Greetings from the 18 European Biomass Conference and Exhibition, 2010 in Lyon

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Central Ostrobothnia University of Applied Sciences
CENTRIA R&D
Ylivieska
What has been achieved so far?

- 1973 – “new” energy research and policy
- 1975 – security of energy supply
- 1988 – global warming became “public”
- 1995 – technology options basically known
- 2006 – “market failure” became obvious
- 2010 – required policy actions uncertain
18th European Biomass Conference and Exhibition, 3-7 May 2010, Lyon, France

Conference on Biomass research, demonstration and application

- 1505 participants from 72 countries
- 58 exhibitors presented their products and services

Registrations by country

<table>
<thead>
<tr>
<th>Country</th>
<th>Exhibitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>13</td>
</tr>
<tr>
<td>Italy</td>
<td>8</td>
</tr>
<tr>
<td>Germany</td>
<td>9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>7</td>
</tr>
<tr>
<td>Other European Countries</td>
<td>13</td>
</tr>
<tr>
<td>Overseas</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>58</strong></td>
</tr>
</tbody>
</table>
TOPICS

T1 Biomass resources
T2.1 Thermochermal conversion
T2.1 Gasification for power and CHP and polygeneration
T2.2 Gasification for synthesis gas production
T2.3 Pyrolysis for power, CHP, polygeneration and chemicals
T2.4 Combustion and co-combustion
T2.5 Combustion for small scale applications
T2.6 Biological conversion - fermentation, enzymatic processes
T2.7 Biomass chemistry
T2.8 Biomass torrefaction
T3 Fuels from biomass
T4 Industrial demonstration and market implementation
T5 Policies and ensuring sustainability

Abstracts share by Topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Abstracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Biomass Resources</td>
<td>177</td>
</tr>
<tr>
<td>T2 Conversion Processes</td>
<td>342</td>
</tr>
<tr>
<td>T3 Biofuels</td>
<td>140</td>
</tr>
<tr>
<td>T4 Market</td>
<td>87</td>
</tr>
<tr>
<td>T5 Policies</td>
<td>137</td>
</tr>
<tr>
<td>Plenaries</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>890</td>
</tr>
</tbody>
</table>
World Primary Energy mixture

100 % = 500 EJ (eksajoule = 10^{18} J)
Challenges ahead

For the R&D community
• R&D to reduce energy unit costs
• Realistic perception of resource availability
• Sustainable production and closed carbon cycle

For policy makers
• Recognize cost gap to fossil fuels, the resulting market failure requires policy measures
• **Message to consumers:** higher cost cannot be compensated by public subsidies
• In a level playing field industry will take over

Overall

20% Renewables means 2/3 Bioenergy

Finally..

“The stone age did not end for the lack of stones and the oil age will end long before the world runs out of oil”

**Sheiikh Zaki Yamani former Saudi Arabia Oil minister**
MESSAGE FROM THE INDUSTRY
BIOENERGY AND BIOFUELS an opportunity for the forest industry

Hans Sohlström
Executive Vice President
Corporate Relations and Development
UPM- Kymmene Corporation, Finland

UPM is one of the world's largest forest industry companies with operations in Europe, Asia and America in the business areas of Energy and Pulp, Paper and Engineered Materials.

Hans Sohlström from UPM made an excellent presentation about the biorefinery as an opportunity for the pulp and paper industry.
BIOENERGY AND BIOFUELS an opportunity for the forest industry

NEW BUSINESSES

Hans Sohlström Executive Vice President of UPM

UPM - The Biofore Company

UPM leads the integration of bio and forest industries into a new, sustainable and innovation-driven future.

Business Groups

- Energy and Pulp
- Paper
- Engineered Materials

BIOREFINERY

New Businesses

- Biofuels
- Biochemicals
- Nanocellulose
- RFID tags
- Biocomposites
BIOENERGY AND BIOFUELS an opportunity for the forest industry

BIOFUELS FROM BIOMASS  
Hans Sohlström Executive Vice President of UPM

Strong biofuels demand growth

World demand 2009 was ~30 B€ and estimate 2020 is ~100 B€. Europe represents ~20%.

