SHELL COAL GASIFICATION PROCESS

An integrated solution for efficient coal-to-products value chains

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Resources: Our use of the term "resources" in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Resources plays: Our use of the term 'resources plays' refers to tight, shale and coal bed methane oil and gas acreage.

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Shell Gasification technology portfolio

SHELL GASIFICATION PROCESS (SGP)
with natural gas feedstock e.g. for GTL
with residue feedstock e.g. for refineries

SHELL COAL GASIFICATION PROCESS (SCGP)
with solid feedstock (coal, pet coke and biomass) e.g. for chemicals, hydrogen and power generation

“One proven technology, two line-ups”
SCGP licensing reference in China

- 15 years of commercialisation in China
- 22 license projects, 23 gasifiers in operation, 6 gasifiers to start-up

17 gasifiers with >2000t/d coal intake capacities
- Largest gasifier delivered 3,200t/d, start-up in 2015

Pulverized coal intake capacity
- > 3,000 t/d
- > 2,000 t/d
- < 2,000 t/d
Mature core of the technology: reactor and burners

Protection against high operating temperatures via a slag layer on a membrane (water) wall
Performance and reliability: wide coal suitability

FEED FLEXIBILITY

- Handled over >150 different kinds of coal incl. challenging feedstocks like lignite and petcoke
- Four projects successfully used petcoke blended with coal, with one reaching 328 days at full operation load
- Based on extensive operating experience, several modelling tools were developed to confidently assess novel coals and optimise coal blends

Property range of feedstocks operated in SCGP

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Ash (MF) wt%</th>
<th>Moisture wt%</th>
<th>FT, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignite</td>
<td>36.4% - 5.9%</td>
<td>35.0% - 3.8%</td>
<td>&gt;1500°C - 1140°C</td>
</tr>
<tr>
<td>Sub-bituminous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bituminous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthracite</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Petcoke</td>
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</tbody>
</table>

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Continuous technology improvement

Lessons Learnt (first-hand operation experience)
- Complete lessons learnt database with hundreds of lessons learnt, covering years of experience from all SCGP users.
- Continuous improvement with all accumulated lessons learnt integrated into latest master design.

Operation and management experience
- Rich coal gasification plant operation experience, share the know-how on coal management and assessment for stable and reliable operation.
- Systematic equipment and operation management system, the foundation for long-term reliable running.

R&D focus and goal
- Reduce CAPEX and widen feed flexibility.
- Examine the integrated value chain to increase overall energy efficiency.
- Improve reliability and operability of licensed plants.
SAFE OPERATION
- Dongting JV achieved 9.4 million man-hours without LTI on April 30, 2015 (since 9th Feb 2006)

HIGH RELIABILITY
- Overall SCGP plant reliability in 2014 is 96.1%: 11 plants clocked more than 300 accumulative running days the longest one reaching 333 days in 2014
- In 2014 several SCGP plants achieved continuous runs of more than 200 days, the longest one reaching 322 days for a single gasifier

LATEST START-UP
- Hanichemco coal to ammonia/fertilizer plant in Vietnam successfully started up in December 2014, reached 90% load, and produced on-spec end-use product within the first month of operation. Its performance testrun was passed in May 2015
**SCGP - SGC Lu’an CTL project**

- Lu’an Coal-to-liquids project is the flagship coal-to-chemical project of Shanxi, also China’s national CTL demonstration project in the 12\textsuperscript{th} Five Year Plan
  - Project Phase I with 1.8 mln ton/a liquids produced
  - SCGP gasification: 4 × 3200 ton coal/day
  - Syngas capacity: 825,000 Nm\textsuperscript{3}/hr (CO+H\textsubscript{2})

- Why SCGP?
  - an impressive operational performance
  - better efficiency and environmental performance
  - can offer large gasifiers (economy of scale) manufactured in China

- Project progress
  - Gasification license contract signed in January 2013
  - Key Gasification Equipment manufactured by Chinese vendors, final inspection in April 2015
  - Start-up planned Q4 2015

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A robust and simple, low-cost design, with a wide feedstock range

Syngas cooler replaced with a mature, ‘industry-standard’ water quench technology

- Same membrane wall
- Same multiple burner
- Same dry feed system
Project progress: SCGP Bottom Quench in Nanjing

- **Feedstock**
  Several different coals tested: ash contents between 8 and 25% (with and without flux)

- **Syngas composition**
  (CO+H₂) content up to 90% on a dry basis

- **Carbon conversion**
  > 99% carbon conversion, low carbon in slag (<0.5%) and in filter cake (<5%), high slagging efficiency (>90%)

- **Gasifier and quench**
  Good slag coverage overall inside gasifier and very effective water quench performance

- **Primary water treatment**
  Good settling with black water via proper flocculant to recycle grey water:
  TSS <50 ppm, COD <100 ppm

Longest continuous run of 140 days in first year of operation!
Industrially proven, mature technology

- Carbon efficiency >98-99%
- Highest energy efficiency, lowest consumption
- High-level steam as a very useful ‘byproduct’
- Low water consumption, less wastewater to treat: environmentally friendly

Same design principles as syngas cooler design

- Carbon efficiency >98-99%
- Simplified line-up, reduced Capex
- Even wider coal flexibility
- Easier operation and maintenance (less equipment)
Looking to the future

- **Shell’s world-class gasification technologies** can contribute to a cleaner energy future.
- **Continuous improvement** has seen the reliability of Shell’s gasification technologies steadily improve in recent years.
- Shell has a **strong, global reference list**
- **Coal gasification offers a single proven technology in two line-ups**: SCGP syngas cooler and bottom water quench depending on your business objectives.
- Our **dedicated gasification technical and services team** offers comprehensive and experienced support.
Thanks for your attention