Economical and Environmental Targets for Gasification / SFG Technology Update

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Content

- Gasification Market / New Drivers
- Technology Trends
- Advanced Poly-Generation and Gasification Concepts
- SFGT Project Landscape
Global Gasifier Market and Main Market Segments Today

North America:
- The preference of natural gas (shale gas) to feed chemical plants is giving a negative impact for gasification projects
- Only subsidised projects
- High construction costs
- 2-3 potential new projects

South-America:
- Opportunities for BtL/BtE, e.g. bagasse from sugar plantations of Brazil
- Coal gasification is part of Chile energy master plan
- 1 potential new project

Western Europe
- Focus on biomass to liquid projects subsidised by European and national programs but moving slow

China
- Large coal reserves, no access to cheap NG/LNG
- High industrial need of chemicals and fuels
- > 30 potential new projects

Arabia/India/Turkey:
- Reliance and Saudi Aramco decided to invest into large refinery based gasification projects
- Worldwide Petcoke production expected to grow with 4% p.a.

Asia / Australia
- High LNG price driver
- Several projects in Korea, Mongolia, Indonesia, Vietnam and Philippines under construction or development
- > 8 potential new projects

Polygeneration, IGCC (with CCS)

Coal to Chemicals

Refinery gasification

Biomass to Energy/Liquids - BtE/BtL
Coal to Chemicals in China Today

- Coal mining business under pressure and more valuable products required / Large scale CTL/SNG/CTO profitable
- Government policy prioritize western area development
- Dry feed with full quench gasification become mature and preferred in future due to higher fuel flexibility
- More stringent financing slow down investment decision for coal to chemical industry
- Operational experience with fixed bed for SNG (chlorine corrosion and environmental concerns) have negative impact on gasification image and financing

Gasification plants in operation or under construction

- 8 Projects
  - SNG 5
  - MTO 1
  - CTL 2
- 7 Projects
  - SNG 2
  - MTO 2
  - CTL 3
- 3 Projects
  - MTO 2
  - CTL 4
- Other areas 1 Projects
  - SNG 1

High probability future projects with more than 5000 t/d coal input

- 12 Projects
  - SNG 10
  - MTO 2
  - CTL 3
- 11 Projects
  - SNG 6
  - MTO
  - MEG 3
  - CTL 2
- 1 Projects
  - SNG 1
- Other areas 6 Projects
  - SNG 1
  - MTO 4
  - CTL 1

Approx. 21 million Nm³/h Syngas

Today: more than 160 SFG-500 gasifier

Approx. 28.5 million Nm³/h Syngas

Future: more than 220 SFG-500 gasifier
Siemens Fuel Gasification Technology
Latest Developments

Simple and reliable System for a wide range of different feedstock

Design to Cost
- Reduction of Lock Hoppers
- Simplified Gas cleaning concept
- Optimized plant layout
- Optimized material concept
- Reduction of instrumentation and valves

Lessons learned
- Jet Scrubber instead of Venturi Scrubber
- Improved guide tube design and Burner design
- Optimized coal fluidization and coal feeding control
Evolution instead of Revolution

SFG-500
- Proactive Quality Tool
- Potential problem analysis
- Design to Cost
- Lessons learned NCPP
  - Process enhancement
  - Product Innovation

Product Development Process
Systematic implementation of review processes to ensure product performance

SFG-850

SFG-850MW next generation gasifier available
minimize CAPEX and increase performance
New size for improved CAPEX but still transportable fully assembled

