Current status of biomass cofiring

ExCo55, Copenhagen, May 25, 2005

Jaap Koppejan, Project Manager Bioenergy
Presentation overview

- Concepts applied
- Global status of application
- R&D issues
Biomass Cofiring: Concepts and Technologies
Global coal utilization (Mton/y)

- 5% e cofiring globally ~ 40 GW ~ 300 Mton CO₂/year
Biomass Cofiring: Examples
Why co-firing biomass with coal?

- Strong reduction in emissions of greenhouse gases and other pollutants
- It strongly supports the formation of a biomass commodity market
- Large opportunities, short term (5% co-firing globally ≈ 40 GW ≈ 300 Mton CO₂/year)
- Cheap option for renewable energy
- Highly efficient
- Job creation
Biomass co-firing: Best use of resources

Source: Baxter, 2004
Generation costs of cofiring are low

Source: Antares Group Inc
Biomass co-firing concepts

- Direct co-combustion in coal fired power plants
- Indirect co-combustion with pre-gasification or other thermal pretreatment
- Indirect co-combustion in gas-fired power plants
- Parallel co-combustion (steam side integration)
Direct co-firing of biomass

Delta Electricity, Australia
Direct co-firing of biomass (cont.)

The key issue is the behaviour of the blended fuel in the coal mills (brittle fracture, heat balance,..)
Biomass co-firing via pre-gasification

• Option for waste-derived fuels
• Amer (NL), Lahti (Finland)
• Investment costs: 300-1100 euro/kW_e
Amer-9 wood gasifier

- CFB gasifier
  - waste wood
  - 83 MWth input
  - 170 kton CO₂ red
Biofuel/Multifuel Gasifier at Kymijärvi Power Plant, Lahti, Finland

Lahti CFB Gasifier Fuels
Indirect co-firing for gas fired boilers

Biomass → Pyrolysis → Liquefaction → Bio oil → Bio oil → Boiler → Gas/coal
Parallel co-combustion (steam-side coupling)
Parallel co-combustion (steam-side coupling)

Enstedvaerket power plant – Abenraa, Denmark

- Straw
- Highly corrosive nature of straw at high temperatures
- Contamination of the coal ash.
- Biomass boiler: 40 MWₑ and coal-fired unit: 660 MWₑ

Vasteras CHP plant – Vasteras city, Sweden

- CHP plant has four units using coal and oil with an overall capacity of 500 MWe and 900 MW for district heating.
- CFB boiler for biomass 200 t/steam
Status of application
Status as of 2004

• approx. 40 pulverised coal fired power plants worldwide that cofired biomass on a commercial basis
• on average 3% energy input,
• some 3.5 Mton of coal substituted
• around 10 Mton of CO$_2$ reduction.
Global activities on biomass co-firing

Australia:
About 5 PC power plants cofire up to 5 mass% of wood (demolition wood, fresh wood)

USA:
Approx 40 PC plants have demonstrated cofiring capabilities, hardly any commercial operation

EU:
National goals of 5 – 12% of power production using biomass, near term goals are mostly being accomplished through co-firing

Scandinavia:
150 fluidized bed boilers use secondary fuels such as sawdust, wood chips, forest residues which are co-fired with peat, wood or coal

Germany:
PC plants (lignite and coal) cofire sewage sludge commercially, trials with straw and wood

The Netherlands:
Already applied in all available Dutch coal-fired plants at up to 20%m (about 10%e)
Coal Covenant in the Netherlands

- Agreed May 2002, to be accomplished in 2008
- 3.3 Mton CO$_2$ reduction by co-firing biomass in coal fired power stations
- equals 475 MW$_e$ installed capacity
- 12 % replacement of coal (heat) input
- requiring ~ 2.2 Mton of biomass/waste per year
Global overview of biomass/coal cofiring initiatives

- Recently done by IEA Bioenergy Task 32
- Internet database produced at www.ieabcc.nl
- 135 plants identified that co-fire biomass in plants that originally fire coal as main fuel
- 105 direct, 1 direct + parallel, 5 indirect, 24 yet unknown
### IEA Bioenergy Task 32 database (1)

#### Table

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Database</th>
<th>Resource</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoFfing</td>
<td>25 May 2005</td>
<td>IEA Bioenergy Task 32</td>
<td>Database</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Diagram

![Diagram of the IEA Bioenergy Task 32 database](image-url)

---

23 IEA Bioenergy Task 32
### IEA Bioenergy Task 32 database (2)

#### BioCoComb, Zeltweg, Austria

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of plant</td>
<td>BioCoComb</td>
</tr>
<tr>
<td>Location (Plant)</td>
<td>Zeltweg, Lower Austria</td>
</tr>
<tr>
<td>Country</td>
<td>Austria</td>
</tr>
<tr>
<td>Installed Capacity</td>
<td>8000 m³/d (480 m³/h)</td>
</tr>
<tr>
<td>Total number of biogas plants</td>
<td>8</td>
</tr>
<tr>
<td>Start of operations</td>
<td>October 1999</td>
</tr>
<tr>
<td>Contact person</td>
<td>Dr. Roland Werlau</td>
</tr>
<tr>
<td>Capacity</td>
<td>1356 m³/d (800 m³/h)</td>
</tr>
<tr>
<td>Net power generated</td>
<td>26.7 kWh/day (15.6 kWh/m³)</td>
</tr>
<tr>
<td>CO₂ and methane yield</td>
<td>0.5 m³ CO₂/m³, 0.2 m³ CH₄/m³</td>
</tr>
<tr>
<td>Notes</td>
<td>BioCoComb is a biogas plant that converts waste biomass into biogas. The process is similar to the production of biogas from landfill gas. The biogas is then further processed to produce synthetic fuel (H₂ and CO₂) for use in vehicles. This allows for the efficient use of waste materials and reduces greenhouse gas emissions.</td>
</tr>
</tbody>
</table>
Countries where cofiring has been done:

