Gas Monetization via Emerging “mini-GTL” Options

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GGFR Study with Final Report in February 2012

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Study Research:
Theo Fleisch

Time:
1H 2011
Update in February 2012

Available to GGFR members
Major Conclusions

- Large scale GTL technologies are proven and profitable (Shell, Sasol, Methanex, etc)
- A few “miniGTL” technologies are for the 1st time commercially available to reduce global gas flaring and monetize smaller gas volumes
- Most of these technologies are based on proven “syngas” routes and have been demonstrated in pilot plants
- Onshore and Offshore applications are possible
- Economic returns look attractive because of the high value products associated with high crude prices
Why GTL?

- Monetize “stranded” gas (Trinidad, Qatar,...)
- Add value to gas (gas/oil arbitrage: $4/MMBTU to $20/MMBTU in US today)

- Valuable products
  - Synthetic crude oil
  - Clean drop-in fuels (gasoline, diesel)
  - Advanced fuels and chemicals (DME, methanol, etc)

- Energy security
  - Reduction of imported fuels (1 bcfd/280million m³ gas per day equates to 1MMbpd)
  - Domestic production (investments, jobs)
GTL: Gas to Liquids – Broad Product Options

Step 1: Reforming SMR

Step 2: Fischer Tropsch

Step 3: Upgrading

Gas to Liquids GTL-FT (Fischer-Tropsch)

Synthetic crude

Diesel

Naphtha

Lubes

Gas to Chemicals (GTC) and Fuels

Methanol

DME, Olefins, Gasoline

Fuel Additives (MTBE, butanol, DMC, etc)

Hydrogen, Ammonia, Urea,
Natural gas requirements

- Methane is the preferred feedstock (separation and sale of condensates and NGL)
- However, C2+ (ethane and higher) can be accommodated with minor modifications if gas fractionation is not feasible
- Poisons such as sulfur and mercury must be removed
- Nitrogen and carbon dioxide are diluents and can be tolerated in moderate concentrations
- Pressure is an advantage since the 1st step reformers run at elevated pressures (>20bar)
- Gas feed rates as steady as possible for 10+ years
- Minimum gas feed rate: 50kscfd
Some historic GTL conversion plants
## Large scale GTL plants: economy of scale

<table>
<thead>
<tr>
<th>Plant</th>
<th>Country</th>
<th>Gas Feed Rate</th>
<th>Product</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Bintulu</td>
<td>Malaysia</td>
<td>3.4mm m³/d</td>
<td>Diesel+</td>
<td>12,000bpd</td>
</tr>
<tr>
<td>Mossgas</td>
<td>South Africa</td>
<td>6.8mm m³/d</td>
<td>Diesel+</td>
<td>24,000bpd</td>
</tr>
<tr>
<td>Sasol Oryx</td>
<td>Qatar</td>
<td>10mm m³/d</td>
<td>Diesel+</td>
<td>35,000bpd</td>
</tr>
<tr>
<td>Shell Pearl</td>
<td>Qatar</td>
<td>40mm m³/d</td>
<td>Diesel+</td>
<td>140,000bpd</td>
</tr>
<tr>
<td>Titan</td>
<td>Trinidad</td>
<td>2.1mm m³/d</td>
<td>methanol</td>
<td>2500tpd</td>
</tr>
<tr>
<td>Atlas</td>
<td>Trinidad</td>
<td>4.2mm m³/d</td>
<td>methanol</td>
<td>5000tpd</td>
</tr>
<tr>
<td>Escravos</td>
<td>Nigeria 2013</td>
<td>10mm m³/d</td>
<td>Diesel+</td>
<td>35,000bpd</td>
</tr>
<tr>
<td>Sasol Karshi</td>
<td>Uzbekistan</td>
<td>10.8mm m³/d</td>
<td>Diesel+</td>
<td>38,000bpd</td>
</tr>
<tr>
<td>Uzbekneftegaz</td>
<td>(planned)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SasolTalisman</td>
<td>Canada (planned)</td>
<td>14-28mm m³/d</td>
<td>Diesel+</td>
<td>50,000-100,000bpd</td>
</tr>
<tr>
<td>Sasol Louisiana</td>
<td>USA (planned)</td>
<td>23mm m³/d</td>
<td>Diesel+</td>
<td>80,000bpd</td>
</tr>
</tbody>
</table>
Challenges with flared gas for mini-GTL

- No economy of scale
  - High capital costs with low financial returns?

