About Gas Valorisation Routes

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Presentation’s topics

Share Total’s view about gas utilisation

- Technologies description, including on site
- Reserves vs Products vs Markets
- Technologies comparison
- Conclusions
Gas utilization & monetization routes

Connecting (new) producing areas and consumer countries

**CONDITIONING & TRANSPORT**

- LIQUEFACTION
  - LNG
  - Others (ex: hydrates transport NGH)
- COMPRESSION
  - PIPELINE
  - CNG
- CHEMICAL CONVERSION
  - GTL - FT
  - METHANOL
  - DME
  - Ammonia/Urea

**MARKETS**

- GAS ENERGY
  - EOR
- LIQUIDS
  - FUEL PETROCHEM.
  - FERTILIZERS
- CONDENSATES
  - GTW

**TREATMENT**

- GAS
  - ONSHORE
  - OFFSHORE
  - SOUR
  - FLARED
  - STRANDED

- SOUR gas management
  - H2S
  - O2
  - N2
  - CO2
  - Mercury
  - Others

- Monetization, storage and/or disposal

**COMBUSTION – POWER GEN.**
Gas re-injection context for Total

- **Total commitment:**
  - No continuous flaring on new development (implemented since 2000)
  - Flaring Reduction on existing fields
  - Target: -50% 2005 - 2012

- **Re-injection is part of long term asset management:**
  - Temporary storage before blow down
  - Pressure maintenance
  - EOR
  - Ready for emerging gas value chains

A steady decreasing flaring trend is observed since late ’90s.
As from 2004, amount of re-injected gas is significantly higher than flared gas.
Block 17 – Gas External Storage: second step of global gas management

2009: Gas injection in situ

2012: ALNG Plant start-up

- Screening of potential storage candidates
  - Main criteria: seal, homogeneous depletion, well integrity, 0.4 tcf storable
- Block 2 fields Lombo-East & Tubarao identified as best candidates for external storage
- Multiple stakeholders (Block operators, Angola LNG)
  - Investments of main pipes brought forward, new platform on Block 2
Angola LNG mindset: third step of global gas management from a gas flaring concern to a gas valorization scheme

- **Common Goal**: ensure sustainable oil developments & address gas flaring concerns through a gas valorization scheme

- **Strong Commitment & Alignment of all Stakeholders**: partnership Sonangol - Oil companies

- **Pooling of gas resources**

- **Legal & Commercial Framework** suiting the project characteristics

- **Strong partners** to overcome commercial and technical challenges

- **Start-up**: 2012
Gas injection for pressure maintenance

- Liquid production increase:
  - Oil recovery (pressure maintenance)
  - C3/C4 recovery in gas before re-injection

- No continuous flaring

- The future: blowdown of the field

Gas valorization stake for the host country

Congo – N’Kossa

- FID: December 1992
- First oil: June 1996

Gas injection @ 420 bars since first oil

Cumulative gas injected:
- 30 Gm3 (10 years)
- 71 MTCO2eq
Gas Transport routes:

**BY LIQUEFACTION: LNG**

Transport @ atmospheric pressure and $T=-160^\circ C$

Regasification

*Mature technology → large single train capacity*

**BY COMPRESSION: PIPELINE**

*Standard technology, but international gas pipelines require huge investments and political backing*

**BY COMPRESSION (& REFRIGERATION): CNG**

Transport in dense phase @ 120-250 bar and $T=-30^\circ C + 20^\circ C$

*on-shore trucks, off-shore boats*
Chemical conversions routes:

Syngas generation: common step towards products diversification
Fischer-Tropsch Gas to Liquids process:

Production of liquid hydrocarbons from Natural Gas in 3 steps:

Oxygen source

NG → Synthesis gas production

H₂, CO → Fischer-Tropsch synthesis

Wax & condensates → Upgrading Fractionation

Tail gas → Oil

Power gen → Steam

Fuel → Cooling water

UTILITIES

Markets:
- **Liquid fuels**: Premium Diesel, Jet fuel *(added value)*
- **Petrochemical feedstock**: Naphtha
- **Specialties**
Methanol process:

Main chemical markets:
- Formaldehyde,
- Acetic Acid
- MTBE (banned component, decreasing consumption)

New applications: Biodiesel, Olefins
Di-Methyl Ether process: two routes

**Indirect process: Industrial (small scale plants)**

1. Oxygen source
2. NG → Synthesis gas production
3. H₂, CO (2:1) → Methanol synthesis
4. MeOH → Dehydration
5. DME
6. Water

**Direct process:**

Demo plant Kushiro (Japan) – 100 t/d

1. Oxygen source
2. CO₂
3. NG → Synthesis gas production
4. H₂, CO (1:1) → DME synthesis
5. DME

**Current market: aerosol propellant**

Great potential as: LPG alternative (DME/LPG blend), Transportation fuel (diesel LPG), chemical feedstock (to olefins), Power generation
Production & reserves: order of magnitude

One can produce:

With:

100 MMSCFD of NG

- 0.6 Mt/y LNG
- 11,600 bpd FT/GTL
- 2,300 t/d DME
- 3,600 t/d methanol

Maximum capacity:

(in operation or under construction)

- RasGas (Qatar): 36 Mt/y
- Shell « Pearl » (Qatar): 140,000 b/d
- \( \text{DME}^* \): 6,000 t/d
- Methanex/BP (Trinidad): 5,000 t/d

\( \text{MMSCFD} = \text{Millions of Standard Cubic Feet per day} \)

