Gas:
Social, environmental and economic concerns

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Commodity: global trends

- Demand
- Supply
- Resources
Demand

World gas demand by sector in IEA New Policies Scenario

Supply

Gas production (billion cubic metres)  Gas consumption (billion cubic metres)

Resources

Conventional resources:

• NG: mixture of hydrocarbons containing mostly methane (c.ca 90% mole), ethane (5%), propane and butane. Raw gas can contain significant quantity of sulphur and must be treated.
• LNG: Natural Gas that has been liquefied for ease of storage and transport. The chain includes liquefaction facilities, transport usually in ships, re-gasification facilities.

Unconventional resources:

• Tight gas: natural gas produced from reservoir rocks with very low permeability, requiring intensive hydraulic fracturing (fracking) for economic production. Mostly US.
• Shale gas: natural gas found trapped in shale formations (clastic sedimentary rocks). Produced by fracking. Biggest production currently in US. Biggest reservoirs estimated in China.
• Coalbed methane: natural gas extracted from coal beds. Produced mainly in US, Canada, Australia.
## Resources

**Gas: social, environmental and economic concerns**

### Proven reserves = 90% probability to be extracted profitably

### Reserves to Production ratio (R/P) of around 50 years

### Gas resources (tcm)

<table>
<thead>
<tr>
<th>Region</th>
<th>Conventional</th>
<th>Unconventional</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tight gas</td>
<td>Shale gas</td>
<td>Coalbed methane</td>
</tr>
<tr>
<td>OECD</td>
<td>78</td>
<td>24</td>
<td>81</td>
</tr>
<tr>
<td>Americas</td>
<td>51</td>
<td>11</td>
<td>55</td>
</tr>
<tr>
<td>Europe</td>
<td>17</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Asia Oceania</td>
<td>10</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Non-OECD</td>
<td>356</td>
<td>57</td>
<td>138</td>
</tr>
<tr>
<td>E. Europe/Eurasia</td>
<td>138</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Asia</td>
<td>35</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td>Middle East</td>
<td>104</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Africa</td>
<td>51</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td>Latin America</td>
<td>28</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td><strong>434</strong></td>
<td><strong>81</strong></td>
<td><strong>218</strong></td>
</tr>
</tbody>
</table>

Technologies in the gas chain

- Extraction
- Transportation and storage
- Combustion-based power plants
- Economic, Environmental and Social concerns
Sample Reference Energy System

- **Import / Extraction + processing of fossil fuels**
  - Gas

- **Fuel transportation**
  - Gas

- **Combustion-based power plant**
  - Gas distribution
  - Electricity transmission and distribution

- **Nuclear power plant**

- **Energy demand**
  - Transportation sector
  - Residential sector
  - Commercial sector
  - Industrial sector

**Energy demand**

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Gas: social, environmental and economic concerns
Extraction

Processes - conventional gas:
- Conventional wells: lately case drilling is used
- Deepwater production: made possible by floating platforms. 3000 m reached in 2005.

Processes - unconventional gas:
- Hydraulic fracturing: used for tight gas, shale gas and coalbed methane. It consists in pumping high-pressure liquid in the rocks to fracture them and ease the gas flow. Coupled with horizontal wells.

<table>
<thead>
<tr>
<th>Key characteristics</th>
<th>Conventional gas</th>
<th>Unconventional gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>5.3-63.7 $/boe</td>
<td>-</td>
</tr>
<tr>
<td>VOM cost</td>
<td>3.2-8.3 $/boe</td>
<td>6.6-19.7 $/GJ</td>
</tr>
<tr>
<td>Recovery factor</td>
<td>70-80%</td>
<td>10-70%</td>
</tr>
<tr>
<td>Energy use</td>
<td>0.8-2.3 GJ/toe</td>
<td>20-30% of produced</td>
</tr>
<tr>
<td>CO2 Em. factor</td>
<td>64.9-273.6 ton/ktoe</td>
<td>9.3-15 gCO2/MJ</td>
</tr>
</tbody>
</table>
Transportation and storage

**Transportation**
- Pipelines: used for short to medium distances (including distribution to final users) and large volumes.
- LNG shipping: for long distances and large volumes. This technology also includes liquefaction and re-gasification facilities.

**Storage**
Natural gas is stored for commercial or energy security reasons.
- Underground storage: in depleted gas reservoirs or salt caverns.
- On-board LNG fleets.

