## ANDRITZ Company Profile

### Business Groups

<table>
<thead>
<tr>
<th>ANDRITZ Hydro</th>
<th>ANDRITZ Pulp &amp; Paper</th>
<th>ANDRITZ Metals</th>
<th>Environment &amp; Process</th>
<th>ANDRITZ Feed &amp; Biofuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical equipment for hydropower plants; pumps; turbo generators.</td>
<td>Plants for production of all types of pulp and certain paper grades.</td>
<td>Plants for production and processing of stainless steel and carbon steel strips.</td>
<td>Equipment for mechanical and thermal solid/liquid separation.</td>
<td>Plants for production of animal feed and wood/biofuel pellets.</td>
</tr>
</tbody>
</table>

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[Image of ANDRITZ equipment and carbon cycle]
ANDRITZ Pulp & Paper
Recovery and Power Division / Bioenergy Systems

Recovery and Power Division

- Recovery Boilers
- Evaporators
- Bioenergy Systems
  - BFB Boilers
  - Gasifiers
- Steam Generators and Plants
  - BFB, CFB & Industrial Boilers

Synthesis Gas Production from Biomass
### ANDRITZ Carbona biomass gasification Technologies and applications

<table>
<thead>
<tr>
<th>Fuel gas for kilns</th>
<th>(Co-)firing (boiler)</th>
<th>Co-generation (gas engine)</th>
<th>IGCC (gas turbine)</th>
<th>Syngas production</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-100 MWth.</td>
<td>10-150 MWth.</td>
<td>10-50 MWth.</td>
<td>30-200 MWth.</td>
<td>150-200 MWth/unit</td>
</tr>
<tr>
<td>35-350 MMBtu/h</td>
<td>35-510 MMBtu/h</td>
<td>35-170 MMBtu/h</td>
<td>100-700 MMBtu/h</td>
<td>500-700 MMBtu/h</td>
</tr>
<tr>
<td>Atmospheric CFB</td>
<td>Atmospheric CFB</td>
<td>Pressurized BFB (LCV gas; air blown)</td>
<td>Pressurized BFB (LCV gas; air blown)</td>
<td>Development phase</td>
</tr>
<tr>
<td>Fossil fuel replacement</td>
<td>Power by steam cycle</td>
<td>Power by gas engines</td>
<td>Power by gas/steam turbines</td>
<td></td>
</tr>
</tbody>
</table>

- **Pulp and paper and cement industries**
- **Utilities and all industries with large fossil fuel fired boilers**
- **Municipal utilities**
- **New mid-size power plants with max power**
- **BTL producers (P&P & others) and utilities**

- **Fuel gas**
- **Green power**
- **Green power**
- **Green power**
- **Bio liquids**
BFB gasification technology basis
Low Calorific Value gas for power generation
Gasification / gas engine CHP plant in Skive, Denmark
Skive Gasification CHP Plant
Main parameters & equipment

Biomass feed 20 MWth (66 MMBtu/h)
Designed for 28 MWth (95 MMBtu/h)
Power 6.0 MW (3x2MW GEJ620 gas engines)
District heat as CHP 11.5 MW / 39 MMBtu/h
Optionally 2x10 MW / 34 MMBtu/h gas boilers
Load range 50-130%
Feedstock: Wood pellets & wood chips
Skive Gasification CHP Plant
Process & product gas

- **Gasification plant process:**
  - Air blown, low pressure BFB gasifier
  - Limestone based bed material
  - Catalytic tar reforming
  - Gas cooling and filtration
  - Gas scrubbing
  - System pressure 0.5 – 2 bar / 7-29 psi

- **Typical dry gas composition** after reformer:
  - CO  %-vol  20
  - CO2 %-vol  12
  - H2 %-vol  16
  - CH4 %-vol  4
  - N2 balance
  - LHV MJ/m3n  4.8 – 5.2
  - Btu/scf  122-132
Skive Gasification CHP Plant
Gas composition & operation pressure

- Gasifier temperature
- CO
- H2
- CO2
- Gas LHV
- Gasifier pressure
- CH4

Synthesis Gas Production from Biomass
Low Calorific Value Gas for Power Generation

