IEA 2012 Workshop “Cofiring biomass with coal”
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ORAL SESSION: Emissions and Ash

Co-firing Tests of Bosnian Coal with Woody Biomass and Natural Gas in Laboratory and on 110 MWe Power Station

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Content of presentation

1. Background – Sustainability of the Project?
2. Question arisen
3. R&D: Experimental – Cofiring coal with woody biomass - Fuel test matrix, Laboratory set, Cofiring test trials and Results
4. Co-firing coal with woody biomass and natural gas – EXPERIMENTAL
5. Business Plan of introducing cofiring coal with woody biomass into Kakanj Thermal Power Plant (Kakanj TPP)
6. Trial run at Large utility: Kakanj TPP Unit 5 (110 MWe) – Program, Realization, Results
7. Conclusions
1. BACKGROUND

How to check and prove if Project is “sustainable”?

Project is “sustainable” if generates poitive effects to the Economic, Environmental and Social aspect, measured through the strictly defined sustainable indicators, and which Total Sustainability Index aggregated is to be better than in Base-line scenario, considering complete LifeTime of the Project.

The Work presents R&D activities and operation with cofiring in a Power plant, starting from the Project development, via Laboratory setting and the tests runs, till the Trial run in Large Utility, i.e. Introducing cofiring regimes into regulat Operation of a TPP, with the checking the results (on the base of settled indicators) by measurement in praxis.
2. QUESTIONS ARISEN

- Potential of woody biomass in case of Bosnia and Herzegovina?

- Why Cofiring of Bosnian Coal with woody biomass in existing Coal-based power plants?

- Which are expected benefits of the cofiring?

- Which obstacles can be expected in practical application?
Potential of woody biomass in Case of Bosnia and Herzegovina ??

- Large potential (53% of area of Bosnia and Herzegovina is under forest).
- Wood industry well developed, there is a number of saw mills.
- Large amount of wooden residues and waste woody biomass.
Why Cofiring coal with woody biomass in existing Coal-based power stations?

- Existing coal-based power plants are surrounded with large sources of wooden biomass - forest, saw-mills...
- Improving environmental issue of existing coal-based power plants and reduction of CO$_2$.
- Cheaper investment solution for use of woody biomass.
- Saving coal reserves for future generation.
- Synergy effects at co-firing of low-rank coal with biomass.
Which are expected benefits?

- Improving **Environmental Indicators** of power production:
  - Reduction of CO₂
  - Reduction of SO₂
  - Use of wooden residues will also improve local environment

- Improving **Resource Indicators** due to reducing of coal consumption

- Improving **Economic Indicators** of power production due to potential lower price of the fuel (??) and potential certified CO₂ reduction (CER)

- Improving **Social Indicator**: New jobs on wood collecting
Which are possible obstacles in praxis?

I. Key point: Price of woody biomass in EUR/GJ or in EUR/t!
- Organization of wooden biomass collecting
- Insufficient auxiliary infrastructure in forests (roads, depotes for auxilary storage) and transport of woody biomass to the sites

II. Key point: Investments on sites for co-firing regimes!
- Providing the depotes or boxes on sites for wooden biomass storage
- Adopting the boiler equipment for the woody biomass introducing

III. Key point: Possible increasing of O&M costs!
- Possible problems during combustion in co-firing regimes regarding combustion controll, slagging and fouling, corrosion...
3. R&D: Experimental - Cofiring coal with woody biomass
Fuel test matrix, Laboratory set, Cofiring test trials and Results
### FUEL TEST MATRIX

#### Fuels Kakanj TPP

<table>
<thead>
<tr>
<th>Fuels</th>
<th>Symbol</th>
<th>% wt</th>
<th>% thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kakanj brown coal</td>
<td>K</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Spruce saw dust</td>
<td>S</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Co-firing blend</td>
<td>K93S7</td>
<td>93/7</td>
<td>89/11</td>
</tr>
<tr>
<td>Co-firing blend</td>
<td>K80S20</td>
<td>80/20</td>
<td>72/28</td>
</tr>
</tbody>
</table>

