Siemens Gasification: Progress and Innovation

Gasification Technologies Conference 2013
October 14, 2013
Agenda

• Global gasification trends and opportunities
• Siemens gasification project update
• Gasification Innovations
• Conclusions
Trends and Opportunities
The commercial attractiveness of a project is indicated by its end-product market pricing.

<table>
<thead>
<tr>
<th>Gasification</th>
<th>Product/Volume/Prices*</th>
<th>Revenue / t of coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 t coal (sub-bituminous)</td>
<td>420 Nm³ SNG**</td>
<td>50 USD</td>
</tr>
<tr>
<td>1,600 Nm³ Syngas (CO + H₂)</td>
<td>2.4 MWhₐₜₐₚₚ Power</td>
<td>145 USD</td>
</tr>
<tr>
<td></td>
<td>420 Nm³ SNG**</td>
<td>225 USD</td>
</tr>
<tr>
<td></td>
<td>0.19 t Polypropylene</td>
<td>300 USD</td>
</tr>
<tr>
<td></td>
<td>0.72 t Methanol</td>
<td>325 USD</td>
</tr>
<tr>
<td></td>
<td>95 gal Gasoline</td>
<td>330 USD</td>
</tr>
<tr>
<td></td>
<td>0.98 t Ammonia</td>
<td>485 USD</td>
</tr>
</tbody>
</table>

* Applied end-product market prices may differ to actual prices  ** SNG...Substitute Natural Gas

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### Market trends and opportunities for Gasification

#### Products ...

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Synthetic Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. Ammonia, Methanol, Polypropylene,...</td>
<td>Synthetic natural gas</td>
</tr>
</tbody>
</table>

#### Trends and Opportunities ...

<table>
<thead>
<tr>
<th>CtC¹ plants will remain the market with the highest realization potential, especially in Asia</th>
<th>Serious alternative for (coal rich) countries, with lack on cheap natural gas availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile oil and gas prices, security of supply concerns and climate protection cause search for alternative fuel sources</td>
<td>Increasing demand for cleaner and lighter fuels are the drivers for higher H₂ consumption within refineries</td>
</tr>
</tbody>
</table>

#### Alternative Transportation Fuels (CtL²)

- High-quality diesel from FT³-synthesis
- Fuels with higher biomass content

#### Power

- IGCC⁴ with Carbon Capture and Sequestration as environmental friendly alternative to Steam Power Plants

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¹CtC...Coal to Chemicals; ²CtL...Coal-to-Liquids; ³FT-synthesis...Fischer-Tropsch synthesis; ⁴Integrated Gasification Combined Cycle

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Gasification Project Update
Siemens most advanced gasification projects listed according to coal quality

<table>
<thead>
<tr>
<th>USA (ASTM)</th>
<th>Germany (DIN)</th>
<th>Water content (%)</th>
<th>Volatiles maß (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignite</td>
<td>Weichbraunkohle</td>
<td>75</td>
<td>63–73</td>
</tr>
<tr>
<td></td>
<td>Mattbraunkohle</td>
<td>35</td>
<td>55–63</td>
</tr>
<tr>
<td></td>
<td>Glianzbraunkohle</td>
<td>25</td>
<td>45–48</td>
</tr>
<tr>
<td>Flammkohle</td>
<td></td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Gasflammkohle</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Medium Volatile</td>
<td>Gaskohle</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>Fettkohle</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Eltkohle</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Low Volatile</td>
<td></td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>Semi. Anthracite</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Anthracite</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Syngas/Methanol Plant in GSP/Germany
Configuration: 1 x SFG 200

SNG Project with CPI¹) Yinan/China
Configuration: 8 x SFG 500

Methanol Plant with SNCG²)/China
Configuration: 4 + 1 x SFG 500

Fuels Project with SNCG/China
Configuration: 22 + 2 x SFG 500

Urea/Power/CO₂ Project with Summit/USA
Configuration: 2 x SFG 500

Methanol Project with MidAmerica/USA
Configuration: 2 x SFG 500

Ammonia Project with Shanxi Lanhua Gr.
Configuration: 1 + 1 x SFG 500

¹) China Power Investmetn ²) Shenhua Ningxia Coal Group

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### NCPP project in Ningxia/China
### Ningxia Coal-to-PolyPropylene

