Production of new clean fuels from gasification processes

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6th International Freiberg Conference
Feedstock flexible solutions needed!

Black liquor

Waste

Associated Gas Flare

Biomass

Synthesis Gas Platform

H₂

CO

Power

Bulk Chemicals

Liquid fuel

HALDOR TOPSOE
Clean & green fuels and chemicals from gasifications

- Focus on past, current and future activities emphasizing sustainable solutions

- Highlights from ongoing activities involving:
  - BioElectricity
  - BioSNG
  - BioDME
  - BioGasoline

- Mainly small-scale biomass based activities, but …
Skive CHP plant
Process overview

- **Gasification Plant Process:**
  - Carbona air blown, low pressure bubbling fluidized bed gasifier
  - Limestone based bed material
  - Catalytic tar reforming
  - Gas cooling, filtration, and scrubbing

- **Power Plant Process:**
  - 3 Gas Engines with heat recovery and 2 Gas Boilers
Tar reforming

- Gasification of biomass results in a syngas that contains tars and contaminants
  - 2500 ppm tar (toluene, benzene, naphthalene)
  - 100 ppm S, particulates
  - 850-930 °C, 10-20 bar g

- Benefits:
  1. Increased gas production
  2. Convert polyaromatic components to an extent that allows the syngas to cool for further processing without fouling or precipitation
  3. Utilize the high temperature levels from gasification for increased efficiency
Tar reforming achievements

- Extended lifetime
  - More than a factor 4

- Regeneration cycle
  - Increased on-stream factor
  - Further increased lifetime

- Major improvements from Topsøe catalyst and tar reformer operation support

- Side-stream piloting to establish kinetic data for reactor design (+1500 hrs)
BioSNG

GoBiGas Plant - phase 1, 20 MW bio-methane

Existing hot water boilers, fired with wood pellets

GoBiGas Site Office
GoBiGas Scope and project partners

- Evaluation during 7 years – until 2020
  - Start-up in progress
- Cooperation between Göteborg Energi AB/GoBiGas and the main suppliers
- Purpose to learn from the demonstration plant to enable scaling up to 100 MW in phase 2
- Evaluation of the following parameters:
  - Product quality
  - Plant performance – efficiency etc.
  - Plant availability
  - Environmental footprint
  - Maintenance needs
  - Operating costs
BioSNG production overview

**Gasification**
- Forest residues → Dryer → Wood pellets → Fuel handling → Gasifier → Combustor → Air preheater → Hot water → Flue gas → Bag filter De-NOx
- Hot water → Tar removal
- Bed material → Tar

**Methanation**
- Haldor Topsøe A/S Scope
- Biomethane → Drying Upgrading → Methanation → CO2-removal → Shift → CO2 to inert gas system/atm
Production of DME from Biomass and utilisation as fuel for transport and for industrial use
Project partners

CHEMREC
- BioDME Plant engineering, construction and operation
- BioDME Plant owner

ETC
- Laboratory support to plant operation

DELPHI
- DME injection system development

HALDOR TOPSOE
- DME production technology provider

VOLVO
- BioDME Project Coordinator
- Engine development
- Vehicle manufacturing
- Field test responsible

preem
- BioDME distribution
- BioDME filling stations

TOTAL
- DME fuel specification
- Fuel Additive development
BioDME production - overview

The plant incl. gasification is operated by 2 operators per shift

Key operation data:
- Gasification at 30bar/1050°C
- Methanol synthesis at 130 bar
- DME synthesis at 15 bar

Over 4 ton DME/d was reached in Sep -12
Black Liquor to Green DME Demo

- More than two years of continues operation!
- New MeOH technology

Black Liq.  
\[ \text{CO}_2 \]

BioSyngas Center

- AGR
- Sulphur Guard
- MeOH Synthesis
- DME Unit
- Water

18-2  Optimal design of coal gasifiers in combination with sour shift (Rasmus Trane-Restrup, Haldor Topsøe A/S – Denmark)

18-5  Influence of feed impurities on CoMo-based sour shift catalyst (Mads Kaarsholm, Haldor Topsøe A/S – Denmark)
Methanol Synthesis

MeOH reactor

Conrad

Synthesis Gas

Steam

Synthesis Gas

Steam

Raw MeOH

MeOH cat.
Presented at NGCS in Oslo 1990

Various reactor layouts and sizes tested, but economic assessment was unfavourable due to low STY
The CONRAD concept