#### Fuels Tuzla TPP

<table>
<thead>
<tr>
<th>Fuels</th>
<th>Symbol</th>
<th>% wt</th>
<th>% thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dubrave/Šikulje lignite</td>
<td>L</td>
<td>D80:Š20</td>
<td>D81:Š19</td>
</tr>
<tr>
<td>Spruce saw dust</td>
<td>S</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Co-firing blend</td>
<td>L93-S7</td>
<td>93/7</td>
<td>87/13</td>
</tr>
<tr>
<td>Co-firing blend</td>
<td>L80-S20</td>
<td>80/20</td>
<td>70/30</td>
</tr>
</tbody>
</table>
Bosnian coal types; lignite and brown coal
### General coal characteristics

#### BOSNIAN LIGNITE
- Lower heating value: 7 – 12 MJ/kg
- Sulphur content: 0.1 – 2.5 %
- Ash content: 10 - 30 %
- CaO content in ash: 4 – 35 %

#### BOSNIAN BROWN COAL
- Lower heating value: 12 – 21 MJ/kg
- Sulphur content: 2.0 – 5.0 %
- Ash content: 22 – 44 %
- CaO content in ash: 8 – 30 %

*Low rank coals!!*
Net calorific value and ash content for some world low rank coal types
Characteristics of tested Fuels

Kakanj brown coal (K)
Hd = 12 657 kJ/kg , W = 11.3%, A = 42%, S = 2.2%
CaO = 12%, SiO$_2$ = 44%

Dubrave/Sikulje lignite (L)
Hd = 8 588 kJ/kg , W = 34%, A = 24%, S = 0.7%
CaO = 4.4%, SiO$_2$ = 50%

Wooden biomass Spruce (S)
Hd = 15 612 kJ/kg, W = 11.2%, A = 0.26%,
CaO = 14.6%, SiO$_2$ = 21.3%
Laboratory for combustion of coal and biomass at Faculty of Mechanical Engineering of Sarajevo University

20-kW PF entrained flow reactor
Scheme of the reactor

Diagram showing the reactor's components:
- Feeder
- Carrier – primary air
- Secondary/Tertiary air
- Blower
- Burner
- Electricity supply and Control
- Chimney
- Gas analyser
- Probes
- OFA
- Measurements:
  - T1 at 2.39 m
  - T2 at 1.76 m
  - T3 at 1.14 m
  - T4 at 0.51 m
- PID pressure control
Electrical and control equipment

Temperature can be varied at desire from ambient till 1550 °C

70 kW electrical
Systems for air and fuel supply

Fuel mass flow 0.25 – 5.0 kg/h
20 kW thermal

Controlled air distribution, including adjusting primar / secundar and primar+secundar / OFA

Air staging, Fuel staging
Ash Depozit and flue gas sampling

Collecting ash depozits on ceramic probes and water cooled lance

Emissions measurement
## Particle size distribution

<table>
<thead>
<tr>
<th>Rest</th>
<th>Total</th>
<th>200 μm</th>
<th>100 μm</th>
<th>90 μm</th>
<th>80 μm</th>
<th>71 μm</th>
<th>63 μm</th>
<th>45 μm</th>
<th>Passed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 K</td>
<td>100</td>
<td>18,2</td>
<td>28,0</td>
<td>-</td>
<td>17,4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36,4</td>
</tr>
<tr>
<td>2 Spruce</td>
<td>100</td>
<td>67,5</td>
<td>-</td>
<td>-</td>
<td>26,7</td>
<td>2,0</td>
<td>1,0</td>
<td>1,2</td>
<td>1,6</td>
</tr>
<tr>
<td>3 K93S7</td>
<td>100</td>
<td>21,1</td>
<td>-</td>
<td>-</td>
<td>34,2</td>
<td>4,7</td>
<td>22,3</td>
<td>3,0</td>
<td>14,7</td>
</tr>
<tr>
<td>4 K80S20</td>
<td>100</td>
<td>29,6</td>
<td>-</td>
<td>-</td>
<td>31,3</td>
<td>5,7</td>
<td>16,9</td>
<td>4,0</td>
<td>12,5</td>
</tr>
<tr>
<td>5 L93S7</td>
<td>100</td>
<td>49,5</td>
<td>-</td>
<td>-</td>
<td>25,5</td>
<td>3,7</td>
<td>12,5</td>
<td>2,0</td>
<td>6,8</td>
</tr>
<tr>
<td>6 L80S20</td>
<td>100</td>
<td>49,0</td>
<td>-</td>
<td>-</td>
<td>27,9</td>
<td>3,1</td>
<td>8,6</td>
<td>2,9</td>
<td>8,5</td>
</tr>
</tbody>
</table>
## Co-firing test program

