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Distribution of proved natural gas reserve by region, 2008  
“Trillion cubic metres”


Reserves-to-production (R/P) ratio “Years”

Global proved reserves of natural gas increased by 7.47% in 2008, and the R/P ratio increased to 80.4 years. Increases in Turkmenistan and Iran accounted for most of this growth.
**Share of NG Consumption -%**

**Share of NG in primary energy consumption by region-% (2007)**

**NG consumption, production, and reserves by region, 2007**

**NG consumption per capita- 2008 “tonnes oil equivalent)”**
NG Transportation: Pipelines & LNG

Facts and considerations for NG transportation

NG Properties “depends on NG well)

• Composition (CH4, C2H6, C3H8 and others)
• Density (less than air “0.6-0.8 kg/m3’)
• Flammability (5-15% by volume)
• Self ignition temp. (600-700 deg. c)
• Heating value (acceptable 990-1090 btu/ft3)
• NG advantages “as a fuel” (technical, economic and environmental advantages)
Facts and considerations for NG transportation

• 1 ton NG occupies a volume around 1350 m³, whereas 1 ton of oil occupies a volume slightly higher than 1 m³.
• Because of its physical nature, NG is more difficult and costly to transport/store than oil. It needs high pressures and/or low temperatures to increase the bulk density.
• The cost of transporting NG per unit of energy is perhaps 10 times of oil.
• There are two methods to transport NG (PIPEGINES and LNG).

Natural gas chain
Gas chains

Transport by Pipelines: Production, Processing, Transmission, and Storage
• The first pipelines were built in the late 1800s.
• Pipeline is a convenient method of transport but are not flexible as the gas will leave the source and arrive at its (one) destination

• The volume of transported gas depends on:
  • Pipeline operating pressure
  • Pipe diameter.

• Operating pressures:
  • About 70 bars/onshore
  • 100-150 bars/off shore
  • Recompression station/100-150 km.

NG network in Egypt
Capital costs allocation and pipeline construction workforce (%)

<table>
<thead>
<tr>
<th>Labor Category</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe fitters and welders</td>
<td>6</td>
</tr>
<tr>
<td>Equipment operators</td>
<td>27</td>
</tr>
<tr>
<td>Truck drivers</td>
<td>29</td>
</tr>
<tr>
<td>Laborers (including welder’s helpers)</td>
<td>18</td>
</tr>
<tr>
<td>Superintendent</td>
<td>6</td>
</tr>
<tr>
<td>Others (construction inspectors, camp and catering, electricians, iron workers, etc.)</td>
<td>13</td>
</tr>
</tbody>
</table>

Relation between gas pipeline capacity and transportation cost

On average: Installation of pipeline costs, 1–5 US$ million per mile, sometimes even higher, depending on the land characteristics (such as for onshore, mountains or for offshore, seabed flatness and depth) plus compressor stations.
Liquefied Natural Gas Chain

• The first commercial LNG facility was built in the U.S. in 1941, and the first large-scale LNG plant was built in Algeria.
• The LNG process is more complex than pipeline.
• Liquefaction plants are typically the most expensive element in an LNG project (8%–10% of gas delivered to the plant is used to fuel the refrigeration process.)
Simplified NG Liquefaction

Cost of LNG Processes (from liquefaction to user)

<table>
<thead>
<tr>
<th>Items</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>liquefaction plant</td>
<td>0.7 - 1 billion $</td>
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<tr>
<td>LNG reservoir + platform for filling LNG from reservoir to Carrier</td>
<td>1 - 1.5 billion $</td>
</tr>
<tr>
<td>A Carrier for LNG transportation</td>
<td>0.3-0.5 billion $</td>
</tr>
<tr>
<td>Platform for unload LNG and reservoirs to receive LNG</td>
<td>1 – 1.5 Billion $</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>3 - 4.5 Billion $</strong></td>
</tr>
</tbody>
</table>
Natural Gas Prices and Cost of Transportation

World and U.S. natural gas price “2005” (US$/Mbtu)

1 Cubic Meter NG = 35 Million btu

NO fixed price for NG

Source: EIA Energy Information Administration

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Average 2007 Price $8.85
Prices of NG in different countries compared to Oil -US$/million btu “1985-2008”