<table>
<thead>
<tr>
<th></th>
<th>SFG-500</th>
<th>SFG-850</th>
</tr>
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<tbody>
<tr>
<td><strong>Coal Input t/d</strong></td>
<td>2.000</td>
<td>3.000</td>
</tr>
<tr>
<td><strong>Operation Pressure bar(a)</strong></td>
<td>42 - 44</td>
<td>46</td>
</tr>
<tr>
<td><strong>Syngas output Nm³/h</strong></td>
<td>130,000</td>
<td>210,000</td>
</tr>
<tr>
<td><strong>Dimensions m (OD x L)</strong></td>
<td>4 x 20</td>
<td>4.8 x 22.4</td>
</tr>
<tr>
<td><strong>Weight t</strong></td>
<td>240</td>
<td>380</td>
</tr>
<tr>
<td><strong>gasifier material</strong></td>
<td>carbon steel (SA 516)</td>
<td>carbon steel (SA 516)</td>
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![Diagram of SFG-500 and SFG-850 gasifiers](image)
New flexible Low Steam CO-Shift Concept jointly developed by Siemens/Clariant

Highly attractive for Methanol and SNG synthesis
Leading to high efficiency and cost reduction

- No additional steam
- No condensation
- High flexibility for inlet Steam/Gas ratio
Advanced Polygeneration Concepts

Addition of renewable Power for auxiliaries (already today)

Addition of Renewable Power

Coal/Biomass

Air Separation

O₂ Storage

Gasification

CO₂, H₂ (deficit)

CO + H₂O = CO₂ + H₂

"Green" H₂

H₂O = H₂ + 0.5 O₂

Electrolysis

O₂

H₂O

H₂

H₂O

CO₂ Capture

CO₂, H₂ (optimally stoichiometric)

H₂ for adjusting stoichiometric ratio (i.e. reduced/no CO shift and CO₂ capture)

Desulfurization

Processes not needed in case of sufficient power from renewables (long-term future)

Syngas, H₂, Off-gases

Combined Cycle

Power (to grid or for auxiliaries)

Sythesis

Chemicals (e.g. SNG, MeOH)

Steam

Polygeneration allows stepwise integration of renewable energy
Up to 90 % CO₂ reduction possible.
9 SFG-500 gasifiers shipped/installed for 3 projects
32 SFG-500 gasifier under manufacturing or shipped
NCPP – SFG-500 Reference plant

front view NCPP plant

SFG-500 achievements

- longest continuous single gasifier runtime: 109 d
- longest continuous plant runtime (4+1): 183 d
- total achieved plant availability: 91%
- CO + H2 content (effective syngas): > 92%
- fast start-up / shut-down capabilities: < 2 h
- high fuel flexibility: up to 22 % ash content

Commercial operation and high availability since 2012
In average more than 5300 t/d methanol production achieved (design 5000 t/d)
SNCG’s CTL project uses SFG Technology

**Facts and Figures**
- Gasifier manufacturing in China
- 24 x 500MW SFG gasifier

**Input / Output**
- > 2300 t/h Coal input
- > 2,700,000 Nm³/h Syngas
- 110 t/h Naphta
- 352 t/h Diesel
- 42 t/h LPG

**Schedule**
- PDP finished
- Hardware procurement ongoing
- Construction started
- 2016: Commissioning
CPI – 2 billion SNG/a with SFG-500 Gasifiers

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 and updates

- Lowers dependency on Natural Gas imports by using local resources
- Project moved from Yinan to Huocheng keeping SFGT hardware and SNG output unchanged: 2 bio Nm³/a (1st of 3 equal project phases)
- Siemens proprietary equipment localized and manufacturing and shipping of gasifiers, feeder vessels and burners almost completed
- Coal/Ash changed but still sub bituminous coal with <30 wt% moisture
- Final environmental and permission planning ongoing

Customer: CPI – China Power Investment Corp.
Location: Xinjing, China
Plant type: Coal to Natural Gas
Configuration: 8 x SFG-500 Gasifiers
Com. operation: COD 2016
### Conclusion

- **Dry feed and full quench gasification** became mature and make low grade coal accessible for very attractive CTL and CTC solutions.

- **Chinese gasification market** still dominates but growing number of projects in rest of Asia due to LNG dependency, low price coal and refinery residues.

- **US gasification market** struggling under high construction cost and shale gas boom.

- **Advanced poly-generation concepts** are available for most effective renewable integration and storage.

- **Subsidized biomass market in Europe and America** dominate and drive alternative gasification developments.
Thank you for your Attention!

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