UCG Syngas: Product Options and Technologies

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BP plc.
Some numbers and facts about BP

- BP is the 2nd largest oil company and 7th largest company in the world
- Market capitalisation of $219 billion (Feb 2005)
- 103,000 employees worldwide
- Presence in over 100 countries and 6 continents
- Production: 1.93 million barrels daily (oil)  
  8.63 bcf daily (natural gas)
- 6.6 million barrels total daily refined product sales
- 29,200 service stations
- Serving 13 million customers daily, more than McDonalds
GTP Experience from Heritage Companies

- **BP**
  - GTL-FT, Compact reformer
  - Numerous direct conversion schemes
  - Autothermal cracking (ATC)
- **Amoco**
  - Focus on oxygenates (methanol derivatives); DMC, DMM
  - Inventors of DME (dimethylether, synthetic LPG)
  - Breakthrough technologies (OTM syngas)
- **Arco**
  - GTL-FT partnership with Syntroleum
  - Cherrypoint demonstration plant (70bpd); now at Catoosa
- **Summary**
  - Total spend: >$400MM over about 15 years
Today’s Gas to Products business:
~20 bcf/d (7%) of world gas

Natural Gas

CO and H₂
“Syngas”

HYDROGEN

Ammonia/Fertilizer Refineries

Ammonia: 12 bcf
Refineries: 6 bcf

METHANOL

Acetic acid

Formaldehyde

MTBE

Methanol: 3 bcf
CO + 2 H₂
“Synthesis Gas”

Synthetic Crude

Hydrogen Synthetic Crude

Jet
Lubes
Naphtha
Olefins

Acetic acid
Formaldehyde
DME
Fuel and Additives

Clean Diesel
Refinery Products
Ammonia
H₂ Power

Methanol

Power and Transportation Fuels and Chemical Feedstocks
## Syngas to Products offers large markets

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<thead>
<tr>
<th>Target Products</th>
<th>Market size, MMTPA</th>
</tr>
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<tbody>
<tr>
<td><strong>Benchmark: LNG</strong></td>
<td>140 (actual)</td>
</tr>
<tr>
<td>Diesel</td>
<td>1100</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>3800</td>
</tr>
<tr>
<td>Methanol, chemical</td>
<td>34</td>
</tr>
<tr>
<td>Methanol to/as gasoline</td>
<td>900</td>
</tr>
<tr>
<td>Methanol to DME (LPG)</td>
<td>215</td>
</tr>
<tr>
<td>Methanol to Olefins</td>
<td>140</td>
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<tr>
<td>DME (power, diesel)</td>
<td>200</td>
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<tr>
<td>Ammonia</td>
<td>130</td>
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<td></td>
<td>GTL-FT</td>
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<td>------------------------</td>
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<tr>
<td>Technology availability</td>
<td>Issue but improving</td>
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<td>Process steps</td>
<td>3</td>
</tr>
<tr>
<td>Efficiencies</td>
<td>60/77</td>
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<tr>
<td>Fuel markets</td>
<td>Conventional Large</td>
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</tbody>
</table>

Comparison GTL and MeOH
Some Large Methanol/MTO/DME plants (built, proposed)

- **Japan DME Ltd**: 5,000 TPD
- **Iran Methanol 1-5**:
  - Iran Methanol: 5,000 TPD
  - Iran DME: 2500 TPD
- **Iran/Lurgi MTP**:
  - 2500 TPD
- **Oman Methanol**: 3,000 TPD
- **Qatar Methanol**: 6,750 TPD
- **Trinidad** - (2) 5,000 TPD
  - Atlas Methanol Holdings
- **Iran DME**:
  - 2500 TPD
- **Nigeria/Eurochem MTO**:
  - 7,500 TPD
- **Qatar/PetroWorld**:
  - >12,000 TPD
- **China DME Plants**:
  - 1,000 TPD
- **DME Int’l Corp.**:
  - 2,500-4,500 TPD
- **Japan DME Ltd**:
  - 5,000 TPD
- **Qatar/PetroWorld**:
  - >12,000 TPD
- **China DME Plants**:
  - 1,000 TPD
- **DME Int’l Corp.**:
  - 2,500-4,500 TPD

Legend:
- Orange: Methanol
- Light blue: Methanol for Power/Olefins
- Green: DME
Atlas Methanol Plant (5000tpd = 15,000bpd GTL)
UCG Syngas offers Substantial Product Optionalities

**UCG** → **Syngas Clean-up** → **Products**

**Market size**
- Globally well over 600 billion tons of coal suitable for UCG production
- Using the power route and assuming 200 years to extract all reserves, yields annual revenues of **$410bn**
- Main markets relative to global reserves: **US (27%)**, **China (13%)** and **India (10%)**
Preliminary Economics of UCG Appear Attractive

Power economics
(@ $1.5/mmBtu of coal)
$/MWh

Capital cost
Cash cost
IGCC
51
30
21
Conventional coal
44
24
20
UCG
41
24
17

Transportation liquids economics
(@ $40/bbl crude)
$/barrel of gasoline/diesel

Capital cost
Cash cost
FCC refinery
41
5
36
Indirect CTL
25
30
30
UCG CTL
47
16
31

UCG has high potential in power and is feasible in liquids at price >$40/bbl
UCG Syngas for Carbon Free Hydrogen Power

Concept

UCG Syngas → Low Carbon Fuel & Electricity → CO₂ capture & storage

Offer

1. A material scale business opportunity
2. A substantial new climate change solution
3. A sustainable alternative to access coal
BP Scotland H2 Power Project (DF 1)

Project Milestones
• Largest CO2 EOR project in North Sea
• 1st CO2 pipeline in the North Sea
• 1st CO2 storage in an offshore oil field
• World’s largest hydrogen-fired power generation facility
• World’s largest Auto Thermal Reformer

Climate Change Milestones
• 480MW of clean electricity
• Capture and store 1.8 million tons of carbon dioxide a year, equivalent of removing 500,000 cars from the road
• Provides more electricity than UK’s entire wind farm capacity combined

• Millar Platform & Field
• Enhanced Oil Recovery
• CO₂ Secuester
• Low carbon Electricity
• Peterhead Power Station
• Gas
• Terminal

107x101
BP Gas to Products Organisation

- Extensive GTP experience from heritage companies - BP, Amoco and Arco
- Global team of ~ 60 providing full-range of technology, commercial and project support services
- Strong relationship with Davy Process Technology (UK) on GTL
- Extensive in-house R&D programme:
  - advanced fixed bed FT technology;
  - innovative slurry phase FT technology;
  - new technologies to convert gas to transportation fuels and petrochemicals
- External R&D programmes:
  - Caltech and Berkeley Universities in USA
  - Chinese Academy of Sciences
  - improved and breakthrough GTP technologies
BP Fischer Tropsch Technology: Fixed Bed

- Capacity 300 barrels per day (3 mmscfd gas feedstock)
- Started production 2002 – over 1 million manhours of safe operation
- Proprietary BP catalyst (cobalt-based)
- Well established multi-tubular reactor – multiple manufacturers and >50 million tonnes per year of applications worldwide
- FT technology developed in BP since 1981; in partnership with Davy Process Technology since 1996
Summary

• Syngas to Products technologies provide MULTIPLE options to monetize UCG
  – LARGE new markets
  – Mature technologies and proof of technologies
  – Product values tied to crude oil (diesel, LPG, etc)

• UCG has the potential to offer an economic route to syngas production – but only if technology is proven at scale and site development costs are contained

• UCG is relevant to India and can contribute to the nation’s energy security

• Carbon management is critical to sustained UCG implementation