- Very remote locations and lack of infrastructure
  - Delivery of bulky equipment
  - Additional costs for utilities

- Gas production profiles (declining with time)
  - Original plant size becomes underutilized

- Local markets for products

Need for small scale, modular, low cost process units with flexible capacity and for readily useable products
Companies developing mini-GTL technologies

- Velocys
- General Methanol
- 1st Resource Group, Inc.
- Compact GTL
- GRT, Inc.
- VERDIS
- Synfuels International, Inc.
- GasTechno
- Carbon Sciences
Evaluation of technologies

- Overall technical risks
- Status of technology development
  - Laboratory, pilot plant and demonstration plant status
  - Remaining hurdles
- Overall Commercial readiness (onshore and offshore)
- Size applicability
  - Small: <1mmscfd (<28,000m³/d)
  - Medium: 1 - 10mmscfd (28,000 – 280,000m³/d)
  - Large: >10mmscfd (>280,000m³/d)
Overall Risk and Time to Commercialization

- **High Risk, Long Time to Commercialization**
  - General Methanol
  - Synfuels International, Inc.
  - Methion
- **High Risk, Short Time to Commercialization**
  - L3 Sciences
  - Verdis
  - Carbon Sciences®
- **Low Risk, Long Time to Commercialization**
  - GasTechno
  - 1st Resource Group, Inc.
  - Velocys
  - Oberon
- **Low Risk, Short Time to Commercialization**
  - Compact GTL
Technology:

- process intensified mini-channel reactor technology for both the reformer and the FT unit (~/<5mm)
- Catalyst placed on metal sheet inserts
- Effective heat transfer

Product: diesel or waxy syncrude

- Successful 20bpd demonstration plant (Petrobras)
- Numerous commercial feasibility studies

www.compactgtl.com
Velocys (Oxford Catalysts)

- Technology:
  - Breakthrough micro-channel technology
  - Reactor channels are <1mm diameter
  - Catalyst coating inside

- Very compact modular design
- Reactor modules can be removed when gas production falls
Velocys: status and path forward

- Commercial development is underway
  - 3 demonstration projects underway (<1MMscfd) in Brazil, Austria and the USA
- All GTL steps proven by 2012 (SMR, FT, Hydrocracking)
- Velocys is accepting commercial orders for FT units now (have already sold about 10 FT reactors)
- Rosneft purchased a 100bpd unit for Angarsk refinery, Siberia, converting 10mm m³/y
- Calumet (PA) will build 1000bpd unit
- Multiple feasibility studies underway
- www.velocys.com
GASTECHNO: Overview

- Relatively simple technology:
  - Direct oxidation of methane to methanol (no catalyst, no syngas)
  - Modular, skid mounted design
- Technology proven in 50kscfd (1400 m³/d) demo with good mass and energy balance
- By-products: formalin, ethanol
- Modules available for sale or lease (~/<30,000m³/d)
- Basic evaluation and engineering packages (28,000 to 850,000m³/d)
- [www.gastechno.com](http://www.gastechno.com)
OBERON FUELS: Overview

- **TECHNOLOGY**
  - Skid mounted DME
  - Modular design
  - Targets are small natural gas and/or biogas sources (<2MMscfd or <50,000m³/d)
  - Markets: local heavy duty diesel fleets converted to DME

- **1st plant** to be built in CA in 2013 (feed is methanol)
- **2nd plant** will demonstrate the whole chain from natural gas

- [www.oberonfuels.com](http://www.oberonfuels.com)
Attractive economics: product/feedstock thermal value spread is >3
  E.g. gas at $4/MMBTU and diesel at $20/MMBTU equals spread of 5

Plant size
  10,000scfd (280m$^3$/d) == 1bpd liquid product
  Example: 5MMscfd (140,000m$^3$/d) == 500bpd

Capex
  ~$80,000/daily barrel
  500bpd plant: ~$40MM +/-50%

Annual revenue: ~$17MM (at $100/barrel and 350 days of operation)
  Minus Opex: ~$3MM
  Minus gas cost
  Carbon credits?
Oil-gas spread: past, present and future

GTL economics works well at oil-gas spreads at 3 and above.
Conclusions

- The GTC and GTL industries are global and well established.
- A few “miniGTL” are now available to reduce global gas flaring and monetize smaller gas volumes.
- Most of these technologies are based on proven syngas routes and have been demonstrated in pilot plants.
- Offshore applications are possible.
- Economics look attractive because of the high value products associated with high crude prices.
- Numerous other technologies are under development and some might see commercialization within the next 5 years.
Recommendations

- Evaluate mini-GTL technologies as potential new options
- Time is right for commercial applications
  - CompactGTL
  - Velocys
  - Oberon Fuels
  - Gastechno
- The World Bank GGFR Partnership is ready to assist you
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