- Australia: 8
- Austria: 5
- Belgium: 1
- Denmark: 5
- Finland: 18
- Germany: 27
- Indonesia: 2
- Italy: 1
- Norway: 1
- UK: 2
- The Netherlands: 5
- Thailand: 1
- Taiwan: 1
- Sweden: 15
- Spain: 2
- USA: 41
- Australia: 8
- Austria: 5
- Belgium: 1
- Denmark: 5
- Finland: 18
- Germany: 27
- Indonesia: 2
- Italy: 1
- Norway: 1
- USA: 41
- Australia: 8
- Austria: 5
- Belgium: 1
- Denmark: 5
- Finland: 18
- Germany: 27
- Indonesia: 2
- Italy: 1
- Norway: 1
- USA: 41
Database details

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Number of plants that co-fire this fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>41</td>
</tr>
<tr>
<td>Sludge</td>
<td>30</td>
</tr>
<tr>
<td>Peat</td>
<td>20</td>
</tr>
<tr>
<td>Straw</td>
<td>16</td>
</tr>
<tr>
<td>Oil</td>
<td>12</td>
</tr>
<tr>
<td>Bark</td>
<td>10</td>
</tr>
<tr>
<td>RDF</td>
<td>7</td>
</tr>
</tbody>
</table>
Research and demonstration issues
Ash deposition may widely vary

- Red Oak Wood
- Danish Wheat Straw
- Pittsburgh #8 coal
- 15% Imperial Straw / 85% Pittsburgh #8 Coal
Ash deposition may widely vary (2)
Corrosion rates can sometimes be predicted with (sometimes complex) chemical mechanisms.

![Corrosion Potential Diagram](image)

- **Deposit Chlorine (% dry mass)**
- **2*Fuel Sulfur/Max (Available Alkali, Chloride)**
- **Stoichiometric Sulfur:Alkali Vapor**
- **Corrosion Potential**
  - High
  - Low
Striated Flows: particle path trajectories
Insufficient mixing in a boiler may lead to unexpected and problematic combustion conditions

Oxygen Contours

Temperature variations
Striated flows: Ash deposition [g/m²/h]
Striated Flows: Model vs. experiments

- CO₂ model prediction

- O₂ model prediction

- Measured CO₂

- Measured O₂
Task 32 project: SCR deactivation through biomass cofiring
SCR deactivation

Source: Larry Baxter, BYU, 2004
Project: SCR deactivation

**Catalyst Activity vs. Ca Poison Amount**

- Activity (kA/s)
- Poison Ratio (Ca/V)

**Catalyst Activity vs. Na Poison Amount**

- Activity (kA/s)
- Poison Ratio (Na/V)
Technical challenges for cofiring

- Cost effective methods for getting more and and wider varieties of fuels into the boiler
- Occurance of insufficient gas mixing / stratified flows in the boiler
- Fouling and corrosion of the boiler (alkali metals, chlorine)
- Continuation of fly ash utilization (unburned carbon, contamination, behaviour in cement)
- Impact on performance of flue gas cleaning (SCR DeNOₓ, performance of FGD unit)
Non-technical barriers

- Economic aspects
  - lack of financial incentives
  - uncertain fuel prices/availability

- Legislative aspects (utilization of fly ash in cement, determining green share of electricity produced, unclear emission legislation)

- Public perception of co-firing of biomass/waste

- Getting the permits through
Concluding remarks

- Co-firing represents a cost effective, short term option at a large scale

- Although more needs to be done, there is already a wealth of practical experience under different conditions

- IEA Bioenergy Task 32 wants to contribute to the problems the cofiring community is facing
## Task 32 workshops 2004-2006

<table>
<thead>
<tr>
<th>Topic</th>
<th>Organising Country</th>
<th>Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-firing</td>
<td>Netherlands</td>
<td>Rome, May 2004</td>
</tr>
<tr>
<td>Public perception of biomass cofiring</td>
<td>Canada + USA</td>
<td>Victoria, Aug- Sept. 2004</td>
</tr>
<tr>
<td>Aerosols</td>
<td>Austria</td>
<td>Austria, March 2005</td>
</tr>
<tr>
<td>Small scale systems</td>
<td>Netherlands</td>
<td>Paris, Oct 2005</td>
</tr>
<tr>
<td>Fuel Flexibility</td>
<td>Sweden</td>
<td>?, Spring 2006</td>
</tr>
<tr>
<td>Cofiring (tentative)</td>
<td>NL (with Task 33)</td>
<td>Netherlands, 2006</td>
</tr>
<tr>
<td>Corrosion and deposit formation</td>
<td>UK</td>
<td>Glasgow, autumn 2006</td>
</tr>
</tbody>
</table>
Thank you for your attention