Demonstration of a new gasification technology for indirect co-firing of difficult biomass with coal

2nd International Workshop on Cofiring Biomass with Coal, March 2012

Martin Møller
Pyroneer
Technologies for using straw and wood at DONG Energy power plants

- Grate firing of straw and wood chips
  - 12 plants – 4 central, 8 local
- Co-firing of straw in coal-fired power plant
  - 2 central plants
- Co-firing of wood pellets, gas and oil
  - 1 central plant
- CFB combustion of straw and coal
  - 1 local plant

CFB combustion of straw and coal not further applied as there are no possibilities for using residual products

Main driver was:
Political agreement in 1993 to obligate power plants to apply 1.4 mio. tonnes of biomass (mainly straw) for power production by the year 2000
Direct Co-firing of straw in coal-fired power plants

Low investment costs, low emissions and high electrical efficiency

Challenges
- Combustion/burn out
- 1 GJ straw requires 10 GJ Coal
- Super heater corrosion
- Fly ash utilisation
- SCR catalyst deactivation

Straw handling plant

Combined coal/straw burner
Challenges with direct co-firing can be solved by the use of a low temperature gasifier

- **Maintain high steam data**
  - High efficiency can be maintained
  - Reduced corrosion, alkaline species removed from the gas

- **High percentage Co-firing**
  - Not limited by maximum 10-15% biomass to coal
  - More biomass can be used, also when boiler is on low load

- **Performance of HD-SCR**
  - Less physical destruction
  - Less chemical deactivation

- **Sustainability & Fuel flexibility**
  - Various high ash biomass and waste fractions can be used
  - Nutrients in bio-ash can be reused as fertilizer
Pyroneer: The fuel flexible gasifier - at a glance

Straw
Energy Crops
Industrial leftovers
Manure
Fibre
Sewage sludge

Gas:
Substitution of coal at power stations
Later even substitution of gas and oil

Ash:
With accessible contents of nutrient salts - specially potassium and phosphorus

Efficiency around 95%
Milestones in developing the low temperature gasifier

1999 – prototype 50 KW gasifier at DTU
2003 – Up-scaling 500 KW gasifier at DTU
2007 – Several Fuels 100 KW gasifier at DTU

DONG Energy Procured the rights to the technology in 2009
When DONG Energy took over the technology in December 2009, first step was to design a demonstration plant

- Conversion of low value biomass and waste fractions into "alkaline free" gas
- Technology to be tested in 3 steps
- Concept based on experiments in 3 pilot plants (50 KW, 100 KW and 0.5 MW)

**Schedule**

<table>
<thead>
<tr>
<th>Year</th>
<th>Up-scaling</th>
<th>Integration</th>
<th>Demonstration</th>
</tr>
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<tr>
<td>2010</td>
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<tr>
<td>2014</td>
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- Total budget 90 MDKK (EUR 12 Million)

**Features**

- Fuel: straw, manure fibres........ local residues
- Operating temperature is around 650 °C
- Efficiency is ~ 95% (LHV in the fuel that enters the boiler)
- Capacity: 6 MW\textsubscript{th} / 1,5 ton straw per hour
- Location: ASV 2, Kalundborg
- Commissioning during spring 2011
The three phases of the 6 MW demonstration project

**Demonstration**
Long time operation

**Integration**
Advanced and flexible fuel handling system

**Up-scaling**
- Fuel Silo
- Pyrolysis Chamber (Pyrolysis at 600°C)
- Char Reacter (Gasification at 730°C)
- Sand, Char, Pyrolysis gas
- 1st Cyclone
- 2nd Cyclone
- Gas
- Ash
- Air

**Integration**
Gas duct to boiler, combusting the gas in a coal boiler

**Integration**
Advanced and automated ash handling system

<table>
<thead>
<tr>
<th>Year</th>
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<th>2011</th>
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<tr>
<td>Demonstration</td>
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Site status August, 2010:

Up-scaling

Foundation for gasifier and N\textsubscript{2} tank.
Site status March 2011 – Erection completed

Up-scaling
Site status April 2011 – First CO, H₂ & CH₄ produced

Night between 28-29th of April
3 hours of stable operation at 80% load
The flare was a challenge
The produced gas was flared during the first phase.
Automated operation – easy to control temperature

Char reactor temperature: ± 2°C

Pyrolysis temperature: ± 3°C

12 hours operation

~745 °C

~650 °C
The ash is low in heavy metals, and can be distributed on farmland as a fertiliser

<table>
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<tr>
<th>Mg/kg</th>
<th>PAH</th>
<th>Cd</th>
<th>Cr</th>
<th>Hg</th>
<th>Ni</th>
<th>Pb</th>
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<td>2,4</td>
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</table>

**Limits to be meet for straw ash¹**

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<tr>
<td>Limits</td>
<td>12</td>
<td>5</td>
<td>100</td>
<td>0,8</td>
<td>60</td>
<td>120</td>
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</table>

All limits can be met with big margins

**Conclusion:**
Ash can be distributed on farmland

Note 1: Danish legislation "Biomasseaskebekendtgørelsen"
New growing test results from Risø DTU (example)

Plant response in barley:

Same amount of fertilizer N application according to recommended optimum barley requirement

CO1 = Control 1

CO2 = Control 2 = fertilizer P (P according to recommended optimum barley requirement)

Ash H1 = Pyroneer cereal straw ash with total P application equivalent to control 2
Results from the first tests campaigns in May – June 2011 – Up-scaling was successful

- Operated between 90% and 135% load
- 240 ton straw has been gasified
- No additives used
- 200 hours of stable operation

- Gas composition
  - $\text{H}_2$: 7-10%
  - $\text{CO}$: 12-14%
  - $\text{CO}_2$: 16-18%
  - $\text{CH}_4 +$: ~5%
- Tar compounds are an essential contributor to the LHV
- Stable process easy to control
Integration phase was initiated in Autumn 2011

- **Integration**
  - Design and construction of gas duct from gasifier to the boiler
  - Design and construction of a new flexible fuel feeding system
  - Design and construction of new ash handling system
  - Commissioning of new equipment
  - Re-commissioning the gasifier, burning the gas in the coal boiler
March 2012, Installing the gas duct
The main challenge was the position of the crane, assistance was needed
Status of today
Next step with the demonstration plant

- **Integration & Demonstration**
  - Re-commissioning of the gasifier
  - Optimising performance
  - Optimising procedures
  - Testing various fuels

- **Financed operating plan:**
  - 1000 operating hours in 2012
  - 2000 operating hours in 2013
  - 1300 operating hours in 2014
  
  expected to be increased through other projects
Next step with the technology is up-scaling to 50 MW - Commissioning is expected in 2015

- **Baled straw**
- **Cuttet straw**
- **Bio Ash**

**Storage and Hammer mills**

**New Gasifier**

- **95% Efficiency**
- **650 °C hot gas**

**Existing coal Boiler**

- **250 bar, 540/540 °C, 300 kg/s**
- **42% electrical efficiency**

**Coal**

**Wood**

**Power**

**District Heating**

**Existing straw infrastructure**
Pyroneer - a unique gasifier for the future

- High efficiency
- Very fuel flexible
- Easy to operate
- Reuse of ash as fertiliser
Thank you for your attention

For more information and contact, please visit: WWW.Pyroneer.dk