temperature at the inlet to the cyclone and to the second pass
  - 20% lower power of the superheater PP2
- due to the higher ash deposits, at the outlet superheater the steam temperature about 16 ° C bellow of the nominal value
  - Water regulatory injection was completely closed
  - Superheater PP3 power drop by 18%
  - Flue gas temperature at the end of the boiler higher by 24 ° C

	Heat transfer resistance at the surfaces increased about
PP3	42,7%
PP1	12,6%
ECO	7,2%
LUVO	20,4%

Effect of biomass co-firing on boiler efficiency

- formation of alkaline buildup at the outlet superheater of the boiler

Effect of biomass co-firing on boiler efficiency

	1. 2013	9. 2013	difference
Loss of combustible matter in flue gases	0,004%	0,004%	0,000%
Loss of combustible matter in solid combustion products	0,112%	0,126%	0,014%
The loss through heat of the flue gas	5,814%	7,156%	1,342%
The loss through heat in solid combustion products	0,084%	0,088%	0,004%
Loss of heat transmission (evaluation)	0,700%	0,700%	0,000%
Boiler efficiency	93,286%	91,926%	-1,360%

- Decrease of the boiler efficiency about 1,36 %
- impact on the quality of combustion is not significant

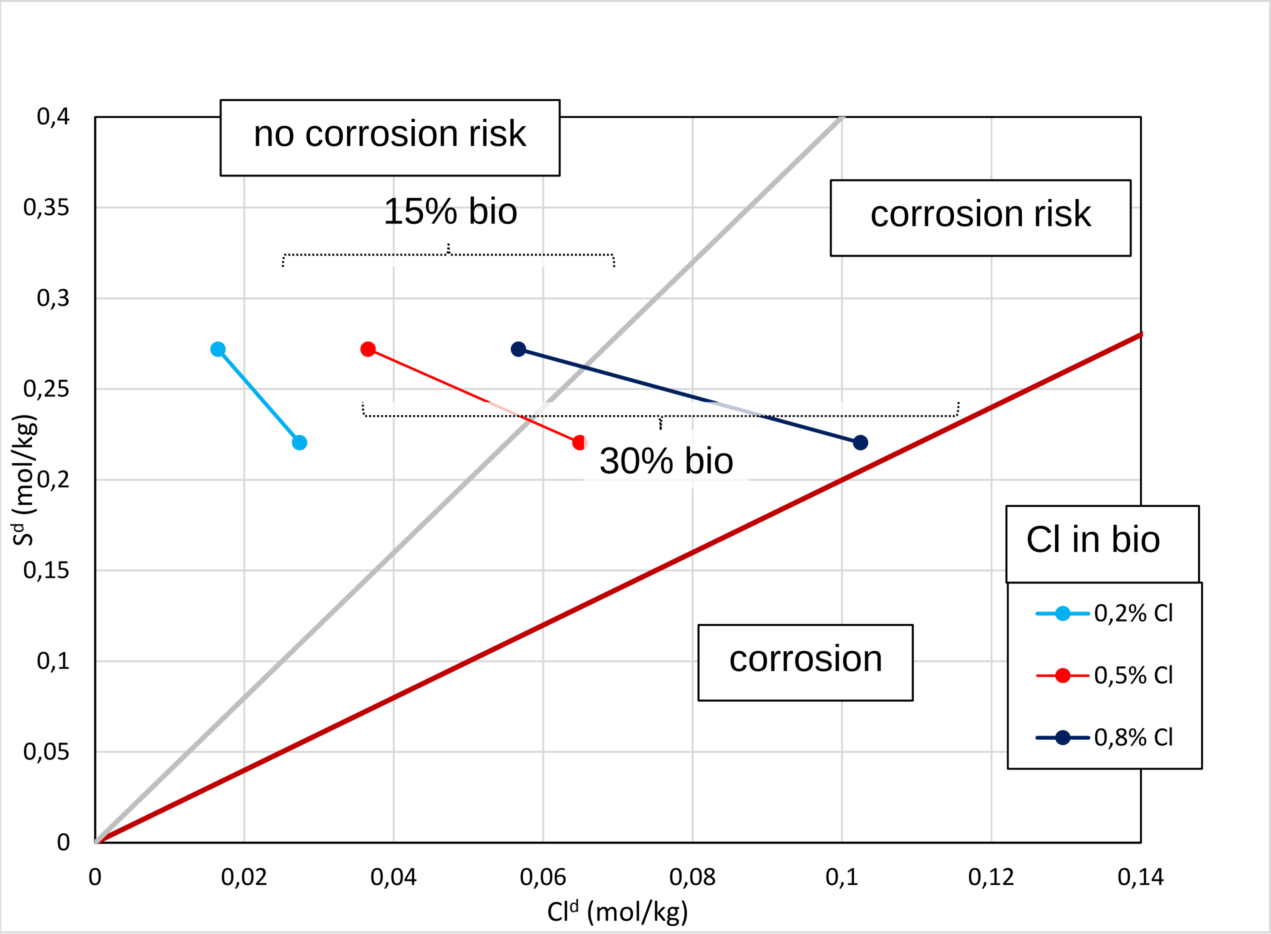
Effect of biomass co-firing on corrosion of boiler

