
International Association for Energy Economics
Houston

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Houston, Texas
Introduction

- Recent interest in GTL technology and its products
- Units to come on line in the next 5 years
- What is GTL?
- How might it impact the global energy and petroleum products markets?
Key GTL Steps

- Production of synthesis gas ("syngas"):  
  - Partial oxidation: $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO} + 2 \text{H}_2$ (exothermic)  
  - Steam reforming: $\text{CH}_4 + \text{H}_2\text{O} \rightleftharpoons \text{CO} + 3 \text{H}_2$ (endothermic)

- Fischer-Tropsch synthesis  
  - $\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_2{\text{--}} + \text{H}_2\text{O}$ (very exothermic)
## Sample GTL Product Slate
### 50 MBD Plant

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<thead>
<tr>
<th></th>
<th>No HC (MBD)</th>
<th>With HC (MBD)</th>
<th>Comments</th>
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</table>
| LPG   | 1           | 2             | • Similar to other plant (LNG, refinery) LPG  
          |             |               | • Can be co-processed and marketed with them |
| Naphtha | 4           | 13            | • Straight chain paraffinic  
          |             |               | • Near zero sulfur  
          |             |               | • Preferred use: steam cracker feed |
| **Diesel** | 25          | 35            | • High cetane  
          |             |               | • Near zero sulfur  
          |             |               | • Low density  
          |             |               | • Low aromatics |
| Lubes | 15          | <1            | • High grade  
          |             |               | • Low volatility  
          |             |               | • Low pour point  
          |             |               | • Low viscosity  
          |             |               | • Low sulfur |
| Wax   | 5           | <1            | • n-paraffins  
          |             |               | • High quality |

**E-MetaVenture, Inc.**
GTL Drivers

- Reduction in cost of transport of NG
  - Monetization of stranded natural gas
  - Economic utilization of associated gas

- High current and projected demand for liquid transportation fuels
  - Higher costs tied in with crude markets and refining capacity issues
  - Clean fuels

- Flaring reduction and environmental concerns
Natural Gas Transport Mechanisms

After “Natural Gas Production, Processing, Transport” by Rojey et al.
### 4.1 TCF Natural Gas Flared in 2000
Excluding FSU

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<th>Region</th>
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After World Bank
A. D. Little, Inc. Study (2000)
GTL-FT CAPEX Reduction Due to Improved Technology

- Capacity differences
- Lube and wax manufacture v. no lube/wax
- Financing structure
- Short-term v long-term (increased capacity) case
- Technology differences
- Current claims in $25,000-35,000/Bbl range
## Key Commercial GTL Plants in E&C

<table>
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<tr>
<th>Company</th>
<th>Location</th>
<th>Size (BPD)</th>
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<tbody>
<tr>
<td>Sasol Chevron QP</td>
<td>Ras Laffan, Qatar (“Oryx GTL”)</td>
<td>33,700</td>
<td>2006 completion; Technip-Coflexip; $850 MM; studying increase to 100 MBD by 2009</td>
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<td>Sasol ChevronTexaco</td>
<td>Escravos, Nigeria</td>
<td>34,000</td>
<td>? completion; FW; $1,200 MM</td>
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<td>Shell QP</td>
<td>Qatar (“Pearl”)</td>
<td>140,000</td>
<td>2009 completion Two phases</td>
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<tr>
<td>ExxonMobil QP</td>
<td>Qatar</td>
<td>150,000</td>
<td>2011 completion</td>
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Over 50 other projects (total capacity ~2 million BPD) at different phases (study, planning, preliminary design) in African, Americas, Middle East and Asia, and Australia.
Projected Natural Gas used by GTL

GTL Proj~2% world consumption

- Developing
- Eastern Europe/Former Soviet Union
- Industrialized
GTL Diesel
Automotive Diesel/Mid. Dist. Market
Historical

- Global middle-distillate market: 27 MMBD
  Approx. 3% annual growth
  14 MMBD automotive diesel
Growth Projections (1)

- Europe: increase in diesel-powered autos
  - Currently over 60% of auto sales in France and Austria
  - Emission mandates, jurisdictional tariff strategies, improved auto designs, increased low-emission fuel availability

- US: driven by commercial sector and tied to overall economy growth (average about 5% annual)
  - Light diesel vehicles 4% of total market
  - Regional and regulatory efforts are likely to increase diesel auto usage

