Lummus’ E-Gas Gasification Technology
E-Gas Technology Overview

E-Gas Global Projects
### E-GAS BACKGROUND

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Capacity</th>
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<tbody>
<tr>
<td>Bench-Scale, Mini Plant, Pilot</td>
<td>1975 – 1982</td>
<td>36 TPD</td>
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<tr>
<td>Plant</td>
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<tr>
<td>Proto 1</td>
<td>1979 - 1983</td>
<td>400 TPD</td>
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<tr>
<td>Proto 2</td>
<td>1983 - 1987</td>
<td>1600 TPD</td>
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<tr>
<td>LGTI</td>
<td>1987 - 1995</td>
<td>2,400 TPD</td>
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<td>Wabash River</td>
<td>1995 - 2000</td>
<td>2,500 TPD Coal</td>
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<td>(Multiple Refineries)</td>
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<tr>
<td>Lignite</td>
<td></td>
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<tr>
<td>Sub-Bituminous Coal</td>
<td></td>
<td></td>
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<tr>
<td>(Rochelle Mine)</td>
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<tr>
<td>Bituminous Coal</td>
<td></td>
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<tr>
<td>(Illinois No. 6)</td>
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<tr>
<td>Wabash River</td>
<td>2000 - 2016</td>
<td>2,000 TPD Petcoke</td>
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<td>Petroleum Coke</td>
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### 40+ YEARS OF CONTINUOUS IMPROVEMENT
• **Petcoke feedstock** 15 years of experience, >5 MM tons processed

**Petroleum Coke**
- 10 % Moisture
- 2 % Ash + Flux
- 5-7 % Sulfur
- >5 Million Tons
Key Differences which influence design and operation

• Higher heating value, therefore less consumption

• Ash quantity and composition:
  - requires flux addition
  - eliminates much of ash deposition concerns
  - less abrasive char

• Lower Reactivity:
  - finer slurry PSD
  - operate 1st Stage Gasifier warmer
  - increased recycle of unreacted material

• Lower Volatile Matter, less aromatics

• Harder (lower HGI)

• Reduced water system pH:
  - eliminated pipe scale concerns
  - change in settling system polymer
E-GAS ADVANTAGES

**KEY FEATURES**
- Two Stage Design
- Slurry Fed
- Oxygen Blown
- Entrained Flow
- Refractory Lined
- Heat Recovery

Two-stage design with dry char filtration and recycle combines advantages of slurry and dry feed systems → High conversions, efficient, simple

Demonstrated for low reactivity as well as reactive fuels → Fuel flexible

Continuous Slag Removal – no lock hoppers → Lower cost, more reliable slag system

Compact design, efficient water handling system → Lower cost

Experience-driven design → Licensor hands-on operating experience

Continuous technology improvements → Innovation for better performance, high availability

Balance of low cost and high efficiency
E-GAS GLOBAL PROJECTS

Overview and Status Update
E-GAS GLOBAL PROJECTS

Wabash River IGCC
Reliance Jamnagar Polygen
CNOOC Huizhou Hydrogen
POSCO Gwangyang SNG
Sincier Shandong Hydrogen

4 projects, 19 gasification trains, 3.5 million Nm³/hr (H₂+CO+CH₄) licensed since 2010
WABASH RIVER IGCC, USA

- Single train, coal/ petcoke
- Permitted, Designed and Built in ~4 years
- 262 MWe net output by repowering 1953-vintage PC 100MW STG (+ GTG)

- Operation began in 1995
- Largest IGCC in the World in 1995
- Cleanest IGCC Power Plant
- CB&I provided Operations Management services for 21 years

The Wabash River Gasification Project is located in West Terre Haute, Indiana and owned by Quasar Syngas LLC.
Blend Feedstock – Petcoke + Coal

Total Ten (10) – Gasification Trains

2,720,000 Nm³/hr (H₂ + CO + CH₄)

Syngas for Power Generation, Fuel, Chemicals and Hydrogen, Startup 2017
CNOOC REFINERY EXPANSION, CHINA

Coal, Coke or 80/20 Coke/Coal Blend
- Coal: 4,075 mtpd
- Coke: 2,825 mtpd
- Blend: 3,021 mtpd

Total Three (3) – Gasification Trains

Total Syngas: 240,000 Nm³/hr
- Syngas to H2: 225,000 Nm³/hr
- Extraction gas to Oxo Chemical: 15,000 Nm³/hr

HP Steam Production: 190 MT/hr @ 120 bar
Startup in 2018
SHENCHI SINCIER REFINERY EXPANSION, CHINA

- Coal + Pitch
- Total Three (3) – E-Gas Plus Gasification Trains
- 230,000 NM3/hr H2 + CO
- Syngas to Hydrogen for Refinery Expansion, In design (on hold)
Indonesian Sub-bituminous Coal

Total Three (3) – Gasification Trains

287,000 Nm³/hr (H₂ + CO + CH₄)

Syngas for pipeline SNG