IGCC technology

- High-efficiency Biomass Based Power Generation
- Basic concept:
  - Pressurized air-blown BFB gasifier (20 bar / 290 psi)
  - Hot gas cleaning by filtration (300-500 °C / 570-950 °F) and gas cooling integrated steam cycle
  - Gas turbine with air extraction and burner for high temperature LCV gas (LHV 5 MJ/m³n / 130 Btu/scf)
- New or existing steam cycle for integration, repowering
- Biomass IGCC plant components are of conventional technology
- IGCC process is demonstrated in smaller scale
Pressurized Gasification Pilot Plant for IGCC development
Operated by Carbona Tampere, Finland

80 tpd, 22 bar /310 psi, 3850 test hours
Synthesis gas for transportation fuels and SNG
Oxygen blown BFB gasification

Typical plant size: 150 MWth (510 MMBtu/h), ~ 1000 tpd feedstock @ 20% moisture,
Multiple plants for higher capacities
Syngas for BTL and SNG production

Project development

**ANDRITZ Carbona cooperates with**
GTI & Haldor Topsøe A/S
_for the_
Biodiesel project of UPM –Kymmene Finland
SNG project E.ON Sweden

**Pilot Plant Testing at GTI**

- Further develop pressurized oxygen/steam gasification of biomass at the 5 MWth / 17 MMBtu/h gasification pilot plant
- Develop tar reforming and gas clean up of syngas for BTL and SNG applications at the recently built gas cleanup facility
- Test campaigns from June 2008 to October 2011.
- Four feedstock types (3 from Finland, 1 from USA) tested at different operating conditions.
BTL tests at GTI
Test results gasification plant

- Stable operating conditions for steam-oxygen BFB gasification
- High carbon conversion
- Replacement of nitrogen with CO2 inert gas tested
- Recycle of scrubbed product gas tested
- 2\textsuperscript{nd} stage fines recycling to be tested
- Required design data collected
Catalytic Tar Reformer
Concept & performance in BTL tests at GTI

Catalytic Tar Reformer Development with Haldor Topsøe A/S for:
- Reforming tars & lighter hydrocarbons
- Controlled reforming of methane
- Reducing ammonia in reformed gas

Catalytic Tar Reformer Concepts:
- “Dirty reformer” for dust containing gas
- “Clean reformer” for filtered gas
- Both concepts tested and demonstrated (GTI, Skive CHP Plant)

Catalytic Tar Reformer Performance (Example test result/GTI. Tar measurement by ETP Method)

<table>
<thead>
<tr>
<th>Component</th>
<th>Reforming efficiency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>96</td>
</tr>
<tr>
<td>Toluene</td>
<td>100</td>
</tr>
<tr>
<td>Ethyl benzene</td>
<td>100</td>
</tr>
<tr>
<td>Phenol</td>
<td>100</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>98</td>
</tr>
<tr>
<td>Higher MW Compounds</td>
<td>95</td>
</tr>
</tbody>
</table>
BTL Tests at GTI
Syngas processing & cleanup performance

- H2/CO: 1 to 1.5 (adjustable)
- CH4: 0.5 to 5.0 vol% (adjustable)
- CO2+H2S: removed by final user
- NH3+HCN: <10 ppmv
- C2+ hydrocarbons: <200 ppmv
- C6 compounds: <100ppmv
- Heavier CxHy compounds: <5 ppmv
- Alkalis: none
- Halides: none
UPM-Kymmene Biodiesel Project
1 MMt/a wood to 150 000 t/a (48 MM US gal/a) biodiesel

Fuel Pre-treatment
- Wood Based Fuel
  - ~1 Million t/a
  - Receiving & Crushing
  - Drying & Pelletizing

Syngas Process
- Gasification
- Initial Gas Conditioning
- Gas Processing
  - Product Upgrade
  - Distribution 150 000 t/a

FT & Refining & Distribution
- Ultra Purification
- FT Synthesis

(source, UPM)
E.ON Bio2G project
950 000 t/a wood to 168 MMm³/a (6000 MMSCF/a) SNG

(source, EGD)

Synthesis Gas Production from Biomass
Project for green gasoline from wood using Carbona gasification and Topsøe TIGAS processes

American Recovery and Reinvestment Act: Demonstration of integrated bio refinery operations

Target:
- Demonstration of Thermochemical Conversion of Woody Biomass to Gasoline at GTI’s Pilot Plant (FFTF / AFTF)
- Plant fuel feed 24 ton/day of woody biomass to produce 23 BPD of gasoline

Project Team:
- Haldor Topsøe A/S
- Andritz Carbona
- UPM-Kymmene Oy
- ConocoPhillips
- GTI

Synthesis Gas Production from Biomass
Any questions?

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