CARBONA BIOMASS GASIFICATION TECHNOLOGY

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SUMMARY

• Biomass Gasification for Heat & Power and Syngas Production for Liquids
• Technology with Commercial Operating Plant Experiences
• Something about Carbona
• Carbona Biomass Gasification Technology
• Plant for CHP in Denmark
• Plants for Lime Kiln Gasifiers in Europe
• Program for Syngas Production
CARBONA/ANDRITZ

- Carbona is a biomass gasification technology based company supplying plants for various applications
- Andritz Oy acquired minority ownership in Carbona Inc. in 8/2006 with option for full ownership in future
- Andritz has biomass gasification background from 1980’s as Ahlstrom Machinery Oy
- Carbona has developed biomass gasification technology since 1990
- Carbona now offering plants on combined Carbona/Andritz technology
- Initial target in P&P industry
  - Lime kiln gasifier
  - Fuel for power boilers
- Future target in P&P
  - Biorefinery/motor fuels
  - Biomass IGCC power plant
CARBONA TECHNOLOGY & APPLICATIONS

Fluidized Bed Gasification for Biomass
- Bubbling Fluidized Bed (BFB) & Circulating Fluidized Bed (CFB)
- Low pressure and High Pressure
- Air or Oxygen

Applications
- BFB, high pressure, oxy - Liquid Fuels, SNG, Hydrogen
- BFB, high pressure, air - IGCC (gas turbine)
- BFB, low pressure, air - BGGE (gas engine), small scale
- CFB, low pressure, air - Boilers and Kilns, large scale
BFB GASIFIER
LOW PRESSURE

BIOMASS
FEED HOPPER
FEEDING SCREW
GRID
ASH REMOVAL SCREW
ASH
AIR
FLUIDIZED BED
CYCLONE
GASIFICATION REACTOR
HOT PRODUCT GAS
CFB GASIFIER (Former Ahlström Pyroflow)

1. Gasifier
2. Uniflow cyclone
3. Air distribution plate
4. Air wind box
5. Feeding port
6. Dipleg
7. Ash out-take
8. Air preheater
9. Forced draft fan
10. Lime kiln
GASIFICATION PILOT PLANT
Tampere, Finland
PILOT EXPERIENCE, FINLAND

• 26 test runs
• 3850 test hours
• 6000 tons of fuel processed
• 700 tons of Polish coal, Colombian coal, coke and lignite
• 5300 tons of biomass, wood chips, paper mill waste, forest residue, willow, straw, pellets
• mixtures of coal/wood and coal/straw
• test operating parameters:
  - pressure: up to 23 bara
  - temperature: 700-1100 °C
  - fuel input: 2-20 MJ/s (MWth)
    - coal 50 tpd, biomass 100 tpd
  - gas cleanup temperature: up to 650 °C
BIOMASS FEEDSTOCKS TESTED

- Hard wood chips
- Soft wood chips
- Hard & soft wood mix
- Forest residue
- Bark
- Paper mill waste
- Wood pellets
- Saw dust
- RDF pellets
- Wheat straw
- Willow
- Alfalfa
- Rice straw
- Oil palm
- Bagasse
<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Size/Fuel</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTI, Chicago, USA RenuGas</td>
<td>1988</td>
<td>1 MW/biomass</td>
<td>Pilot Plant, air/oxygen</td>
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<tr>
<td>Tampella Power Finland</td>
<td>1991</td>
<td>20 MW/biomass (&amp; coal)</td>
<td>Pilot Plant</td>
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<tr>
<td>Hawaii, RenuGas Maui, USA</td>
<td>1993</td>
<td>20 MW/bagasse</td>
<td>Pilot Plant</td>
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<tr>
<td>GTI, Chicago, USA</td>
<td>2005</td>
<td>4 – 8 MW/coal &amp; biomass</td>
<td>Pilot Plant, air/oxygen</td>
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<td>Skive Fjernvarme Denmark</td>
<td>2006</td>
<td>28 MW/wood pellets/chips</td>
<td>CHP (gas engines)</td>
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</table>
GASIFICATION PLANTS