<table>
<thead>
<tr>
<th>Key characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipeline</strong></td>
<td></td>
</tr>
<tr>
<td>Capital cost</td>
<td>194-226 M$/km</td>
</tr>
<tr>
<td>Energy use</td>
<td>1.8-2.7% of transported</td>
</tr>
<tr>
<td><strong>LNG liquefaction</strong></td>
<td></td>
</tr>
<tr>
<td>Capital cost</td>
<td>2.9-3.8 $/MMBtu</td>
</tr>
<tr>
<td>VOM and FOM cost</td>
<td>10500 $/ton</td>
</tr>
<tr>
<td>Natural gas losses</td>
<td>15%</td>
</tr>
<tr>
<td><strong>LNG shipping</strong></td>
<td></td>
</tr>
<tr>
<td>Capital cost</td>
<td>245 M$/150000 m3</td>
</tr>
<tr>
<td>Energy use</td>
<td>Diesel, NG, HFO</td>
</tr>
<tr>
<td>CO2 Em. factor</td>
<td>Depends on fuel</td>
</tr>
<tr>
<td><strong>LNG re-gasification</strong></td>
<td></td>
</tr>
<tr>
<td>Capital cost</td>
<td>45-75 $/ton</td>
</tr>
</tbody>
</table>
Combustion-based power plants

Open Cycle Gas Turbines (OCGTs):
Typical size between 10 and 300 MW. Fast ramping, usually used for peak generation. Also fed with oil products.

Combined Cycle Gas Turbines (CCGTs):
One unit consists in a Gas Turbine + a Heat Recovery Steam Generator (HRSG) with a Steam Turbine. Power plants usually combine 2 or 4 of these units. Largely used and efficient, flexible, but not as much as OCGTs. Used for both base and peak generation.

<table>
<thead>
<tr>
<th>Key characteristics</th>
<th>OCGTs</th>
<th>CCGTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>900 $/kW</td>
<td>1100 $/kW</td>
</tr>
<tr>
<td>VOM and FOM cost</td>
<td>36 $/kW/a</td>
<td>44 $/kW/a</td>
</tr>
<tr>
<td>Lifetime</td>
<td>30 years</td>
<td>30 years</td>
</tr>
<tr>
<td>Efficiency</td>
<td>35-42%</td>
<td>52-60%</td>
</tr>
<tr>
<td>CO2 Em. factor</td>
<td>480-575 kg/MWh</td>
<td>340-400 kg/MWh</td>
</tr>
</tbody>
</table>
Economic concerns

Are prices of oil and gas still coupled?

Spot prices of NG on selected markets compared to LNG and Oil prices [US $/million Btu]

Source: BP Statistical Review of World Energy 2017
Economic concerns

Greater geopolitical concerns about the role of natural gas in the international relationships:

• Competition between 1) the SouthStream project launched by Gazprom and initially supported by ENI (now abandoned), bringing gas from Russia, and 2) Nabucco, backed by several EU Member States, bringing gas from Iran and Azerbaijan.

• New reservoir discovered offshore Israel – Cyprus – Egypt – Lebanon – Syria. How is it going to affect the relations and diplomacy between the countries?

• Just when the revolution came in 2011, Syria had approved a pipeline from Iran, while rejecting one from Qatar through Saudi Arabia.
Economic concerns

In addition, big discussion ongoing in some markets (e.g. Europe) about the role of NG-fired generation in the power system in the next decades:

Increasing penetration of renewables causes generation to be intermittent

Gas-fired power plants are fast ramping and will be called to balance intermittency

This turns to be economically unsustainable for the operators of the power plants
Environmental and social concerns

Environmental concerns:

• The combustion of gas (e.g. for electricity generation or transportation) is again responsible for emissions at local, regional and global level, such as CO₂, NOₓ, SOₓ;

• In addition, Methane (CH₄) is a GHG with 20 times stronger effect than CO₂! Any direct emission of CH₄ from gas leaks through the production chain contributes to the global warming.

Social concerns:

• Similar concerns to those for Oil apply.
Conclusions
• There is high demand for gas and it is expected to increase, especially in the power sector;
• Gas is less CO2 intensive than oil and coal. Replacement of the latter with gas will decrease the pressure of GHGs emissions;
• Gas-fired generation is flexible enough to provide backup for large shares of variable renewables in the electricity supply;
• Still, gas shares most of the economic, environmental and social concerns of oil.
References and reading material
IEA, World Energy Outlook 2016;


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How natural gas could be a geopolitical game-changer in the Mideast: https://www.youtube.com/watch?v=pay5dKYvXGU

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