- chlorine promotes corrosion in the boiler heating surfaces - especially superheater
- the cause of the corrosion are alkali metal chlorides - KCl and NaCl
  - condense at temperatures of 650-800 ° C
  - on the walls of the heat transfer surfaces they create a corrosion-aggressive layer
- the presence of SO2 reduces the production of chlorides

$$2SO_2 + 4KCl + 2H_2O + O_2 \rightarrow 2K_2SO_4 + 4HCl$$

Assessment of the impact of chlorine on corrosion rate

- Diagram of the corrosion

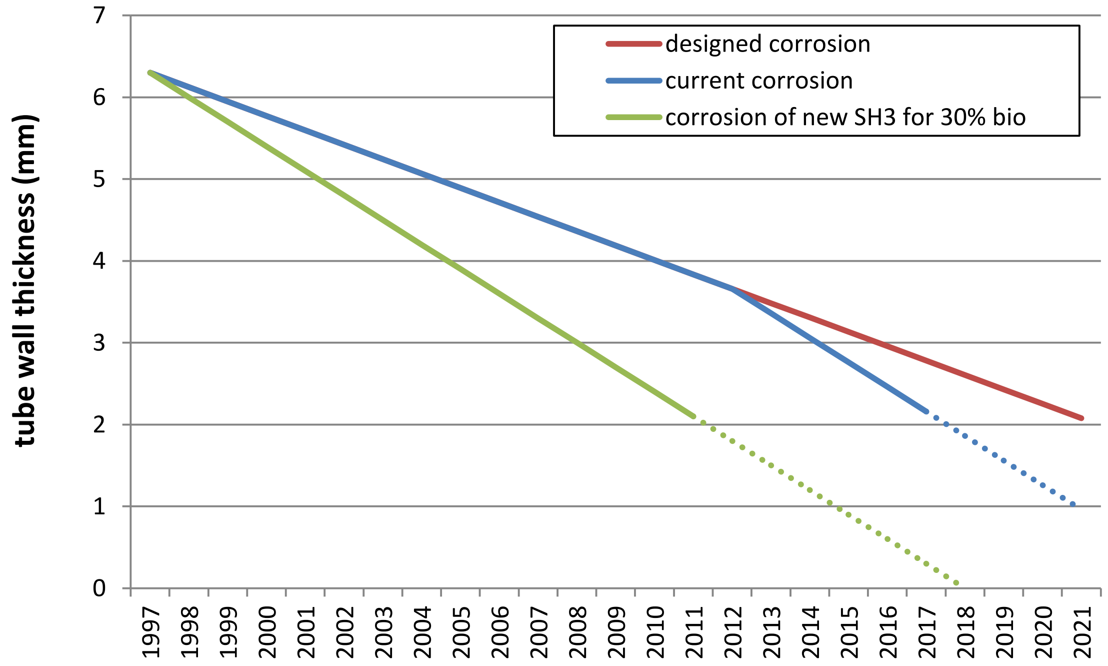


Assessment of the impact of chlorine on corrosion rate

- intensive corrosion occurs under the layer of chloride deposit

Assessment of the impact of chlorine on corrosion rate

- coal combustion - usual corrosion rate is by 22 nm / hr (0.176 mm / year),