- GTI Old Pilot Plant Facility, Chicago
- Coal Gasifiers in Shanghai
- Tampere Pilot Plant
- Skive CHP Plant
- GTI New Pilot Plant, Chicago
- RenuGas, Hawaii
BIOMASS GASIFICATION – GAS ENGINE CHP PLANT

- Biomass
- Fuel feeding
- Gasifier
- Tar reformer
- Gas cooler
- Gas filter
- Gas cooler
- Gas tank
- Stack
- Heat recovery
- Power
- Gas engine(s)
- Heat
SKIVE BGGE CHP PLANT
5.5 MWe and 11 MWth
SKIVE PROCESS DESIGN BASIS

• **Plant Configuration:**
  - low pressure fluidized bed gasifier
  - tar reforming
  - gas cooling and scrubbing
  - gas engines
  - district heating system

• **Plant Capacity:**
  - biomass feed 110 tpd
  - power generation max. 5.5 MW
  - 11.5 MW district heat, supply at 94/50 °C

• **Fuel:**
  - wood pellets, thermal input 19.5 MJ/s
  - 9.5 % moisture content

• **General:**
  - annual operation 8000 hours
  - technical life time >15 years

• **Plant Efficiency:**
  - electrical efficiency 28 % (LHV, net)
  - electrical efficiency 30% (LHV, gross)
  - overall efficiency 87 % (LHV)
TAR REFORMER

General

• Removes tars and higher hydrocarbons from gas

• Converts tars and higher hydrocarbons to lighter combustible gas components: Carbon monoxide (CO) and hydrogen (H$_2$)

• Removes also ammonia (NH$_3$)

• No loss of energy

• No waste
GASIFIER VESSEL
PLANT OPEN CONSTRUCTION

Flare, Gasifier, Reformer
SKIVE PROJECT STATUS

Status at the end of March 2007

- Building 100% Completion
- Mechanical 100%
- Piping 100%
- Electrical 100%

- Hot commissioning started in April 2007
- Gasification testing scheduled to start in May 2007
## BIOMASS GASIFICATION REFERENCES

### Andritz/Ahlstrom CFB Gasifier

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Size/Fuel</th>
<th>Application</th>
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<tbody>
<tr>
<td>Wisaforest Oy</td>
<td>1983</td>
<td>35 MW/ bark/saw dust</td>
<td>Lime Kiln</td>
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<td>Finland</td>
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<td>Norrsundet Bruk Ab</td>
<td>1985</td>
<td>25 MW/bark/saw dust</td>
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<td>Sweden</td>
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<td>ASSI</td>
<td>1986</td>
<td>27 MW/bark/saw dust</td>
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<td>Karlsborg Bruk, Sweden</td>
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<tr>
<td>Portucell</td>
<td>1986</td>
<td>17 MW/bark</td>
<td>Lime Kiln/Boiler</td>
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<td>Rodao Mill, Portugal</td>
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LIME KILN CFB-GASIFIER

CYCLONE

GASIFIER

SILO
LIME KILN GAS BURNER
EXPERIENCE WITH LIME KILN GASIFIERS

- Four plants supplied in 1980's; one still operating
- Able to replace 100% of NG or oil with biomass gas
- Must dry fuel to about 15% moisture
- Able to maintain lime quality & kiln capacity
BIOMASS GASIFICATION – SYNTHESIS GAS
HIGH PRESSURE OXYGEN GASIFICATION

- BIOMASS
- GASIFIER
- ASH
- GAS CONDITIONING (COOLING, FILTERING, SCRUBBING, REFORMING)
- GAS PROCESSING AND CLEANUP
- SYNTHESIS GAS
- GAS TO LIQUID SYNTHESIS
  - MOTOR FUELS
- METHANATION
  - SNG
- PURIFICATION
  - HYDROGEN
- ASU
- OXYGEN & STEAM
- AIR
GTI GASIFICATION FACILITY, FLEX-FUEL
Chicago, USA
FLEX-FUEL PLANT