* Feasibility study only
Reserves* vs Products

Natural Gas reserves

- DME: 6000 t/d (feasibility)
- Methanol: Methanex/BP Trinidad: 5000 t/d
- FT-GTL: Shell Bintulu: 14 700 bpd
- CNG: Sasol/QP « Oryx »: 34 000 bpd
- LNG: Shell « Pearl » Qatar: 140 000 bpd
- LNG (flexible): Flex LNG (Nigeria) – 1.7 Mt/y
- LNG: Yémen LNG: 6.7 Mt/y
- LNG: Oman LNG: 10.5 Mt/y
- Pipeline:

Oman LNG: 10.5 Mt/y → 23 Tcf

* 25 years production
Distance to markets

Flow rate (MMSCFD) vs Distance (x 1000 km)

- FT-GTL
- DME, MeOH
- LNG
- Mini LNG
- CNG
- Pipeline

Legend:
- FT-GTL
- DME, MeOH
- LNG
- Mini LNG
- CNG
- Pipeline
# Maturity

<table>
<thead>
<tr>
<th>Paper study</th>
<th>Pilot unit (lab)</th>
<th>FEED</th>
<th>Demo unit</th>
<th>Industrial units</th>
<th>Standard technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating LNG</td>
<td>Floating (mini)LNG</td>
<td>CNG</td>
<td>DME (direct)</td>
<td>FT-GTL MeOH DME (indirect)</td>
<td>Onshore/offshore pipelines, LNG, onshore mini LNG</td>
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</tbody>
</table>

**On-goings / next steps:**

- **LNG:** Mini, Floating
- **CNG:** ready for off-shore applications
- **FT-GTL:** breakthrough technologies, compact units
- **DME:** Nigata (Japan) first industrial plant (MeOH feedstock, 80,000 to 100,000 tpa) to fuel market in Japan
## Technologies comparison

<table>
<thead>
<tr>
<th></th>
<th>LNG</th>
<th>CNG</th>
<th>FT-GTL</th>
<th>Methanol</th>
<th>DME</th>
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</thead>
<tbody>
<tr>
<td><strong>Maturity</strong></td>
<td>Standard technology</td>
<td></td>
<td>Few industrial units</td>
<td>Several industrial units</td>
<td></td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>~ 80-85% (ex:10,000 km + regas)</td>
<td>~ 90% (ex:1700km) f(distance)</td>
<td>~ 55-60%*</td>
<td>~ 65%*</td>
<td>~ 62%*</td>
</tr>
<tr>
<td><strong>CO₂ emissions</strong></td>
<td>~ 50 (ex:10,000 km + regas)</td>
<td>~ 30 (ex:1700km) f(distance)</td>
<td>100*</td>
<td>70*</td>
<td>77*</td>
</tr>
<tr>
<td><strong>Markets</strong></td>
<td>150 Mt/y (Regasification)</td>
<td>Regional</td>
<td>1100 Mt/y (Diesel)</td>
<td>40 Mt/y</td>
<td>Great potential</td>
</tr>
<tr>
<td><strong>CAPEX</strong></td>
<td>First train, added trains</td>
<td>Leasing/service contract</td>
<td>Multiple trains</td>
<td></td>
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</tr>
<tr>
<td><strong>OPEX (incl. CO₂)</strong></td>
<td></td>
<td>OPEX = Transport f(distance, capacity, gas composition)</td>
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<tr>
<td><strong>Transport</strong></td>
<td>f(distance)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Prices (relative)</strong></td>
<td>Gas market</td>
<td>Gas market</td>
<td>Premium diesel</td>
<td>?</td>
<td>[LPG, +20% LPG]</td>
</tr>
</tbody>
</table>

* Transport excluded
Conclusions:

- On site use is always considered (energy needs, reservoir pressure maintenance, EOR, storage).

- When there is no local market or existing pipeline system, **LNG remains the preferred monetization option** ⇒ effort to improve its efficiency and profitability at smaller capacities (mini-LNG, Floating-LNG)

- CNG represents a viable niche for small capacities and short transport distances (provided regional markets)

- Gas conversion technologies produce added value products, especially in a high oil price scenario, but different challenges still to be tackled:
  - FT-GTL: high investment costs, efficiencies & CO₂ management
  - Methanol: relative price fluctuations, single large plant impact on world scale production
  - DME: new market ⇒ commitment in future development

- Methanol and DME ⇒ feedstocks for (poly)olefins production
  - MTO demonstration plant in Feluy
TOTAL, a major LNG player

- Yemen LNG (39.6%)
  - Capacity: 6.7 Mt/y
  - Start-up early 2009(e)
  - US, Asia*

- Qatargas II TrB (16.7%)
  - Capacity: 7.8 Mt/y
  - Start-up 2009(e)
  - Europe, US*

- Angola LNG (13.6%)
  - Capacity: 5.2 Mt/y
  - Start-up 2012(e)
  - US*

- NLNG T7 (15%)
  - Capacity: 8.5 Mt/y
  - FID 2009(e)
  - US*

- Brass LNG (17%)
  - Capacity: 10 Mt/y
  - FID 2009(e)
  - Europe, US*

- Shtokman (25%)
  - Capacity: 7.5 Mt/y
  - FID 2009(e)
  - Europe, US

- Ichthys LNG (24%)
  - Capacity: 8.4 Mt/y
  - Start-up early 2009(e)
  - Asia

Total’s LNG projects
- 9 liquefaction plants existing or under construction
- 5 liquefaction plants under FEED or study
- 5 regas facilities

Close to 20% of Total’s production by the middle of the next decade

* base case destinations
** Group share of LNG sales by affiliates and participations, including FAS69 production equivalent on Bontang sales and excluding trading