Transformational gas monetisation 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?
3 proven and operational GTL processes today

World scale GTL
Gas monetization
3,000 MMscm/annum+

Compact GTL
Oilfield access
<= 500 MMscm/annum
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 this now possible?

Conventional steam reformer / ATR
Conventional FT reactor
Fixed bed or slurry phase

CompactGTL reactors using brazed plate & fin construction

10x increase in specific throughput

Compact SMR Reactor
Compact FT Reactor
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
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 – 1000 MMscm/annum plant

Completed client study

- 1000 MMscm/annum & 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
Technology overview
Technology demonstration & qualification

Pilot plant
Wilton, UK - 2008

• > 5 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
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

BR
PETROBRAS
TOTAL
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
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
SMR reactor core construction

Modular SMR Reactor

61,000 hours SMR reactor & SMR catalyst in operation
FT reactor core construction

Modular FT Reactor

52,000 hours FT reactor & FT catalyst in operation

FT reactor & FT catalyst in operation
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

FT synthesis
- FT cooling system
- Produkt flash

Gas feed
- High CO₂ Possible!

No Oxygen Required!

FT 1 reactor modules
- FT 2 reactor modules
- Syncrude
- HC rich tail-gas
- H₂ rich tail-gas
- GT drivers
Typical 1,000bpd CompactGTL plant

- Blend Syncrude with the Crude Oil Export
- Standardised mass produced SMR & FT modules
- Road / rail transportable reactor modules
- Bespoke balance of plant to suit client project

FT
40’ FT modules

SMR
20’ SMR modules
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
Stranded gas

- Over 40% of the world’s discovered natural gas is classified as stranded
- Distance to market, lack of alternative solutions and location of reservoirs restricts development
- The abundance of gas and sustained high arbitrage between gas and oil prices, represents a compelling opportunity for CompactGTL projects

>6,000 Trillion cubic feet of proven natural gas reserves worldwide

Source: BP Statistical Review and IEA
Associated gas and stranded oil

800 oilfields with problematic associated gas @ <50MMscf/d.
Reserves of 73 bn barrels of oil

Analysis carried out by Wood Mackenzie and Fugro Robertson
Compelling economics – 5,000 bopd

- 29% IRR : 6 Year pay back, based on production of diesel, naphta and LPG
- Reliable 2 year EPC schedule : Supply chain pre-invested & tested
- Reliable capital cost data : Fluor studies & long term reactor supply contracts
- Capex @ $100,000 per bbl for GTL plant
- 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