- Asia-Pacific: rapid yet uncertain growth
  - China factor: 8-10% annual economic growth; loosely correlated to diesel fuel usage
Growth Projections (2)

- Globally: diesel powered autos at about 30%
  - Projected to grow to about 40% by middle of next decade
  - Followed by partial replacement with hybrids

- Overall:
  - Projected middle distillates demand to grow by 3% annual
  - To 44 MMBD in 2020
  - 22.5 MMBD automotive diesel
Global Middle Distillates Projection

Middle Distillate Consumption (MBD)

- Projected Total at 3% growth
- Rest of World (Excl FSU)
- Asia Pacific
- Europe
- North America

- 1977
- 1987
- 1995
- 2000
- 2005
- 2010
- 2015
- 2020
Question: what is the potential impact of GTL on this market?
GTL Diesel Supply Projections

- A large number of potential projects
- Only a small fraction are likely to be built short-term

- Qatar: self-described GTL capital
  - Oryx I: 2006 start up
  - Shell Pearl: 2009
  - ExxonMobil: 2011

- California Energy Commission estimate:
  - 2010: 75 MBD global GTL diesel capacity (seems low)
  - 2015: 388 MBD
  - 2020: 800 MBD

- Sasol Chevron estimate: 600 MBD by 2016-2019
GTL Diesel v. Global Middle Distillates

- Small as fraction of total diesel supply (less than 3% by 2020)
- Unlikely to impact global market greatly
Potential Impact on Local Diesel Markets

- GTL supply could potentially form a significant portion of a region’s diesel
  - Example: Shell estimates one large GTL plant would fully satisfy the city of London and 10 plants would satisfy PADD V

- Possible to develop a critical mass of GTL diesel as blendstock for a small market
  - Example: Shell Bintulu has offered 30% Pura throughout Thailand
  - Also sold as blendstock in Greece, Germany, and South Africa
Comments on GTL Diesel Quality

- Virtually no sulfur
- Very low aromatics
- Highly paraffinic ➔ typical cetane numbers in 70-80
- Lower density than refinery diesel
  - 0.77-0.80 Kg/L v. 0.83-0.85 Kg/L
  - ➔ Density premium
  - ➔ Perceived lower fuel efficiency (in MPG)
- Relatively poor cold-start; low lubricity
- A number of studies (90s) show a premium of 5-10 ¢/gal
GTL Diesel Quality & Effect of Regulatory Environment

- Regulations on
  - Fuel composition
  - Emissions
  - “Alternative” fuel content (e.g., biofuels)

- Fuel composition regulations:
  - Tightening standards for light and heavy-duty diesel vehicles
  - Expected to continue to tighten
  - Sulfur, aromatics, PNAs
  - US, WE, Japan: sulfur down to 10-50 ppm
  - Developing world: mandates down to 200-1000 ppm
# The Evolving Diesel Sulfur Content Regulations

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Key: >5000 ppm | 501-3000 | 3001-5000 | 51-500 | 16-50 | <50

Source: Pytte (22)
GTL Diesel Emissions

- A number of studies demonstrated tailpipe emission benefits
  - Neat or in blends
  - Compared to both conventional as well as reformulated

- Typical examples of tailpipe emission results:
  - 40-50% reduction in HC, 9% in NOx, 30% in particulates when compared with low-sulfur refinery diesel
  - Benefits with current as well as new engine technologies (Euro-4 and Euro-5) using neat and blend GTL diesel

- Well-to-Wheel: no great benefit for GTL diesel
  - Shifts CO₂ emissions from auto to plants (away from population centers; potential for sequestration)
Likely GTL Diesel Scenario

- Pure GTL diesel would require separate infrastructure and auto modifications.

- In jurisdictions with very tight specifications, volume of GTL required would be very high.

- Most likely use: as a premium blendstock to bring slightly off-spec diesel into compliance.

- Competition:
  - HT in refineries, improvement in FCCs and other units.
  - Biofuels.
  - GTL diesel sulfur premium might erode.
  - Some observers: GTL diesel premium will be primarily due to its high cetane and low aromatics.
In Summary

- After many decades of discussion and R&D GTL new GTL plants will on stream within the decade

- GTL is capable of producing high quality diesel as well as lubes and waxes

- GTL is unlikely to have a major impact on the global diesel markets
  - Can be a positive component in meeting high quality blend-stock demands

- GTL lubes (and waxes) can have a significant effect on the worldwide pool
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