- CONdensing RADial flow converter
- Reactor comprising two-zone tubes
  - High T zone in center of tube
  - Low T zone along tube wall
- Internals for gas-liquid separation
- Balance between heat transfer and mass transfer
BioDME production - status

- Authority inspection
- Change of ceramics and catalysts
- Holidays
- Main DME storage full + ceramic repair
- Rebuild for steam supported atomization
- No operation during change of ownership

500 tons
April 20, 2013
Fleet test - status

- 10 trucks from Jan 2011 to Dec. 2012
  - ~825,000 km
- 8 trucks from Jan 2013 to Dec. 2013
  - Total: 1,144,000 km, (230,000 km max.)
Project partners

- **Haldor Topsoe** is a leading worldwide supplier of catalysts and catalytic technology for fuel conversion and upgrading.
  - Provides: TIGAS process, syngas cleanup including tar reforming and conversion; overall project management

- **Carbona** is a supplier of biomass gasification and gas cleanup plants
  - Provides: fluidized-bed gasification, tar reforming, commercialization support

- **GTI** is the developer of gasification technology, licensor of acid gas removal process, and owner/operator of pilot plant test facility
  - Provides: design, construction, and operation of pilot plant plus modeling, data analysis, commercialization support

- **UPM-Kymmene** is one of the world’s largest pulp and paper companies with more than 100 production facilities.
  - Provides: gathering, handling and transporting of wood; 1st commercial plant site

- **Phillips 66** is a leading oil refiner & contributor to TIGAS
  - Provides: Liquids fuels handling, transportation and marketing, sample characterization, pilot plant design, construction, operation and scale-up assistance
Overview of project

- **Wood chips**
- **Oxygen steam**
- **Gasifier**
- **Tar reformer**
- **Scrubber**
- **Morphysorb**
- **Off-gas**
- **Gasoline**
- **Water**
Wood2Gasoline achievements

- **Status:**
  - +1000 hours of operation
  - > 2000 gallons gasoline product
  - RON = 97, MON = 86

- Independent engineer approval: October 2013

- Engine Emissions Testing
  - Toxicology review of gasoline components – approved by P66

- Fleet Testing - Ongoing
  - 25-30 vehicles over ~6 months
  - Accumulate ~250,000 miles
  - Timing of tests are dependent on fuel availability
Comparison with conventional gasoline

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<tr>
<th></th>
<th>Euro 5 specification</th>
<th>TIGAS</th>
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<tbody>
<tr>
<td>Research octane no</td>
<td>95°</td>
<td>&gt;93</td>
</tr>
<tr>
<td>Motor octane no</td>
<td>85°</td>
<td>&gt;83</td>
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<tr>
<td>Density at 15 degC</td>
<td>720-775 kg/m³</td>
<td>730 kg/m³</td>
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<tr>
<td>Lead content</td>
<td>max. 5 wt ppm</td>
<td>nil</td>
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<tr>
<td>Sulfur content</td>
<td>max. 10 wt ppm</td>
<td>&lt; 10 wt ppm</td>
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<tr>
<td>Hydrocarbon type content:</td>
<td></td>
<td></td>
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<tr>
<td>Olefins</td>
<td>max. 18 vol%</td>
<td>5-15 vol%</td>
</tr>
<tr>
<td>Aromatics</td>
<td>max. 35 vol%</td>
<td>25-35 vol%</td>
</tr>
<tr>
<td>Benzene</td>
<td>max. 1 vol%</td>
<td>&lt; 1 vol%</td>
</tr>
</tbody>
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*) Including ethanol (octane booster), and country dependent (e.g. Denmark, RON = 92 and 95)
Take-home messages

- Industry is preparing for biomass as feedstock for production of fuels and bulk chemicals
  - SNG, Methanol, DME, Gasoline, …
- Industry will be ready when it becomes economic to use biomass as feedstock
- Syngas makes a perfect platform for the production of many fuels and bulk chemicals from biomass derived sources
- Small-scale applications is challenging from an economic process economic point of view
- Gas conditioning is the key challenge!
Thank you

“The corporate world in itself means nothing unless it improves the lives of people and the conditions in poor countries.”

Haldor Topsøe