- Oil supply and price
- CO₂ and global warming
- Policies and regulation

USA
- 2009: 10 B€
- 2020: 32 B€

Brazil
- 2009: 8 B€
- 2020: 13 B€

European Union
- 2009: 6 B€
- 2020: 20 B€

China: 15% by 2020

India: 20% by 2012

2G Biofuels
1G Biodiesel
1G Ethanol
BIOENERGY AND BIOFUELS an opportunity for the forest industry

BIOFUELS FROM BIOMASS Hans Sohlström Executive Vice President of UPM

Several biofuels concepts

Feed Stock

- 1G: Sugar & Starch $C_{12}H_{22}O_{11}$
  - Sugar cane
  - Sugar beet
  - Corn
  - Maize
  - Wheat
- 1G: Oleic Acid $C_{18}H_{34}O_{2}$
  - Rapeseed
  - Canola
  - Palm
  - Jatropha
- 2G: Cellulose ($C_6H_{10}O_5)_n$
  - Switch grass
  - Bagasse
  - Straw
  - Wood

Processes

- 1G
  - Fermentation
  - Transesterification
- 1.5G
  - Hydro treatment
- 2G
  - Enzymatic/acid hydrolysis (2010 .. 2012)
  - Gasification (2010 .. 2012)
  - Fischer-Tropsch

Products

- 1G
  - Ethanol $C_2H_5OH$
    - 5% gasoline blend
    - E85 for FFV cars
    - 30% less energy
    - 0 .. 90% less CO$_2$
- 1.5G
  - Methyl ester diesel
    - 5% diesel blend
    - 10% less energy
    - 30 .. 60% less CO$_2$
- 2G
  - Synthetic biodiesel $C_nH_{2n+2}$
    - high performance
    - 50 .. 90% less CO$_2$
Small-scale biomass gasification
Small-Scale Biomass Gasification, XYLOWATT

XYLOWATT (www.xylowatt.com)
- Belgian wood CHP manufacturer and turnkey provider
- aims to be a strong international actor in the small-scale Woodgas CHP (0.1—10 MWe)

Markets for small scale CHP
1. Biomass CHP Power Plants
   Small scale CHP has growing markets in Europe and other OECD countries
2. Carbon-free Gas for Industry
   Energy-intensive industries (metals, cement etc.) has a strong needs to diversify fuel consumption and reduce energy costs & carbon dioxide emissions
3. Decentralized Power
   Remote areas are affected by high-increasing prices of fossil fuel for power production based on diesel generators
The NOTAR ® downdraft gasifier

**PYROLYSIS ZONE**
Wood is decomposed into charcoal (30%) and pyrolysis gas (70%)
- Complete pyrolysis before combustion zone

**COMBUSTION ZONE**
Pyrolysis gas (composed mainly of heavy tars) is burned and cracked with air to CO₂ & H₂O at high temperature (1200°C)
- Almost complete destruction of tars (>99.95%)
- No solids in the combustion zone (no ash melting)

**REDUCTION ZONE**
Exhaust gases react with the carbon of the charcoal to form the fuel gas:

\[ \text{CO}_2 + \text{C} = 2\text{CO} \text{ and } \text{H}_2\text{O} + \text{C} = \text{H}_2 + \text{CO} \]
**Small-Scale Biomass Gasification, XYLOWATT**

**Combined Heat & Power plant**

- **Biomass** 270 kg odt/hr
- **Heat ENERGY** 600 kW
- **Exhaust gas** 110°C

**Global efficiency = 75% (25% electricity, 50% heat)**

**Produce**
- 1 950 MWh/yr of electricity
- 3 900 MWh/yr of heat
- Saves 1644 CO₂ Tons/yr
- Uses 600 odt/yr of wood

**Fully automated plant**
- High efficiency (75% total efficiency, 25% net electrical efficiency)
- Flexibility for the operation (100% woodgas or 100% NG)
- Fully automatic, instantaneous power regulation, totally remote controlled
Small-Scale Biomass Gasification, XYLOWATT

Advantage of the NOTAR® technology

**Downdraft standard gasifier with tar concentration 2000 mg/m³N**
- Low concentration in comparison with updraft gasifier
- High maintenance and operation cost to clean the gas before the power generation

**Downdraft NOTAR® gasifier with tar concentration <50 mg/m³N**
- Tar conc. reduced by a factor 40
- Maintenance and operation costs are reduced by a factor 10
- Increase availability on yearly basis

**Other advantages**

The pyrolysis gas is burned at a temperature up to 1000 °C
- pollutant destruction at the combustion zone
The gas is going through the carbon bed
- heavy metal condensation in the reduction zone
- contaminated wood
- agricultural products and residues
Small-Scale Biomass Gasification, XYLOWATT

Experimental and Numerical Investigation of the Air Ratio on the Tar Content in the Syngas of a Two-Stage Gasifier

B Berger1 - A. Bacq2 - H. Jean Mart1 - F. Bourgois2

1 Université catholique de Louvain, Institute of Mechanical, Material and Civil Engineering, Louvain-la-Neuve, Belgium
2 XYLOWATT s.a., Charleroi, Belgium, www.xylowatt.com

In February 2010, the T.G.P. experimental plant was first started.