<table>
<thead>
<tr>
<th>Year</th>
<th>LNG (\text{Henry Hub}^*)</th>
<th>European (\text{NYMEX}^*)</th>
<th>Middle East (\text{NBP}^*)</th>
<th>US (\text{NYMEX}^*)</th>
<th>Canada (\text{NBP}^*)</th>
<th>Declared Equivalent (\text{EUR}^\dagger)</th>
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<td>1986</td>
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Share of transmission and distribution cost decreases by time due to technology improvement

Average breakdown natural gas prices (US$ per million btu), 1995-2007

Source: UNCTAD based on data from Energy Information Administration, Natural Gas Monthly

Share of transmission and distribution cost decreases by time due to technology improvement

Price of natural gas

Transmission and distribution costs
Costs Of NG Transportation Versus Oil

ILLUSTRATIVE COSTS OF GAS, OIL AND COAL TRANSPORTATION SHOWING GAS'S HIGHER COSTS AND THE EFFECT OF SCALE (Gas Delivery Capability in MMcf/d)

[1] Includes Regasification
## International NG Trading and Arab Share

NG trade movements “export & import” by pipelines, 2008
(billion cubic meter)

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<thead>
<tr>
<th>Region</th>
<th>Total Exports</th>
<th>Total Imports</th>
<th>Europe</th>
<th>Middle East</th>
<th>Asia</th>
<th>Oceania</th>
<th>Africa</th>
<th>Latin America</th>
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</tr>
</tbody>
</table>

Notes:
- Flows are net exports and may not correspond to individual gas flows in all cases.
- Figures for total exports and total imports include the North Sea gas fields.

Source: Enerdata (principal authors, mondialisation des gaz naturels, 2008).
NG trade movements by LNG, 2008 (billion cubic meter)

Trade movements 2008 – liquefied natural gas

<table>
<thead>
<tr>
<th>To</th>
<th>US</th>
<th>Mexico</th>
<th>Argentina</th>
<th>Dominican Republic</th>
<th>Puerto Rico</th>
<th>Europe</th>
<th>Total Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>7.47</td>
<td>1.20</td>
<td>0.33</td>
<td>0.47</td>
<td>0.51</td>
<td>0.24</td>
<td>9.94</td>
</tr>
<tr>
<td>S. &amp; Cent. America</td>
<td>0.40</td>
<td>0.29</td>
<td>0.08</td>
<td>0.51</td>
<td>0.01</td>
<td>0.41</td>
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<td>Europe</td>
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<td>0.56</td>
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<td>Total exports</td>
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<td>0.24</td>
<td>0.10</td>
<td>0.24</td>
<td>0.01</td>
<td>0.01</td>
<td>4.44</td>
</tr>
</tbody>
</table>

Note: The negative entry for 'from Belgium to Belgium' represents the re-export of LNG which was delivered to Zeebrugge terminal and then reloaded and shipped to other destinations.

Sources: Cedigaz (provisional) and ETP report.

Major NG trade movements worldwide – pipelines & LNG (billion cubic metres)
Total NG trade “pipeline & LNG” in the Arab region-2008 (billion cubic meter)

<table>
<thead>
<tr>
<th></th>
<th>LNG</th>
<th>Pipelines</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>226.5</td>
<td>578.3</td>
<td>804.8</td>
</tr>
<tr>
<td>Arab countries/ total world</td>
<td>94.6</td>
<td>67.4</td>
<td>162</td>
</tr>
<tr>
<td></td>
<td>(41.7%)</td>
<td>(11.5%)</td>
<td>(20.1%)</td>
</tr>
<tr>
<td>Trade within Arab region/Total Arab trade</td>
<td>----</td>
<td>21.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(32.2%)</td>
<td></td>
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<tr>
<td>(LNG + Pipelines)</td>
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<td></td>
<td>“13.5% within the region”</td>
<td>“86.5% outside the region”</td>
<td></td>
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</tbody>
</table>

Growth of NG trading

- The global gas trade is forecasted to increase by more than 2% per year for the next twenty years.
- LNG global trade has increased by 7.4% per year (1995 to 2005)
- By the end of 2007
  - There were 15 LNG exporting countries and 17 LNG importing countries, with four more (Yemen, Angola, Peru, Russia) by 2012.
  - The three biggest LNG exporters were Qatar (28 MT), Malaysia (22 MT) and Indonesia (20 MT)
  - The three biggest LNG importers in 2007 were Japan (65 MT), South Korea (34 MT) and Spain (24 MT).
- More than $250 billion of new investment will be required to meet LNG demand until 2030.
Main Articles of NG Agreement/Contract

A. Agreement for all participating countries "umbrella for all parties" to address fundamental issues that pertain to all parties.

