Natural Gas to Ethylene
Breakthrough Technology to Convert Natural Gas to Liquids or Petrochemicals

Proprietary Technologies

Oxidative Coupling of Methane to Ethylene (OCM)

Ethylene to Liquids (OCM + ETL)

Products

Ethylene (via purification)

Gasoline (via reactive separation)

Inputs

Methane

Ethane (optional)

Protected with an IP portfolio of >90 granted or pending patents and patent applications in the U.S. and internationally

Business Areas

Multi-Billion Dollar Opportunities Across the Hydrocarbon Value Chain

Today’s Focus is Ethylene

Midstream Gas Processing Industry

Small-Scale and World-Scale Ethylene

Distributed-Scale Gas Monetization

Large-Scale Gas Monetization
Two Proprietary Technologies With Multiple Applications Across the Energy and Petrochemical Industries

Today’s Focus

Inputs
- Natural Gas (Methane & Ethane)
- O₂ Source

OCM
(oxidative coupling of methane)

Purification/Se parations

Ethylene and Associated Products

ETL™
(ethylene to liquids)

ETL process can selectively produce any one of these liquid products

Gasoline (RBOB)
Aromatic Chemicals
Distillates (diesel/jet)
Success required performance across a wide spectrum
Siluria has succeeded where others have not

Example Performance Metrics
- Conversion
- Selectivity
- Catalyst Activity
- Operating Conditions
- Catalyst Life/Scaling

Technically & Economically viable envelope

Others
Siluria
A Key Aspect of Siluria’s Development Process:
Constraining Catalyst Innovation to Conventional Process Conditions

Siluria’s first generation of commercial OCM features:
• Fixed bed axial reactor design
• Conventional scale-up techniques
• Conventional geometry
• Conventional metallurgy
• Conventional catalyst loading/unloading procedures
Successful Scale-Up of OCM Catalyst

OCM Catalyst Scale-Up

- Proprietary catalyst recipe has been successfully transferred to commercial catalyst producers
- Performance replicated from batches of catalyst >100kg
- In-house catalyst manufacturing already capable of supplying demonstration unit facility
Process Demonstration and Pathway to Ethylene Market
Through Operating and EPC Partnerships

Demonstration Plant with Operating Partner Braskem:

Technology Licensing and EPC Partner:

- Partner will provide full process licensing package with performance guarantees for:
  - Stand-alone OCM
  - OCM Retrofits into Existing Crackers

OCM Scale-Up

- Lab Scale
- Pilot
- Commercial Plant

Multiple Pilots Operational for Two Years

~72ft
Siluria 1000kTA OCM Process Configuration

- **OCM (Reactor & Heat Recovery)**
  - Converts methane and ethane into ethylene
- **PGC (P.G. Compressor)**
  - Delivers process gas to recovery and separations
- **Pre-Treatment**
  - Removes CO2 and H2O
- **Separations**
  - Separates recycle streams (C1 and C2) from products (C2= and C3+)
- **MET (Methanator)**
  - Reacts CO and CO2 with H2 to form CH4
- **ASU + GTCC (Gas Turbine Combined Cycle)**
  - Supply O2 to the plant and it is fueled with the purge gas
Key Proprietary Process & Technology Features

OCM Reaction System
• Technically and commercially viable catalytic conversion of methane and ethane to ethylene
• Proprietary catalyst/reactor system

Methanation
• Recovery of combustion by-products (CO and CO₂) via reaction with H₂ produced in reactor
• Unique integration within OCM process

Product Separation & Recovery
• Process design optimized for OCM effluent composition
• Unique demethanizer process design for proper heat and material integration
## Key Performance Technical & Economic Metrics

World Scale First Generation OCM Deployment

<table>
<thead>
<tr>
<th></th>
<th>OCM</th>
<th>Ethane Cracker (1)</th>
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<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nat. Gas Feed (SCF/MT of C2=)</td>
<td>84,000</td>
<td>23,700</td>
</tr>
<tr>
<td>Ethane Feed (gal/MT of C2=)</td>
<td>179</td>
<td>955</td>
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<tr>
<td><strong>Specific Energy/Feedstock Consumption</strong></td>
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<tr>
<td>Nat. gas Specific Consumption (MMBtu/MT of C2=)</td>
<td>78</td>
<td>22</td>
</tr>
<tr>
<td>Ethane Specific Consumption (MMBtu/MT of C2=)</td>
<td>11</td>
<td>59</td>
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</tbody>
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| **Notional Specific Capital Cost** |           |                    |
| CapEx ($/MT_{cap}$) | 1,500 – 2,200 | 1,800 – 3,000 (2) |

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(1) IHS 2013 Ethylene Cost Curve Service
(2) Based on recent project announcements
OCM Advantages Over Existing Options Can Be Very Substantial

World Scale (1000MT/yr) Ethylene Production

- Cracker Cash Cost + Capital Charge ($/MT)
- OCM Cash Cost + Capital Charge ($/MT)
- Cumulative Advantage ($MM)

Small Scale (75kT/yr) Ethylene Production

- Annual Margin ($MM/Yr, 75kTA)
- Cumulative Margin ($MM, 75kTA)

Based on Four Year Look-Back Commodity Pricing from Bloomberg Monthly Average on US Gulf Coast Basis (2009 through 2012)
Ethylene Cash Cost Model Based on IHS Ethylene Cash Cost Service. Ethylene Value is based on Spot Pricing
Conclusions

Siluria’s OCM breakthrough is a platform technology from which we are addressing multiple markets:

- Improving economics and feedstock flexibility for world scale ethylene producers:
  - Joint development with a world-leading EPC/Licensor to co-license and guarantee new world scale plants and retrofits of existing crackers for feedstock flexibility and/or capacity expansion

- Enabling on-site ethylene generation for merchant buyers:
  - Actively engaged in a number of feasibility studies for first commercial projects
Thank you!

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