- critical superheater tube wall thickness is 2 mm => superheater lifetime is about 25 years
- 15 % bio – experimental value of the corrosion rate is 0,3 mm/year => lifetime of superheater is shorter 21 years
- 30 % bio - lifetime of the new superheater will be only 15 years



Assesement of biomass co-firing effect on emissions of pollutants

Statistic data:

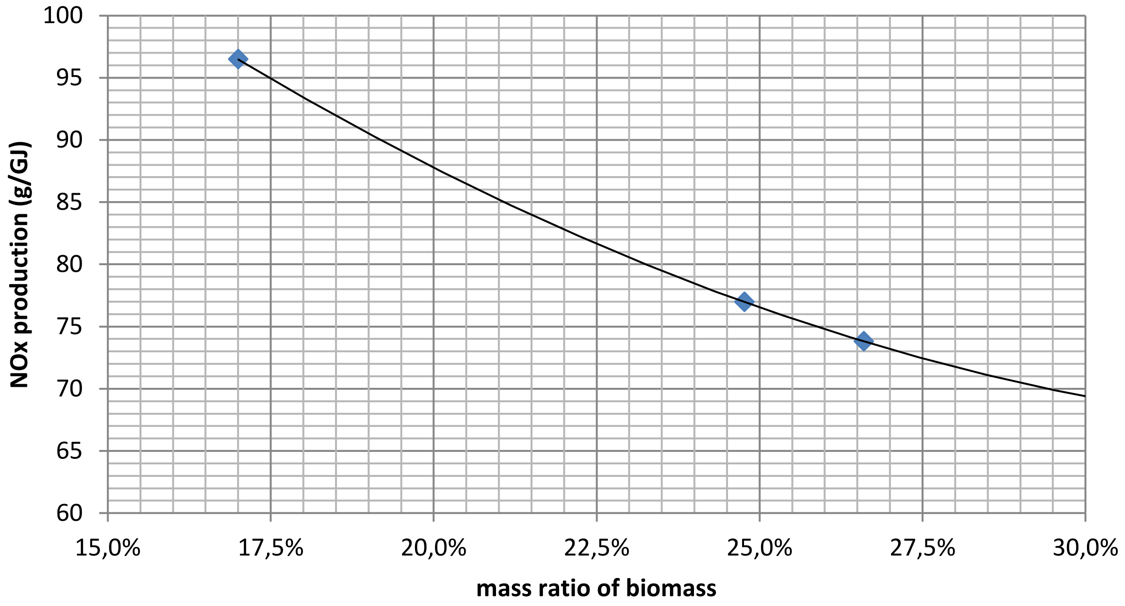
- semi-annual emissions for the years 2013-15
- semi-annual consumption of fuels and limestone for the years 2013-15
- the average share of co-firing of biomass in these periods

Assessment of the impact on SO2 emissions

- after increasing the share of biomass it was possible to reduce the feeding of limestone
- reduction of the Ca / S ratio from 1.92 to 1.70