#### Coal features
- Sub-bituminous coal
- Ash content: typ. 10–20 wt% min.-max. 7–28 wt%
- Moisture: <30 wt%

#### Performance features
- Gasifier operation mode: 4 (in operation) + 1 (standby)
- Dry coal input: 85 t/h per gasifier
- Total syngas output: 540,000 Nm³/h (CO+H₂)
- Methanol output target: 5,000 t/d
**NCPP I Project**

**Gasifier Performance**

**Operational Highlights**
- 4 lines in stable, parallel operation
- More than 1,500,000 tons of coal gasified
- More than 5,000 t/d methanol production
- Has accommodated coals with a ash content that typically varies between 10% and 20%
- All gasifier performance guarantees achieved and exceeded

**Performance Summary**
- Gasification Temperature Range: 1350°C to 1750°C (2,462°F to 3,182°F)
- Carbon conversion 99%
- CH₄ < 0.1% (Vol)
- Effective syngas (H₂+CO) > 91% of dry syngas
- Oxygen consumption < 310 Nm³/1000 Nm³ H₂+CO
- Longest continuous run of a single gasifier is 90 days
CPI - Coal to Substitute Natural Gas (SNG) project, Yinan, China

<table>
<thead>
<tr>
<th>Customer:</th>
<th>CPI – China Power Investment Corp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>Yinan, China</td>
</tr>
<tr>
<td>Plant type:</td>
<td>Coal to Substitute Natural Gas</td>
</tr>
<tr>
<td>Configuration:</td>
<td>8 x SFG-500 Gasifiers in operation</td>
</tr>
<tr>
<td>Com. operation:</td>
<td>COD 2016</td>
</tr>
</tbody>
</table>

### Scope of supply
- Basic Engineering (PDP, BEDP)
- 8 xSFG-500 Gasifiers and Feeder Vessels
- 12 Combined Burners (4 spare)
- Operator Training
- Start-up support (Technical Field Assistance)

### Project features
- Coal: Chinese low rank lignite: <30 wt% moisture
- SNG output: 2 bio Nm³/a (1st of 3 equal phases)
- Engineering Company: ECEC
- Localization of main Siemens proprietary equipment: pressure vessel of gasifiers and feeder vessels

### Customer benefits
- Ability to process low ranked coal into high value pipeline quality, sulfur free Substitute Natural Gas
- Lowers dependency on Natural Gas imports by using local resources
- Application of environmental most friendly gasifier techn.
Shenhua Ningxia Coal Group – 80,000 BBL/d CtL
World largest CtL Plant, Ningxia, China

Coal features
• Sub-bituminous coal
• Ash content: typ. 10–20 wt%
• Moisture: <30 wt%

Scope of Supply
• 24xSFG-500 gasifiers and Feeder Vessels (Increased local content)
• Engineering (PDP, BEDP)
• Start-up support

Project Schedule
• End 2012: PDP/BEDP
• 2014/15: Gasifier delivery
• Beginning 2017: Start of Commissioning
IGCC Projects

**Summit Power**
Texas Clean Energy Project

- 400 Mw_{egross}, UREA, CO₂
- 90% carbon capture (2.7M tons of CO₂/year)
- Siemens scope:
  - SFG-500 gasifiers
  - SGCC6-5000F 1x1 power block operating on high H₂ syngas
  - Plant Operation and Maintenance services
- Located directly atop Permian Basin and CO₂/EOR opportunities

**Mississippi Power**
Plant Ratcliffe IGCC Project

- 582 MW_{enet}
- ~65% carbon capture (~3 M tons of CO₂/year)
- Siemens scope:
  - Two SGT6-5000F Gas Turbine Generators
  - Will Operate on high H₂ syngas as the primary fuel and natural gas as the backup/startup fuel
  - Will include capability to extract air for integration with the air-blown gasifier
- Located in Kemper Co., Mississippi

**Huaneng Greengen Co. Ltd.**
Tianjin IGCC Project

- 265 MW_{egross}
- In operation, CCS to be included in later phase
- Siemens scope includes one SGT5-2000E gas turbine and auxiliaries
  - Main fuel: Coal-based syngas
  - Secondary fuel: Fuel oil
- Located in Tanggu District, Tianjin, China