### Variation of process temperature, °C

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>-</td>
<td>1140 / 1250 / 1400 / 1550</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K93S7</td>
<td>-</td>
<td>960</td>
<td>1140 / 1250 / 1400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K80S20</td>
<td>-</td>
<td>960</td>
<td>1140 / 1250 / 1400 / 1550</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DŠ</td>
<td>-</td>
<td>880 / 960 / 1050 / 1140 / 1250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DŠ93S7</td>
<td>-</td>
<td>960</td>
<td>1140 / 1250</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DŠ80S20</td>
<td>-</td>
<td>960</td>
<td>1140 / 1250</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Variation of excess air ratio

\[ \lambda = 0.9 / 1.0 / 1.1 / 1.2 / 1.3 / 1.4 \]
Combustion behaviours investigated

- Slagging and fouling
- Emissions
- Combustion efficiency
### Slagging/fouling analysis

Criteria used for evaluation of ash depozit:

<table>
<thead>
<tr>
<th>Criteria No</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SHAPE OF DEPOZIT</td>
</tr>
<tr>
<td>2</td>
<td>MELTING STATE OF DEPOZIT</td>
</tr>
<tr>
<td>3</td>
<td>STRUCTURE OF DEPOZIT</td>
</tr>
<tr>
<td>4</td>
<td>ADHESION OF DEPOZIT</td>
</tr>
<tr>
<td>5</td>
<td>COHESION OF DEPOZIT</td>
</tr>
<tr>
<td>6</td>
<td>DEPOZITION INTENSITY</td>
</tr>
<tr>
<td>+</td>
<td>ASH DEPOZIT CHEMICAL COMPOZITION</td>
</tr>
</tbody>
</table>
CRITERIA 1. Shape of depozit,
CRITERIA 2. Melting state of depozit,
by Visual observation, photografically
CRITERIA 3. Structure of depozit, by Optical observation of ash deposits

“5 multiply” enlargement

M1A – 1250 °C
- slag sample

“100 multiply” enlargement

M1A – 1250 °C
- ash deposit sample
CRITERIA 4. Test of adhesion
CRITERIA 5. Test of cohesion
CRITERIA 6. Depozition Rate $[ld]$

$$lr = \left[ \frac{g}{(cm^2 \times h)} \right]$$
---

## Principle of aggregation of single criteria evaluations

<table>
<thead>
<tr>
<th>Final evaluation</th>
<th>LOW</th>
<th>MODERATE</th>
<th>STRONG</th>
<th>VERY STRONG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zone</strong></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Prevailing gradation</td>
<td>i</td>
<td>ii</td>
<td>iii</td>
<td>iv, v</td>
</tr>
</tbody>
</table>

### Criteria 1

**Shape**
- Pyramid (i)
- Cone (ii)
- Truncated cone (iii)
- Flat (iv)

### Criteria 2

**Melting state**
- Dry (i)
- Start of melting (ii)
- Melted (iii)
- Molten (iv)

### Criteria 3

**Structure**
- Powder (i)
- Particles (ii)
- Particles (ii) Fibres (iii)
- -

### Criteria 4

**Adhesion**
- Low (i)
- Moderate (ii)
- Moderate (ii) Strong (iii)
- Very strong (iv)

### Criteria 5

**Cohesion**
- Low (i)
- Moderate (ii)
- Moderate (ii) Strong (iii)
- Very strong (iv)

### Criteria 6

**Deposition intensity**
- Low (i)
- Moderate (ii)
- Moderate (ii) High (iii)
- High (iii) Very high (iv)
Correlation between base-acid ratio and gas temperature for the Kakanj coal-spruce sawdust co-firing

below line 1: low slagging/fouling, above line 2: strong slagging/fouling, between line 1 and line 2: moderate slagging/fouling
**NO\textsubscript{x} emissions in co-firing tests**

There was no clear relation noted between the share of woody biomass in the fuel mixture and NO\textsubscript{x} emissions!!
Investigation of NO$_x$ emissions in air staging combustion
Reduction of SO2 emissions (even till 25% for the fuel mixture with 20%wt of wooden biomass) was recorded in all cofiring tests compared with the tests with coal aloen!
Sulphur capture rate

![Graph showing sulphur capture rate as a function of temperature and calcium to sulfur ratio.]

