Natural Gas Facts & Figures

New Approach & Proposal
1. Production and reserves

Sources: Total G&P, WOC1, IEA, Ihs Cera,

- Resources- Reserves
  - Conventional
  - Unconventional: types and reserves
- Countries, companies
- Costs of production
- New technics and advances ?? (undersalt, high depth, distant offshore)
- Environmental issues (as a specific part)
Natural Gas reserves: plenty & more to come

Proven conventional reserves are growing

In addition:
Unconventional gas has come within technological & economic reach

Conventional
Unconventional

Shale gas
Coal bed methane
Tight gas

The total long-term recoverable conventional gas resource base is more than 400 tcm, another 400 tcm is estimated for unconventionals: only 66 tcm has already been produced.

- IEA-Golden Age of Gas 2011-
Conventional Reserves: plenty and more to come

Growing proven reserves

Global proven gas reserves have more than doubled since 1980, reaching 190 trillion cubic metres at the beginning of 2010

Source: IEA World Energy Outlook 2011
World gas resources by major region (tcm)
significant unconventional prospects world-wide

Inventorization of unconventional gas is still at an early stage

Source: IEA Golden Age of Gas, 2011
Proven reserves of natural gas by region (Tcf) - 2012

<table>
<thead>
<tr>
<th>Region</th>
<th>Proved Reserve</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle East</td>
<td>2799.98</td>
<td>41%</td>
</tr>
<tr>
<td>Eurasia</td>
<td>2164.80</td>
<td>32%</td>
</tr>
<tr>
<td>Africa</td>
<td>545.69</td>
<td>8%</td>
</tr>
<tr>
<td>Asia &amp; Oceania</td>
<td>504.75</td>
<td>7%</td>
</tr>
<tr>
<td>North America</td>
<td>412.39</td>
<td>6%</td>
</tr>
<tr>
<td>Central &amp; South America</td>
<td>270.05</td>
<td>4%</td>
</tr>
<tr>
<td>Europe</td>
<td>146.94</td>
<td>2%</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td><strong>6844.60</strong></td>
<td>--</td>
</tr>
</tbody>
</table>

Source: DOE Energy Information Agency
Proven reserves of Natural Gas by Country (Tcf) 2012

Source: DOE Energy Information Agency
Evolution of proved reserves (Tcf) 2000-2012

Source: DOE Energy Information Agency
Proven Reserves of Natural Gas by IOCs (Bcf) 2010-2012

Source: 2012 Annual Reports
### Production of Natural Gas by Region (Bcf) 2011

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Natural gas (Bcf)</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD Total</td>
<td>40252.49</td>
<td>35%</td>
</tr>
<tr>
<td>Africa</td>
<td>7003.48</td>
<td>6%</td>
</tr>
<tr>
<td>Asia (excluding China)</td>
<td>10685.19</td>
<td>9%</td>
</tr>
<tr>
<td>China (P.R. of China and Hong Kong)</td>
<td>3530.04</td>
<td>3%</td>
</tr>
<tr>
<td>Non-OECD Americas</td>
<td>5932.32</td>
<td>5%</td>
</tr>
<tr>
<td>Middle East</td>
<td>18114.02</td>
<td>16%</td>
</tr>
<tr>
<td>Non-OECD Europe and Eurasia</td>
<td>29751.24</td>
<td>26%</td>
</tr>
</tbody>
</table>

Source: IEA International Energy Agency
Production of Natural Gas by Country (Bcf) 2011

Source: IEA International Energy Agency
## Production of Natural Gas by Country (Bcf) 2011

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (Bcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>22706.30</td>
</tr>
<tr>
<td>Qatar</td>
<td>5526.10</td>
</tr>
<tr>
<td>Islamic Republic of Iran</td>
<td>5225.08</td>
</tr>
<tr>
<td>People's Republic of China</td>
<td>3529.32</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2917.89</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>2877.13</td>
</tr>
<tr>
<td>Nigeria</td>
<td>2858.75</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>2214.67</td>
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<tr>
<td>Uzbekistan</td>
<td>2103.07</td>
</tr>
<tr>
<td>Egypt</td>
<td>2049.51</td>
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<tr>
<td>Malaysia</td>
<td>1947.23</td>
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<tr>
<td>United Arab Emirates</td>
<td>1800.69</td>
</tr>
<tr>
<td>India</td>
<td>1580.68</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>1473.21</td>
</tr>
<tr>
<td>Argentina</td>
<td>1433.48</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1200.01</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1106.62</td>
</tr>
<tr>
<td>Oman</td>
<td>1072.26</td>
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<tr>
<td>Kazakhstan</td>
<td>1039.58</td>
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<tr>
<td>Venezuela</td>
<td>983.80</td>
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<tr>
<td>Thailand</td>
<td>903.21</td>
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<tr>
<td>Bangladesh</td>
<td>682.51</td>
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<td>Ukraine</td>
<td>637.90</td>
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<td>Brazil</td>
<td>581.64</td>
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<td>Azerbaijan</td>
<td>563.72</td>
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<td>Bolivia</td>
<td>550.46</td>
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<td>Peru</td>
<td>482.93</td>
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<td>Kuwait</td>
<td>453.99</td>
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<td>Brunei Darussalam</td>
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<td>Myanmar</td>
<td>412.89</td>
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<tr>
<td>Colombia</td>
<td>376.32</td>
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<tr>
<td>Romania</td>
<td>355.93</td>
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<tr>
<td>Yemen</td>
<td>353.48</td>
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<tr>
<td>Bahrain</td>
<td>328.55</td>
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<tr>
<td>Vietnam</td>
<td>305.87</td>
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<tr>
<td>Libya</td>
<td>263.68</td>
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<tr>
<td>Syrian Arab Republic</td>
<td>261.93</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>205.60</td>
</tr>
</tbody>
</table>