B. Bilateral agreements between states and national law of each state can be considered as deemed necessary.

C. The more participating countries in Agreement the more difficulties

Main Articles

(1) Period
Internationally, especially where a gas development project will have a limited number of potential customers, the period could reach 20 or 30 years.

(2) Quantity.
Generally, there are two types of contracts:

1. Depletion contracts, the producing company dedicates the entire production from a particular field or reserve to a buyer.

2. Supply contracts the seller supplies a fixed volume of gas to the buyer for fixed term "20 -25 years". The seller is responsible for sourcing the gas, either from its own reserves or from third parties.
(3) Price

- Gas must be priced at a level competitive with alternate fuels in the marketplace and provide an adequate return for all parties in the chain.
- Pricing may be:
  - **Fixed** price over the period of the contract and is usually found in shorter-term contracts.
  - **Floating “fixed price with an escalator”** increases by certain percentage every year or other specified time frame.
  - **Floating price** “varies according to prices reported by neutral sources, such as newspapers and NYMEX “New York Mercantile Exchange” quotations. In this case, the contracts are revalued every month, or every week according to the reported prices.
  - **Combinations of fixed and floating** prices.

(4) Delivery obligation

- **Rigid delivery** “obligates the producing company or seller to deliver the specified quantities over the period of the contract. If the delivery obligation is not fulfilled, the seller may be obliged to pay damages or cover the costs of alternate fuels used by the buyer”.
- **Flexible delivery** “obligates the producing company to make attempts to fulfill the delivery obligation but does not require fulfillment of all the delivery obligations”.
(5) Take-or-pay (TOP) obligations

- The buyer is obliged to pay for a percentage of the contracted quantity if the buyer is unable or fails to take the gas supplied by the seller, other than due to fault of the seller or force majeure incidents.
- The seller usually requires TOP obligation on the buyer to guarantee a predictable minimum cash flow.
- Financial institutions involved in the gas field or pipeline development may require these obligations as a condition for financing.

(6) Delivery point / location where gas is delivered to the buyer

It could be at the gate of the power plant, the center of grid city, the site of a compressor, international border, or the boundary of LNG plant.

(7) Gas quality

- Maximum and minimum heating values (Btu/MMcf);
- Maximum level of impurities like oxygen, CO₂, SOₓ, and NOₓ and Water vapor content.
- Delivery pressure;

**Note:** The LNG agreements requires numerous legal/articles than pipelines..
Findings and conclusions

• NG is more difficult and costly to transport than oil (transporting NG per unit of energy is about 10 times higher than oil) – Therefore, the countries which produce oil and gas should maximize their use of NG locally and export the oil.

• The global NG trade is expected to increase by about 2% per year for the next 20 years.

• LNG global trade has increased by 7.4% per year (1995 to 2005). The three biggest LNG exporters were Qatar (28 MT), Malaysia (22 MT) and Indonesia (20 MT).

• More than $250 billion of new investment will be required to meet LNG demand until 2030.

• The Arab countries NG trade represents 21% of the total world (13.5% of this percent is carried out within the Arab region, while 86.5% outside the region). Therefore there is a need to find appropriate mechanisms to promote NG trading between Arab countries.

• The Arab region has a huge NG reserve (reserve/production in the middle east = 200 years), this gives a trust to establish long term NG transportation/trading projects in the region.

• Main obstacles against NG transportation and trading:
  – High investment
  – Crossing the borders between countries
  – Differences between interests of counties/parties
  – Differences in regulations/laws for each county/party
  – Political, financial and technical risks
Some common unit conversions

These conversions are based on:

- bbl oil = 5.8 MMBtu = 5,800 MBtu
- 1 ft³ gas = 1,000 Btu = 1 MBtu

Thus:

- 1 bbl oil ≈ 5,800 ft³ gas = 5.8 Mcf gas
- 1 boe ≈ 5.8 Mcf gas

References for more information

1. [http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V2S-49CKW33-1&_user=1916176&_coverDate=11/30/2003&_rdoc=1&_fmt=full&_orig=search&queryId=C000055305&_version=1&_userid=1916176&md5=0a27004b9b08dd6300fa387rdbb0d767f1]
2. [http://www.natgas.info/html/gastrade.html]
3. Energy Information Administration: [http://www.eia.doe.gov/]
Thank you for your attention