- Linear fitting for different compositions:
  - Linear (L)
  - Linear (L80S20)
  - Linear (L93S7)

- Temperature ranges:
  - 960 °C
  - 1140 °C
  - 1250 °C
  - 1400 °C

- Calcium to sulfur ratio ranges:
  - 1.28 to 1.4

The graphs illustrate the sulphur capture rate under varying conditions, highlighting the effectiveness of different linear models for capturing sulphur at different temperatures and calcium to sulfur ratios.
Recommendation from Experimental

- Blend of the coal with 7% of woody biomass could be used in Large Boiler of existing TPP Kakanj and TPP Tuzla with no any unusual operational problem related to regular operation of the main or auxiliary equipment, slagging/fouling problem, or stability of combustion process, i.e. with no reasonable risk to regular operation.

- However, this must be checked and finally proven in praxis in a trial run on a real large utility of Kakanj TPP and Tuzla TPP.
4. CO-FIRING TESTS OF COAL WITH WOODY BIOMASS AND NATURAL GAS - EXPERIMENTAL
## COAL (U)-WOODY BIOMASS (B)-NATURAL GAS (P) --- COFIRING TEST MATRIX

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Fuel type</th>
<th>Symbol</th>
<th>% Weight</th>
<th>% Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal with Natural gas (Reburning!)</td>
<td>Co-fuel</td>
<td>U95P5</td>
<td>95:5</td>
<td></td>
</tr>
<tr>
<td>Coal with Natural gas (Reburning!)</td>
<td>Co-fuel</td>
<td>U90P10</td>
<td>90:10</td>
<td></td>
</tr>
<tr>
<td>Coal with Biomass and Natural gas (Reburning!)</td>
<td>Co-fuel</td>
<td>UB95P5</td>
<td>95:5</td>
<td></td>
</tr>
<tr>
<td>Coal with Biomass and Natural gas (Reburning!)</td>
<td>Co-fuel</td>
<td>UB90P10</td>
<td>90:10</td>
<td></td>
</tr>
</tbody>
</table>
Scheme of the reactor with gas supply system
NOx emissions during cofiring of coal and woody biomass with natural gas

NOx emissions for different fuels, 
\( t_{F1} = 1400 \, ^\circ C, \, OFA = 0.90 / 0.30 \)

\[ e_{NOx} \text{ mg/m}_3 \text{ sdp} \]

- **U100**
- **U95B5**
- **U90B10**
- **U90P10**
- **UB95P5**
Conclusions on Emissions of NO\textsubscript{x} in cofiring campaigns with natural gas

- Slight increase of NO\textsubscript{x} emissions recorded with increase of process temperature from 1350 till 1450 °C.
- Slight decrease of NO\textsubscript{x} emissions with an increase of share of bioamss – but not in all campaigns!
- Use of OFA have reduced NO\textsubscript{x} emissions in all campaigns.
- Lower NO\textsubscript{x} emissions when upper OFA is used (OFA 1 - closer to the burner zone of the reactor).
- With use both OFA, NO\textsubscript{x} emissions equel to the NO\textsubscript{x} emissions when only OFA 2 is used.
- Significant reduction of NO\textsubscript{x} emissions recorded in cofiring campaigns “reburning with natural gas” (till 35% lower NO\textsubscript{x} emissions compared to the case coal alone).
5. Business Plan

Introducing of cofiring coal with woody biomass into regular operation of Kakanj TPP Unit 5 (110 MWe)
Switching 7%\text{w} of brown coal by woody biomass, based on optimization in laboratory and recommendation of limitation to 7%\text{w} to maintain net efficiency of the unit, avoid slagging and fouling problems and avoid woody biomass transportation problems.
### ENVIRONMENTAL INDICATORS