Source: IEA International Energy Agency
Production of Natural Gas by IOCs (Mmcfd) 2010-2012

Source: 2012 Annual Reports
Production of Natural Gas by NOCs (Mmcfd) 2010-2012

- 13536 Mmcfd (2010)
- 2832 Mmcfd (2011)
- 7511 Mmcfd (2011)
- 42100 Mmcfd (2012)
Oil and Gas fields Worldwide

Legend
- Undisclosed
- Coal Mine Gas, Developing
- Coal Mine Gas, Producing
- Dissolved Gas, Developing
- Coal Bed Methane, Discovery
- Coal Bed Methane, Developing
- Coal Bed Methane, Producing
- Gas Hydrates, Developing
- Gas Hydrates, Producing
- Gas, Discovery
- Gas, Developing
- Gas, Producing
- Oil Gas, Discovery
- Oil Gas, Developing
- Oil Gas, Producing
- Tight Gas, Discovery
- Tight Gas, Developing
- Tight Gas, Producing

Source: IHS (2014)
Oil and Gas fields Middle East

Source: IHS (2014)
Oil and Gas fields Africa

Source: IHS (2014)
Oil and Gas fields Continental Europe

Source: IHS (2014)
Oil and Gas fields North Sea

Source: IHS (2014)
Oil and Gas fields Asia Pacific

Source: IHS (2014)
Oil and Gas fields Latin America

Source: IHS (2014)
# Types of Unconventional Gas

<table>
<thead>
<tr>
<th>Tight Gas</th>
<th>Shale Gas</th>
<th>Coalbed Methane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occurs in ‘tight’ sandstone</strong></td>
<td><strong>Natural gas trapped between layers of shale</strong></td>
<td><strong>Natural gas in coal</strong> (organic material converted to methane)</td>
</tr>
<tr>
<td><strong>Low porosity = Little pore space between the rock grains</strong></td>
<td><strong>Low porosity &amp; ultra-low permeability</strong></td>
<td><strong>Permeability low</strong></td>
</tr>
<tr>
<td><strong>Low permeability = gas does not move easily through the rock</strong></td>
<td><strong>Production via triggered fractures</strong></td>
<td><strong>Production via natural fractures (‘cleats’) in coal</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Recovery rates low</strong></td>
</tr>
</tbody>
</table>

Source: Shell
Technically Recoverable Shale Gas Resources by Country (Tcf)

Source: DOE Energy Information Administration 2013
North American gas forecast: the growing importance of US Shale Gas

Source: Canadian Imperial Bank of Commerce (CIBC)
US current and prospective shale plays

Source: DOE Energy Information Administration 2013
China’s Shale Gas and Shale Oil Basins

Source: EIA/ARI 2013, PETRONAS SR Unit
Unconventional Plays - Europe

Legend
- Shale Oil & Gas, Established
- Shale Oil & Gas, Prospective
- Shale Gas, Prospective

Source: IHS
Unconventional Plays – L.A.

Source: IHS
Unconventional Plays – South Asia

Legend
- Shale Oil & Gas, Established
- Shale Oil & Gas, Prospective
- Shale Gas, Prospective

Source: IHS
2. Transmission

- Gas pipelines
  - Main roads and infrastructures
  - New projects
  - Costs, losses, ..

Sources: WOC3,
Infrastructures Middle East

IHS January 2014
Infrastructure: Australasia

IHS January 2014

LNG Regasification Plant
- Operating
- Planned
- Under Construction

LNG Liquefaction Plant
- Operating
- Planned
- Under Construction

Pipelines
- Operating, under 13"
- Operating, 13" to 34"
- Operating, above 34"
- Under construction
- Planned
Future Infrastructure – World LNG

Legend

Gas Fields (IHS)
- Gas Fields
- Oil and Gas Fields

Regas
- Existing
- Proposed

Liquefaction facilities
- Existing
- Proposed

Operating Pipelines
- under 24"
- 24" to 36"
- 36" and more

Proposed Pipelines

Source: IHS

4/24/2014
Infrastructures Africa

LNG Regasification Plant
- Operating
- Planned
- Under Construction

LNG Liquefaction Plant
- Operating
- Planned
- Under Construction

Pipelines
- Operating, under 13"
- Operating, 13" to 34"
- Operating, above 34"
- Under construction
- Planned

