Solving the problem of Associated Gas Small Scale GTL Plants
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Stranded Oil!
2010: Vision realised

Delivering a turnkey associated gas solution to enable oilfield development

- Petrobras plant commissioned and now running under test
- Client commercial plant studies & pre-FEED’s at 200 bpd to 2,000 bpd
- Volume manufacturing supply chain established
- Continuously strengthening team with World-scale GTL experience
- CompactGTL Brazil subsidiary established in Rio de Janeiro
CGTL offers a workable technical solution

• **Safety**
  – Conventional SMR technology
  – No oxygen supply required
  – Offshore certification

• **Operability & Reliability**
  – No catalyst handling on facility
  – Exchangeable 25 tonne reactor modules
  – Handles high CO$_2$ gas
  – Handles variable gas composition & flow-rate

• **Seaworthiness**
  – Low liquid inventory
  – Low centre of gravity (C.O.G.)
  – Motion insensitivity

• **Scalability**
  – Accommodates production decline over field life
Commercial plant design

- 10 MMscfd gas feed
- 1,000 bbl/d syncrude production
- 2,400 T operating weight
- Configurable for:
  - Aframax
  - Suezmax
  - VLCC
25MMscf/d GTL integrated FPSO – SBM Offshore

- Fully integrated design
- Up to 32,000 bbl/d crude production
- 2,000 bbl/d GTL liquids production

Image courtesy of SBM Offshore
Process & Technology Overview
Process overview

Gas treatment
- Pre-wash
- Mercury removal
- Heating
- Sulphur removal

Syngas production
- SMR 1 reactor modules
- SMR 2 reactor modules
- Steam generation (WHR)
- Syngas compressor

FT synthesis
- FT cooling System
- Product flash

Gas feed
- Pre-reformer

Steam
- Water treatment

No Oxygen Required!

High CO₂ Possible!

Fuel treatment
- Mercury removal
- Sulphur removal

FT synthesis
- Product flash
- Syncrude

GC rich tail-gas
- GT drivers
- H₂ rich tail-gas
SMR mini-channel reactor layout

FUEL & COMBUSTION AIR

METHANE & STEAM

COMBUSTION LAYER

COMBUSTION EXHAUST

REFORMING LAYER

COMPLETE SMR REACTOR BLOCK

SYNGAS
Development approach

Lab Reactors | UK Pilot Plant | Brazil Plant | Commercial Plant

Commercial Plant Studies

Reactor & Catalyst Supplier Engagement

Prototype Reactor & Catalyst Evaluation

Supplier Selection

Pilot Reactor & Catalyst Manufacture

Requirements

Commercial Supply Chain Establishment
UK pilot plant operational for 4 years

- Installation at Wilton, NE England
- Plant commissioned July 2008

- Confirming catalyst & reactor performance from manufacturers
- Integrated operation – ‘gas in to liquids out’
- Operational stability, start-up & shut down procedures
- Variable feed gas composition & CO₂ content
- Operator training for larger plants
Inside the UK pilot plant

SMR process equipment

FT process equipment
Mini-channel CompactGTL reactors

- Brazed plate-fin reactor construction minimises metal content and weight
- Complete set of GTL reactors despatched by air-freight to Brazil
- Corrugated metallic catalyst inserts maximise active surface area per channel
- Automated catalyst insertion and removal
Commercial Demonstration Plant

World’s first modular fully integrated GTL facility!

Plant commissioned in December 2010. CompactGTL technology now approved by Petrobras for deployment

- Gas pre-treatment
- Pre-reforming
- Reforming
- Waste heat recovery
- Process steam generation
- Syngas compression
- Fischer Tropsch synthesis
- FT cooling water system
- Tail gas recycling

Image shown courtesy of Petrobras
Pre-commissioning and commissioning activities

1. Reduce FT catalyst in-situ, and reinstall Rx’s.
2. Reduction of Desulphurisation catalyst.
3. Commissioned Combustion Air Blower and heat up SMR Rx’s
4. Boil-out and passivate WHB, Steam-drum and Steam system.
5. Dry-out and curing of refractory in WHB.
7. Commissioned Pre-reformer.
8. SMR at 100% NG load with Syngas on-spec
10. Commission Syngas Compressor
11. Commission FT Membrane,
13. Commission FT Tail-gas system and close the Gas-loop.

Time frame from Pressure test with N$_2$ (Mechanical Completion) to First Oil

(13 November 2010 to 23 January 2011)
**Current Status**

- All equipment in pilot plant is operating at design H&MB values.
- Overall robustness of plant is excellent even though a large number of trips were experienced.
- Overall availability of SMR’s > 82% and FT with Gas loop > 70%.
- Design cases for the Commercial Demonstration plant were:
  - Lean Natural gas case
  - Rich Natural gas case
  - 15% CO₂ in the NG feed
- Additional performance and acceptance test runs completed apart form the three design cases mentioned above were:
  - 35% CO₂ in the NG feed.
  - 50% CO₂ in the NG feed.
Combined steam and CO\textsubscript{2} methane reforming

SMR with CO\textsubscript{2} addition

\begin{align*}
3\text{CH}_4 + 3\text{H}_2\text{O} &\quad = \quad 3\text{CO} + 9\text{H}_2 \quad \text{(Steam Methane Reforming)} \\
+ \quad \text{CO}_2 + \text{H}_2 &\quad = \quad \text{CO} + \text{H}_2\text{O} \quad \text{(Dry Methane Reforming)} \\
\hline
3\text{CH}_4 + 2\text{H}_2\text{O} + \text{CO}_2 &\quad = \quad 4\text{CO} + 8\text{H}_2 \quad \text{(Combined Syngas Product)}
\end{align*}

The combined Steam and CO\textsubscript{2} Syngas product is a more FT friendly feed stock i.e. Closer to H\textsubscript{2} :CO ratio of 2:1
## Overall plant availability

<table>
<thead>
<tr>
<th>Trial 1, 2 &amp; 3</th>
<th>SMR</th>
<th>FT &amp; Gasloop</th>
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<tbody>
<tr>
<td>20 Dec 2010 - 22 Oct 2012</td>
<td>82</td>
<td>70</td>
</tr>
<tr>
<td>Overall CDP Availability</td>
<td>92</td>
<td>83</td>
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<tr>
<td>CDP Service Factor</td>
<td>410</td>
<td>309</td>
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</tbody>
</table>

- **Overall availability** = \( \frac{\text{Actual operating time per month}}{\text{Total time per month}} \)
- **Service factor** = \( \frac{\text{Actual plant availability exclude “in sympathy” shut down}}{\text{Total time per month}} \)
## Total number of plant trips

### Trial 1 & 2 - 13 December 2010 - 22 October 2012

<table>
<thead>
<tr>
<th>Trips - Trial 1 &amp; 2</th>
<th>Number</th>
<th>% of trips</th>
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<tbody>
<tr>
<td>OSBL</td>
<td>32</td>
<td>29</td>
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<tr>
<td>E&amp;I</td>
<td>43</td>
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<tr>
<td>Mechanical / Design</td>
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<td>8</td>
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<tr>
<td><strong>Total Trips</strong></td>
<td><strong>111</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Conclusion

‘Standalone’ solution for oilfield development

Manufacturing route & partners established

CompactGTL structuring as a TURNKEY SOLUTION PROVIDER

UK pilot plant operational for 4 years

Petrobras plant commission and 2 years in operation
Solving the problem of Associated Gas
Small Scale GTL Plants

Thank you for your attention

Any questions?