**Saudi Aramco**
Jazan IGCC Project

- 4,000 MWe gross, 2,400 MWe net
- Integrated with Saudi Aramco's Jazan Refinery which will process 400,000 bpd of Arabian Heavy and Arabian Medium crude oil
- Siemens Scope:
  - 5 SGCC6-5000F 2x1 Thermal Islands
  - Main Fuel: Residual-based syngas
  - Secondary fuel: Fuel oil

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Gasification Innovation
R&D Priorities for Gasification

**R&D Focus**

**Gasifier Product Upgrade**
- Larger gasifiers
- Better fuel flexibility
- Better availability and reliability

**Gasifier Island Cost Reduction**
- Lower gasifier island investment
- Lower engineering & project implementation costs

**New Applications**
- Better capability for refinery products (petcoke, resid)
- Positioned for advanced polygeneration
- Improved capability for biomass applications

**Better Tools**
Simulation with CFD, Thermodynamics and Process Simulators, Laboratories, Gasification Test Plant

Advantages
- Larger gasifiers
- Better fuel flexibility
- Better availability and reliability
- Lower gasifier island investment
- Lower engineering & project implementation costs
- Better capability for refinery products (petcoke, resid)
- Positioned for advanced polygeneration
- Improved capability for biomass applications
- Better tools
- Simulation with CFD, Thermodynamics and Process Simulators, Laboratories, Gasification Test Plant
**BtL\(^1\) / BtE\(^2\) – Global gasifier market**

### Markets
- **BtL** projects mainly focused on markets for industrial scale chemical / transportation fuels production
- **BtE** mainly used for small scale power generation

### Political / Economics Drivers
- Financial decision guided by size and location, availability of feedstock, its energy content and processing costs
- Insufficient grid expansion (developing countries)
- Public opinion against fossil fuel plants (industrialized countries)

1\(^{BtL}...\) Biomass to Liquids; 2\(^{BtE}...\) Biomass to Energy

- Gasifier application in renewable applications forecasted to grow within the next years/decades
- Short / Mid-term market will be dominated by small / medium-scale applications
- Large scale lighthouse projects under development
- Availability and low energy density of biomass drive gasifier capacity and location
- Subsidies or feed-in-tariffs are key for biomass

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**USA/Canada/Mexico:**
- Push through subsidies already in place

**Western Europe**
- Large scale projects in Netherlands and Finland under development
- Subsidies available

**Japan:** Feed-in-tariff available

**China**
- Underdeveloped as of today, but government policy and subsidies announced

**Asia Pacific Region**
- (India/Indonesia/Malaysia/Thailand/Vietnam/…)
  - Could support electrification of rural and remote areas, growth rate for small/medium scale applications

**South-America:**
- Opportunities for BtL/BtE at sugar plantations (bagasse) and croplands
WoodSpirit 21 Program
From wood via bio-syngas to biofuels

Feedstock: ~ 1 M t/y woody biomass (dry)
Product: ~ 400,000 t/y Bio-methanol
CO₂ Savings: 900 kton/yr

Key Technologies:
Torrefaction from Andritz
SFG-500R Gasifier from Siemens

Schedule:
Conceptual Design 12/2013
FEED Start 1/2014
Commercial Operation 2017

Project Funded by:
EU (NER300) – 199 M Eur

Stakeholders:
• Siemens
• Andritz
• BioMCM

Location:
Delfzijl, Netherlands
WoodSpirit is...

- an **EU showcase** for conversion of lignocellulose to biofuels
- a first commercial scale demonstration of **gasification** in combination with **torrefaction**
- and an important **alternative to CCS**
- an **innovative** Renewable Energy Source
- able to improve **energy independence**
- a generator of sustainable **second generation** biofuels
  - 500 million liters biofuels = ~3 billion green car kilometers per year
  - In 2020 at least 10% of all energy used in transportation has to be renewable
- able to generate an **significant additional CO₂ savings** of 900 kton per year
- a boost for a **bio-based economy**
Conclusions

Global demand for gasification is still strong

- Chemicals / SNG
- Transportation liquids

And is targeted at higher value products

- Local Coal to Chemicals or Transportation Fuels
- Local Biomass to Chemicals or Transportation Fuels
- Refinery Bottoms to Chemicals, H₂ or Transportation Fuels
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