In pyrolysis zone (A), once a steady-state is reached, air reacts directly with pyrolysis gases before reaching wood.

In combustion zone (B) air reacts with gaseous pyrolysis products and produce the heat necessary for the reduction reactions.

Air ratio $\alpha$ is defined as the ratio between the air injected in the pyrolysis and the total air mass flow rate

$$\alpha = \frac{\text{air mass flow rate}}{\text{total air mass flow rate}}$$

in operation $0.2 < \alpha < 0.5$

The T.G.P. biomass mass flow rate was 30kg/h

CO concentrations measured for $\alpha = 1/4$, 1/3.5 and 1/3
Clearly the CO concentration is the highest for a ratio of 0.28

Simulated results

Temperature (left) and tar concentration (right) in the combustion zone for two values of $\alpha$: 0.33 (blue solid) and 0.25 (red, dashed)

Conclusions

Air ratio should be kept inside a specific interval depending on the size of the facility. For air ratios too low, the pyrolyzer is too cold and for too high, too much air is introduced in the pyrolyzer leading to char consumption and a poor syngas quality. Air ratio has no effect on the tar content, when kept inside the optimal interval.
18th European Biomass Conference and Exhibition
From Research to Industry and Markets
EUROPEAN BIOMASS INDUSTRY AWARD FOR OUTSTANDING ACHIEVEMENT TO THE DEVELOPMENT OF THE BIOMASS SECTOR AND ITS MARKET

was awarded to Bjömm Fredriksson Möller, Project Manager of E.ON Gasification Development AB

E.ON is setting itself challenging CO₂ reduction

- 50% reduction of specific CO₂ emissions compared to 1990
- Until 2030 reduction down to 360 g/kWh

E.ON Gasification Development AB

Design and engineering of the first commercially sized plant - BiO2G
Awarded Posters

**Biomass resources:**
• “Environmental Approach of the Algerian Oasis Biomass Energy Conversion. Mzab Area Case”
• “Torrefaction of Biomass for Energy Purpose: Grindability Behaviour”

**Biomass chemistry:**
• “Improvement of Wet Base Biomass Characteristics Via *Hydrothermal Carbonization Process*”

**Fuels from biomass:**
• “Optimal Technologies for Thermochemical SNG Production from Lignocellulosic Biomass”

**Industrial demonstration and market implementation:**
• “Preparation of Biodegradable Hemicellulose Based Films from Agricultural Biomass”

**Policies and ensuring sustainability:**
• “Can Bioenergy Production and Soil Carbon Storage Be Coupled? A Case Study on Dedicated Bioenergy Crops in the Low Po Valley (Northern Italy)”
• “Economic Assessment of Biomass Heating Projects in France: Impact of a Carbon Tax”
Biomass gasification is a possible way to produce biofuels. Properties of the raw biomass make it impossible to be used directly in a gasifier => BIOMASS TORREFACTION

In this presentation mechanical modification of the torrefied biomass was discussed.

Dynamic compression (High compression rate)

- Impact velocity (1 m/s); duration (~10 ms); radial compression

**CONCLUSIONS**

- A new impact device has been conceived to characterize the biomass grindability.
- Torrefaction eases the wood transformation into small particles, suitable to be injected into the gasifier.
- However, the wood fibrous structure is kept.
Next conference will be in Berlin!

Thank you!
A NOVEL APPROACH TO BIOMASS GASIFICATION IN A DOWNDRAFT GASIFIER

Yrjö Muilu, Kari Pieniniemi, Ulf-Peter Granö, Ulla Lassi

Main topics of the paper presented in

18th European Biomass Conference and Exhibition 2010, Lyon France
Fuels used in the gasification

Solid, air dried wood chips was used as a fuel in the gasification process

Size of the chips were 0 to 100 mm and moisture content can be up to 40 vol-%

EK downdraft gasifier

The EK gasifier (GasEK) gasifies biomass to a gas mixture containing CO and H₂ 25-30 vol-% and 20-25 vol%, respectively.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock mass flow, kg/h</td>
<td>45</td>
</tr>
<tr>
<td>Air flow, Nm³/h</td>
<td>52</td>
</tr>
<tr>
<td>Air temperature, °C</td>
<td>16</td>
</tr>
<tr>
<td>Reactor temperature, °C</td>
<td>1200</td>
</tr>
<tr>
<td>Bottom ash removal rate, kg/h</td>
<td>0.4</td>
</tr>
<tr>
<td>Product gas flow, Nm³/h</td>
<td>78</td>
</tr>
</tbody>
</table>

Process conditions during the stable operation of the EK gasifier
PRODUCT GAS AND PRODUCT GAS ANALYSIS

**Amount of tars**

Gasification, even at high temperatures of 800-1000 °C produces a significant amount of tar, which is still the main problem in gasification processes.

