Technology role for Natural Gas Valorization

MITEI, March 2012

eni.com
**eni** was one of the first companies in the world to believe in the potential of natural gas

- Soon after its foundation in 1953, **eni** was asked to supply energy to Italy and contribute to the country's industrial development. Energy reserves discovered in the country were mainly natural gas and so the **eni**'s founder E. Mattei, began a process of converting the country’s industrial base to the use of natural gas.

This move anticipated the strategic role that natural gas would come to play in the future, and contributed to **eni**’s decisive role in promoting this source of energy, also at international level.
Global primary natural gas demand will increase from 3.1 tcm to 5.1 tcm in 2035, with an average rate of increase being close to 2% per year.
Natural Gas Highlights

Today, natural gas is the fossil fuel with the brightest future for several reasons:

- Natural gas resource base is huge and geographically widespread.
- The “revolution” of unconventional gas and the growing LNG trade have the potential to significantly improve security of supply.
- Natural gas is the least polluting among fossil fuels and it will play an important role in decarbonizing the future energy mix.

The potential of gas is sometimes hampered by its location and IHS CERA estimates some 1,450 Tcf of stranded gas.
Gas resources

- Abundance of proved resources (6,840 Tcf) more than doubled if unconventional are included
- However 1,450 Tcf are stranded
- A technology driven monetization strategy is needed
  - Make gas available to the end user at optimal costs
  - Diversification of products and markets

Role of technology
Transport issues
Gas valorization: Right Balance of Energy Density & Energy Efficiency

Key factor: increase the energy density of the fluid to be transported …..

1 Sm³ volume

... Keeping at high level the energy efficiency……

CNG

T = amb.
P = 250 bar
Energy Efficiency ~ 95%

LNG

T = -160°C
P = amb.
Energy Efficiency ~ 90%

GTL

T = amb.
P = amb.
Energy Efficiency ~ 70%

Physical

Chemical

exploration & production
## The Status of the NG Valorization Technologies Maturity

### Mature Technologies
- **Energy Market**
  - LNG
  - Large Scale Methanol
  - IPP (Ind. Power Project)
  - Pipeline
- **Chemical Market**
  - Methanol
  - Ammonia, Urea

### Technologies under development (R&D)
- **Energy Market**
  - Marine CNG (composite)
  - NGH (Natural Gas Hydrate)
- **Fuel Market**
  - Floating GTL
  - Breakthrough technologies for direct conversion

### New Technologies (limited application)
- **Energy Market**
  - Small-Medium LNG
  - Floating LNG
- **Fuel Market**
  - GTL
  - DME (Di-Methyl Ether)

### New Technologies (no application)
- **Energy Market**
  - Marine CNG
- **Fuel Market**
  - Small Scale GTL
The Conveyance Role of “Stranded Gas”

- The challenge of monetizing associated and stranded gas resources is basically logistical

- A technology portfolio is needed/must to be developed
  - Capex reduction
  - Handling small amount of natural gas
  - New products
Physical new technologies

**MARINE CNG**
- Transportation of compressed gas at 200-250 bar
- Suitable for regional market (max 3000 km) and small-medium reserves (1-3 Tcf)

**Small-Medium LNG**
- On-shore application for local market (20+ units in operation)
- Access to regional or international gas markets
- Suitable for small-medium reserves (typical train capacity: 50 ktpa up to 2 mtpa)

**Floating LNG**
- Typical LNG train capacity for floating application: from 1 up to 3.6 mtpa
- Relevance of the Shell FID for Prelude initiative (3.6 mtpa)
Gas To Liquids (GTL): a different approach

- 1 MMscm of Natural Gas yields:
  - 3600 bbl of ultra clean distillates (30% naphtha and 70% Diesel)
  - 4600 bbl of water
  - Power (5-10 Mwe)
- Total carbon efficiency: 73 % (eni technology)
Environmental Drivers of GTL

High Quality fuels

- legislation trends mandating for low sulphur, lighter, clean-burning fuels
- environmental attributes of the GTL products
  - no sulfur
  - zero aromatic HC in the naphtha
  - Less particulate
  - Less carbon monoxide

<table>
<thead>
<tr>
<th></th>
<th>Conventional vs. eni/IFP GTL Diesel</th>
<th>Standard Diesel</th>
<th>“Green” Diesel</th>
<th>GTL Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling range (°C)</td>
<td>180-360</td>
<td>180-360</td>
<td>150-360</td>
<td></td>
</tr>
<tr>
<td>Density 15°C (kg/m³)</td>
<td>840</td>
<td>831</td>
<td>780</td>
<td></td>
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<tr>
<td>Sulphur (ppm vol)</td>
<td>50</td>
<td>4.5</td>
<td>&lt; 0.5</td>
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<tr>
<td>Aromatics (% vol)</td>
<td>23.4</td>
<td>22.7</td>
<td>&lt; 0.1</td>
<td></td>
</tr>
<tr>
<td>Cetane number (CN)</td>
<td>51</td>
<td>55</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>CFPP(2) (°C)</td>
<td>-15</td>
<td>-11</td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>Cloud point (°C)</td>
<td>0</td>
<td>-1</td>
<td>-15</td>
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Emission Test Cycles with different diesel fuels (NEDC test cycle, VW Passat 1900 TDI-E3)

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<tr>
<td>Hydrocarbons (g/km)</td>
<td>0.06</td>
<td>0.04</td>
<td>0.03</td>
<td></td>
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<tr>
<td>Carbon monoxide (g/km)</td>
<td>0.23</td>
<td>0.17</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Particulate matter (g/km)</td>
<td>0.033</td>
<td>0.030</td>
<td>0.022</td>
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Oil & Gas Market: New Opportunities for GTL

- Raise in price spread between low-cost natural gas and high-cost petroleum products
- Regional differences in the gas market
- Product value (increasing global demands of high quality distillates)

Source: Wood McKenzie
GTL dilemma

Pros

✓ gains access to abundant gas reserves
✓ possible value chain opportunities and synergies (upstream and chemicals)
✓ global growth in liquid fuels demand
✓ legislation mandating low sulphur, lighter, clean-burning fuels

Cons

- High Capex
- Low energy efficiency
- Price spread gas – oil uncertainty
- Limited industrial references
Conclusions

Gas is a very abundant energy resource and will play a primary role in the future energy market

Technology has been a key driver and success factor for the shale gas revolution in North America

Next key technology step for the gas valorization will be related to logistic and transportation

The size of gas reserves, distance to markets, and supply volatility determine the optimal technology for each development

eni has a long history in gas valorization and is a world's leading vertically-integrated natural gas company

eni owns a complete technological portfolio that include proprietary processes for GTL to enter what is expected to be the: “golden age of gas”