**Expected reduction of Emissions**

<table>
<thead>
<tr>
<th>tones/a</th>
<th>$CO_2$</th>
<th>$NO_x$</th>
<th>$SO_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing emissions (Coal only)</td>
<td>689 500</td>
<td>2 011</td>
<td>20 478</td>
</tr>
<tr>
<td>Emissions for Cofiring (7%w)</td>
<td>646 796</td>
<td>1 910</td>
<td>18 430</td>
</tr>
<tr>
<td>Total emissions reduction</td>
<td>42 704</td>
<td>101</td>
<td>2 048</td>
</tr>
</tbody>
</table>
Transport woody biomass into Boiler

Option 1: Preparing of woody biomass and blending with coal on the coal depot, combustion of PF coal-biomass blend on coal burners.
- Investment estimation for a 110 MWe unit: 250 000 EUR

Option 2: Introducing of biomass in the boiler through the biomass transport ducts – combustion of biomass on the rost.
- Investment estimation for a 110 MWe unit: 1,450,000 EUR

Option 3: Gasification of biomass into gassifyer – combustion of biogas in boiler furnace above OFA pozition – Fuel Staging
- Investment estimation for a 110 MWe unit: above 2,000,000 EUR, and is strongly depended on gassifyer thermal power

-Option 1 was choosen!
# TOTAL PROJECT COSTS FOR OPTION 1

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and Planning</td>
<td>170,000 €</td>
</tr>
<tr>
<td>Project Management</td>
<td>70,000 €</td>
</tr>
<tr>
<td>Process measurements (incl. meas. equipm)</td>
<td>160,000 €</td>
</tr>
<tr>
<td>Civil works on the site (arrangement of the depot and storing area, base, fencing…)</td>
<td>250,000 €</td>
</tr>
<tr>
<td>Mechanical equipment of cut machines (vibration plate, metal detector, cutter,…)</td>
<td>300,000 €</td>
</tr>
<tr>
<td>Electrical equipment of cut machines, protections and I&amp;C</td>
<td>200,000 €</td>
</tr>
<tr>
<td>Installation</td>
<td>190,000 €</td>
</tr>
<tr>
<td>Contingencies</td>
<td>120,000 €</td>
</tr>
<tr>
<td><strong>Total investment</strong></td>
<td><strong>1,460,000 €</strong></td>
</tr>
</tbody>
</table>
Prices in 2008 (2011)

- Coal = 31 (35) €/ton
- Woody biomass = 16 (2x > ?) €/ton
- Electricity = 40 (42) €/MWh
- CER = 15 (<10) €/t CO₂
### ECONOMIC INDICATORS

#### Expected annual net savings

<table>
<thead>
<tr>
<th>Saving elements</th>
<th>Present situation</th>
<th>After new measure</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount</td>
<td>€/year</td>
<td>Amount</td>
</tr>
<tr>
<td>Fuel - <em>coal, t</em></td>
<td>518 991</td>
<td>16 213 461</td>
<td>486 847</td>
</tr>
<tr>
<td></td>
<td>32 144</td>
<td>1 004 196</td>
<td></td>
</tr>
<tr>
<td>Fuel - <em>wooden biomass, t</em></td>
<td>0</td>
<td>0</td>
<td>36 644</td>
</tr>
<tr>
<td></td>
<td>- 36 644</td>
<td>- 586 436</td>
<td></td>
</tr>
<tr>
<td>CER (CDM)</td>
<td>640 560</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own electricity consumption of cut</td>
<td>0</td>
<td>0</td>
<td>1 661</td>
</tr>
<tr>
<td>machines, kWh)</td>
<td>0</td>
<td></td>
<td>- 1 661</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 66 447</td>
</tr>
<tr>
<td>Operation/Maintenance</td>
<td>1 100 000</td>
<td></td>
<td>1 177 553</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total annual net savings</td>
<td></td>
<td></td>
<td>273 760</td>
</tr>
</tbody>
</table>
6. Trial run in Large utility: Kakanj TPP Unit 5 (110 MWe) 

*Program, realization, results*
TPP Kakanj unit 5 (110 MWe)

