Modular GTL: Transformational gas solution for the upstream industry

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Industry perceptions of GTL?

- GTL plants are huge?
- GTL needs cheap gas?
- GTL needs a large gas reserve?
- GTL needs excellent site logistics?
- GTL is complicated & unreliable?
- GTL is expensive?

Facts or Myths?
> 100 man-years commercial GTL plant design & operations experience in SA & Qatar
Strong functional organization for project delivery & continuous improvement
3 proven and operational GTL processes today

World scale GTL
Gas monetization
300MMscf/d ++

Compact GTL
Oilfield access
<= 150MMscf/d
Conventional GTL vs. CompactGTL

Shell Pearl Plant - Qatar
140,000 bbl/d GTL products
350 football fields

CompactGTL Modular Plant
1,000 bbl/d plant,
1 Football field
Why is CompactGTL now possible?

Conventional steam reformer / ATR

Conventional FT reactor
Fixed bed or slurry phase

10x increase in specific throughput

Compact SMR Reactor
Compact FT Reactor

CompactGTL reactors using brazed plate & fin construction
CompactGTL - Wide ranging applications

**Onshore**
- 5 - 150 MMscf/d
- 50 – 1,500 MMscm/yr
- ≈ 500 – 15,000 bopd syncrude or diesel
- Monetise stranded & shale gas
- Convert associated gas
- Avoid flaring restrictions & penalties
- Unconventional gas – UCG, CBM

**Offshore**
- 5 – 50 MMscf/d
- ≈ 400 – 4,000 bopd syncrude
- FPSO production ≈ 30 – 60 mbopd crude
- Avoid costly gas export or re-injection
- Avoid flaring restrictions & penalties
- Extended Well Test Facilities
- Early Production Systems
- Full Field Development FPSO
CompactGTL plant configuration

Feed Gas Quality
- Wide range of gas compositions and variability during operation
- Up to 50% CO2 accommodated and utilised by the process – no need for removal
- Contaminants (H2S, Cl, Hg ..) addressed by project specific gas treatment packages
Example – 100MMscf/d plant

Completed client study

- 100 MMscf/d & 10,000 bopd
- Footprint ≈ 335m x 290m
- Capex ≈ $100k per bbl syncrude capacity
- Opex ≈ $18 per bbl syncrude produced
- 4.5 m³/hr water make-up
- 16 MW power demand
25MMscf/d GTL integrated FPSO – SBM Offshore

- Fully integrated design
- 32,000 bbl/d crude production
- 2,000 bbl/d GTL liquids production
- Approval in principle from certifying authority

Image courtesy of SBM Offshore
Technology demonstration & qualification

Pilot plant
Wilton, UK - 2008

- > 4 years operations
- Full GTL process from NG to syncrude
- Reactors from candidate suppliers
- Catalysts from candidate suppliers
- Operator training centre & R&D facility

Commercial demonstration plant
Aracaju, Brazil - 2010

- > 2 years operations
- > 90% availability
- Project fully funded by Petrobras
- Associated gas feed from offshore
- Fully integrated GTL process
- Commercial scale reactors - Sumitomo
- Catalysts - Johnson Matthey

Technology approval by Petrobras 2011
World’s first modular fully integrated and operational GTL facility!

Plant commissioned in Aracaju, Brazil, 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
Technology scale up completed

Commercial CompactGTL FT Reactors: Constructed by Sumitomo
Comprise proven reactor cores modularised into 40’ containerised packages by Kawasaki Heavy Industries
Mini-channel CompactGTL reactor cores

Brazed plate-fin reactor construction minimises metal content and weight

Corrugated metallic catalyst inserts maximise active surface area per channel

Automated catalyst insertion and removal
Technology demonstration & qualification

13 years in development since year 2000
IP 100% owned by CompactGTL
222 granted patents worldwide
275 pending patents worldwide
Independent verification by Bayer, SBM Offshore, Nexant, Fluor, TWI
Independent verification by Oil companies
Flexible deployment

CompactGTL plant features

- Wide range of feed gas compositions
- Configurable for railcar transportation
- High availability – multiple modules
- High turn-down & flexibility
- Exchangeable 100 bopd CGTL reactor modules
- Configurable for utility self-sufficiency
- Fully modularised yard construction options

The number of active reactor modules can be adjusted to match the associated gas production profile over time.
CompactGTL - process overview

Gas treatment
- pre-wash
- mercury removal
- heating
- sulphur removal

Syngas production
- SMR 1 reactor modules
- SMR 2 reactor modules
- steam generation (WHB)
- syngas compressor
- water treatment

FT synthesis
- FT cooling System

Gas feed
- High CO₂ Possible!

No Oxygen Required!

Steam

HC rich tail-gas
- GT drivers

H₂ rich tail-gas
- syncrude
Typical 1,000bpd CompactGTL plant

- **FT**
  - 40’ FT modules

- **SMR**
  - 20’ SMR modules

Dimensions:
- Width: 48 m
- Depth: 29 m
Supply chain partners & projects
World-class partners

- Each partnership represents a well established, long term relationship
- Certain exclusivity rights have enabled pre-investment & joint development funding by the supply chain, ensuring early capacity to deliver
- Reactor manufacturing by Sumitomo in Japan, and catalyst manufacture by Johnson Matthey in Europe, utilise established mass production techniques
- CGTL & Sumitomo jointly developed automated catalyst insertion & removal systems for the reactors
## Project examples – global footprint

<table>
<thead>
<tr>
<th>Client</th>
<th>Region</th>
<th>Feed gas rate</th>
<th>Project driver</th>
<th>Project Status</th>
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<td>MENA</td>
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<td>30 MMscf/d</td>
<td>Eliminate flaring</td>
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</table>
The market & project economics
≈ 800 Oilfields with problematic Associated Gas @ <50MMscf/d

800 oilfields with reserves of 73 bn barrels of oil

Analysis carried out by Wood Mackenzie and Fugro Robertson
Options for associated & stranded gas

- Reinjection & Flaring
- LNG
- CNG
- Pipeline
- Power generation

Distance to market for converted product [km]

Associated Gas MMscf/d
Compelling economics – 5,000 bopd

- 23% IRR: 6 Year pay back, based on $100 oil, Texas location
- Reliable 3 year EPC schedule: Supply chain pre-invested & tested
- Reliable capital cost data: Fluor studies & long term reactor supply contracts
- Opex @ $18 per bbl including all operational, catalyst & technology costs
Conclusions

- **GTL plants are huge?** Historically Yes
  - CompactGTL now available @ 200 to 15,000 bopd

- **GTL needs cheap gas?** It helps
  - Associated gas projects insensitive to gas ‘price’

- **GTL needs a large gas reserve?** No
  - Small strategic stranded gas projects now viable

- **GTL needs excellent site logistics?** No
  - CompactGTL deployed in 40’ modules < 35T

- **GTL is complicated & unreliable?** No
  - CompactGTL Brazil plant proven, 2 years operations

- **GTL is expensive?** No
  - Compelling economics & robust performance