Tar concentration is approximately
- 100 g/Nm³ in an updraft gasifier,
- 10 g/Nm³ in a fluidized bed gasifier and
- 1g/Nm³ in a downdraft gasifier.

**Tar reduction**

Tars can be reduced
- in the gasifier itself by modifying gasification conditions or gasifier design *(primary measures)* or
- by mechanical separation or thermal or catalytic cracking of tars in the downstream of a gasifier *(secondary measures)*
ANALYSIS OF PERMANENT GASES

**Permanent gases** CO, H₂, CO₂, CH₄ were continuously monitored by *FTIR gas analyzer* (Gasmet Dx4000N). **Hydrogen** was measured by *Dräger X-am 3000 H₂ analyzer*: Product gas samples were diluted before analysis, because of the concentrations range 0-0.5 vol %

**Diatomıc gases** (H₂ and N₂) can also be measured by *micro-GC*

Typical composition and concentrations of the product gas from the EK gasifier

<table>
<thead>
<tr>
<th>Product gas component</th>
<th>vol-%</th>
<th>g/Nm³ (STP 0°C, 1 atm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>15</td>
<td>187</td>
</tr>
<tr>
<td>H₂</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>CH₄</td>
<td>2.5</td>
<td>18</td>
</tr>
<tr>
<td>CO₂</td>
<td>15</td>
<td>295</td>
</tr>
<tr>
<td>N₂</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Other gaseous compounds</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>
TAR SAMPLING AND ANALYSIS

Tar sampling and analysis

*Analysis of the tars* is often performed by gas chromatography (GC) or gravimetrically.

*Sampling methods* are based on absorption the tars in organic solvent or by adsorption on a suitable solid sorbents.

**Tar protocol**

Traditional tar sampling methods are based on cold trapping coupled with solvent absorption in impingers.

**SPA method**

SPA method consists of adsorption of the tars into multibed solid-phase adsorbent tubes followed by thermal desorption (TD) sampling techniques.
Total tar measurement

SPA method was used to determine the total tar content of the product gas from EK gasifier in CHP production (power 9 kW)

- Tar samples were adsorbed on XAD and the sorbent was extracted with DCM (dichloromethane) at the Soxhlet apparatus
- DCM extract was evaporated and the residue was weighted
- Measured tar content of the cleaned was 24 mg/Nm³

Total tar concentration of the EK product gas before IC-engine

<table>
<thead>
<tr>
<th>Power</th>
<th>Tar concentration of the product gas (dry, STP: 0°C, 1 atm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 kW_e</td>
<td>24 ± 5 mg/Nm³ (k=2)</td>
</tr>
</tbody>
</table>

Flue gas analysis

During the total tar sampling emissions of the internal combustion engine (IC engine) was continuously monitored by measuring O₂, CO₂, CO, NOx and SO₂ concentrations in the flue gas
TAR SAMPLING AND ANALYSIS

Flue gas analysis during the total tar sampling
Emission measurements were based on paramagnetism (O₂), IR absorption (CO, CO₂), UV-fluorescence (SO₂) and chemiluminescence (NOx)

Composition and concentration of the flue gas main gaseous components during the tar sampling along with the estimated combined uncertainties

<table>
<thead>
<tr>
<th>Measured flue gas component</th>
<th>Measured flue gas composition</th>
<th>Concentration (dry, STP (0°C, 1 atm))</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>0.4 ±0.04 vol%</td>
<td>-</td>
</tr>
<tr>
<td>CO₂</td>
<td>17±2 vol%</td>
<td>-</td>
</tr>
<tr>
<td>CO</td>
<td>568±63 ppm</td>
<td>170 ±19 mg/Nm³</td>
</tr>
<tr>
<td>SO₂</td>
<td>8±1 ppm</td>
<td>25 ±4 mg/Nm³</td>
</tr>
<tr>
<td>NOx</td>
<td>162±37 ppm</td>
<td>332 ±37 mg/Nm³</td>
</tr>
</tbody>
</table>