- Cogeneration unit (electricity + heat for district heating)
- PF Boiler with slag tap furnace
- 12 Low NOx swirl coal burners placed in two rows
- 6 Hammer mills
- OFA system (placed in two rows)
- Hybrid dust filter (<10 mg/mn3)
- 91% Boiler efficiency
- 34% net efficiency of the unit
Programme of the Trial Run

FUEL CAMPAIGN:

1. Campaign (6 days): Coal 100%w (U100) - Referent case (Baseline scenario)
2. Campaign (3 days): Coal 93%w / Biomass 7%w (U93-B7)
3. Campaign (3 days): Coal 95%w / Biomass 5%w (U95-B5)

OPERATION, MEASUREMENTS AND ANALYSES:

- Varying thermal load (Power) of the Unit: 100% (110 MW), 80% (85 MW) and 60% (70 MW) during the Trial run Operation.
- Measurements all important parameters on the unit during Operation, checking and monitoring the boiler equipment.
- 4 stopage of the unit: before, between and after the campagnes, to complete all necessary visual inspections, sampling, analyses and measurements.
- Chemical analyses of the fuels, slag and ash samples
Coal and woody biomass mixed and homogenized on coal depot: 11807 t of coal + 890 t (4340 m$^3$) of wooden sawdust

Characteristics of wooden biomass supplied:
- Particle size: max 8 mm (wooden sawdust)
- Hd = 14000 kJ/kg, W = 20%, A = 0.3%
Furnace temperatures for Max. load

Temperature in Furnace for Maximal Boiler load, 320 t/h, 105 MWe

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Furnace temperatures for Opt. load

**Temperatures in Furnace for Optimal Boiler load, 280 t/h, 90 MWe**

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Temperature in furnace, °C
Furnace temperatures for Min. load

Temperatures in Furnace for Minimal Boiler load, 240 t/h, 75 MWe

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Boiler outlet Flue gas temperature during Trial run
Taking the ash deposits from Furnace outlet heating surfaces after campaign “Coal alone”
Furnace outlet after campaign “Coal 93% - woody biomas 7%w” – clean heating surfaces!
Comparison of ash deposits for three fuel campaigns: deposit taken from SH2A superheater placed at furnace outlet
Comparison of ash deposits for three fuel campaigns: deposit taken from a certain SH2 superheater placed in boiler cross draft.

U100

U95-B5

U93-B7
Base/acid ratio for the ash deposits generated in Trial Run
Emissions of SO2

SO2 emission during Trial Run

mg/m³ @ 6%O₂ dry

Load

105 MW  90 MW  75 MW

U100  U95-B5  U93-B7
Emissions of NOx

NOx emission during Trial Run

mg/mn3@6%O2 dry

Load

105 MW  90 MW  75 MW

U100  U95-B5  U93-B7
Pozitive effect to the operation of Electrostatic precipitator – lower electricity consumption in cofiring regimes!
7. Conclusions

From experimental

1. Optimization of coal-biomass blend (share of biomass in the coal/biomass mixture) is performed by an experimental PF entrained flow reactor:
   - Recommended to use till 7%w of wooden biomass with coal in large Bosnian power plants to avoid any risk in operation of Large utility

2. Specific results on emissions in Laboratory research of cofiring coal with woody biomass:
   - Reduction CO₂, Reduction SO₂, no clear relation to NOx!

3. Specific results on emissions in Laboratory research of cofiring coal with woody biomass:
   Significant reduction of NOx emissions recorded in cofiring campaigns “reburning with natural gas” (with 10%th of natural gas used fuel, NOx emissions reduction is till 40% compared to the NOx emissions when coal only is used).
Conclusions from Trial run in Large utility (Kakanj TPP)

1. Results of Trial Run of cofiring coal with 5%w and 7%w of woody biomass on TPP Kakanj unit 5 (110 MWe):
   - No significant operational problems!!
   - Lower ash depozition!
   - No significant influence to SO$_2$ and NOx,
   - Pozitive effect to operation of EP, Lower electricitx consumption and dust emission slightly reduced!

2. Economic benefits do not come any more from lower fuel price than could come from certified CO$_2$ reduction (CER)! CDM?