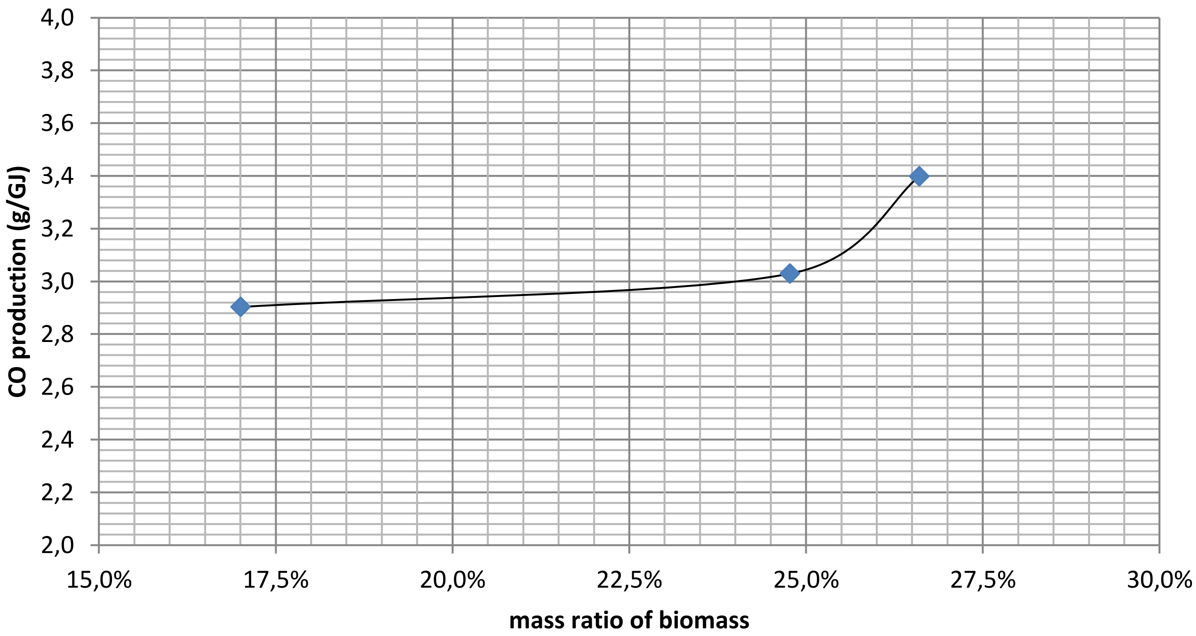
Assessment of the impact on emission NO_x

- evaluation was based on ½ year data of NOx formation in 2013-15
- fuel nitrogen content in the biomass is significantly higher than in coal
- biomass which is fed above the dense region of the fluidized bed acts as a reducing fuel, which reduces NO to N_2



Assessment of the impact on emission CO

- feeding of the biomass into a higher (lean) zone of the furnace is reflected in an increase of the CO production
- the steep increase of the CO production is related to targeted reductions of excess combustion air



Assessment of the impact on emission CO_2

- the burning of the 1 t lignite coal gives 1,756 t CO_2

- CO2 reduction is proportional to the amount of biomass burnt

Conclusions

Increasing the share of biomass combustion from 15 to 30% has these positive effects:

- increasing the share of renewable heat source
  - decreasing of emission NO_x about 27 %,
  - reduce of the production CO_2 about 14 %
- reduce of the limestone consumption to the flue gas desulfurization by about 20%

The negative effects are associated with a deterioration in the operating characteristics of the boiler :

- intensive fouling impairs boiler efficiency by 1.5% and proportionately
  - Increases fuel consumption
  - Increases own electricity consumption especially by the fans
- increasing the corrosion rate of the heating surfaces , in particular the outlet of the superheater and shorten its lifetime

Conclusions

Economic point of view

the price of heat in the biomass is 3.5 times higher

the biomass co-firing saves the CO_2 credits

- support for the use of renewable energy sources for electricity production,

In summary, based on the increase in the proportion of combustion of biomass from 15 to 30% is reflected as fast operational costs saving.

- The saving is mainly due to subsidies for electricity generated by burning biomass. Its withdrawal would be critical.

Thank You for Your Attention

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