IHS January 2014
Infrastructures Far East

IHS January 2014

LNG Regasification Plant
- Operating
- Planned
- Under Construction

LNG Liquefaction Plant
- Operating
- Planned
- Under Construction

Pipelines
- Operating, under 13"
- Operating, 13" to 34"
- Operating, above 34"
- Under construction
- Planned
Infrastructures North America

LNG Regasification Plant
- Operating
- Planned
- Under Construction

LNG Liquefaction Plant
- Operating
- Planned
- Under Construction

Pipelines
- Operating, 13" to 34"
- Operating, above 34"
- Under construction
- Planned
Major gas pipelines in China

Source: SIA Energy
3. LNG

- Trade movements
- Terminals for import, terminals for exports
- Liquefaction, regazeification
- Ships

- LNG by road, fluvial

Sources: Total LNG group, PGCD special report
LNG: More flexibility through new technology

On-board regasification offers low cost and convenient option to supply gas to new and existing markets
LNG: More flexibility through new technology

Small scale LNG offers opportunities to produce otherwise stranded gas and reduce gas flaring

Source: Skaugen
LNG Exports by Country

Figure 3.2: LNG Exports by Country: 2012 Exports & Incremental Change Relative to 2011 (in MTPA)

Sources: Waterborne LNG Reports, US DOE, PFC Energy Global LNG Service
LNG Imports by Country

Figure 3.6: LNG Imports by Country: 2012 Imports & Incremental Change Relative to 2011 (in MTPA)

“Other” includes Canada, UAE, Greece, Thailand, Puerto Rico, Dominican Republic, Indonesia, and the Netherlands

Sources: Waterborne LNG, US DOE, PFC Energy Global LNG Service
Map of Inter-basin Trade

Source: PFC Energy Global LNG Service
Liquefaction capacity by Country

Source: PFC Energy Global LNG Service, Company Announcements
# Small scale export projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Country</th>
<th>Status</th>
<th>Original Capacity</th>
<th>Announced Start</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Phase of LNG Industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenai LNG</td>
<td>US</td>
<td>Existing</td>
<td>0.9</td>
<td>1969</td>
<td>ConocoPhillips</td>
</tr>
<tr>
<td>Brunei LNG T1-5</td>
<td>Brunei</td>
<td>Existing</td>
<td>1.5</td>
<td>1972</td>
<td>Brunei LNG JV</td>
</tr>
<tr>
<td>Skikda - GL1K (T1-4)</td>
<td>Algeria</td>
<td>Existing</td>
<td>1.4</td>
<td>1972</td>
<td>Sonatrach</td>
</tr>
<tr>
<td>ADGAS LNG T1-2</td>
<td>UAE</td>
<td>Existing</td>
<td>1</td>
<td>1977</td>
<td>ADGAS LNG JV</td>
</tr>
<tr>
<td>Arzew - GL1Z (T1-6)</td>
<td>Algeria</td>
<td>Existing</td>
<td>1.1</td>
<td>1978</td>
<td>Sonatrach</td>
</tr>
<tr>
<td>Arzew - GL2Z (T1-6)</td>
<td>Algeria</td>
<td>Existing</td>
<td>1.1</td>
<td>1981</td>
<td>Sonatrach</td>
</tr>
<tr>
<td>Skikda - GL2K (T5-6)</td>
<td>Algeria</td>
<td>Existing</td>
<td>1.4</td>
<td>1981</td>
<td>Sonatrach</td>
</tr>
<tr>
<td>Recent Onshore</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skangass LNG</td>
<td>Norway</td>
<td>Existing</td>
<td>0.3</td>
<td>2010</td>
<td>Lyse</td>
</tr>
<tr>
<td>Sengkang LNG T1</td>
<td>Indonesia</td>
<td>Construction</td>
<td>0.5</td>
<td>2013</td>
<td>Energy World Corp.</td>
</tr>
<tr>
<td>Sengkang LNG T2</td>
<td>Indonesia</td>
<td>Construction</td>
<td>0.5</td>
<td>2013</td>
<td>Energy World Corp.</td>
</tr>
</tbody>
</table>

**Table 4.2: Small-Scale Liquefaction Export Projects**

*Source: PFC Energy Global LNG Service*
Annual send-out capacity

Annual Send-out Capacity of LNG Terminals in 2012 and 2017

Sources: PFC Energy Global LNG Service, Company Announcements
Receiving terminal import capacity

Source: PFC Energy Global LNG Service, Company Announcements
Liquefaction capacity: operating and planned

* All on-going planned projects till 2023

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**Liquefaction capacity: operating and planned**

<table>
<thead>
<tr>
<th>Region</th>
<th>MMty</th>
<th>Operating Capacity</th>
<th>Under Construction Capacity</th>
<th>Planned Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>62,1</td>
<td>4,7</td>
<td>187,5</td>
<td></td>
</tr>
<tr>
<td>Australasia</td>
<td>24,95</td>
<td>68,7</td>
<td>152,47</td>
<td></td>
</tr>
<tr>
<td>C.I.S.</td>
<td>10,61</td>
<td>10</td>
<td>153,77</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>4,76</td>
<td></td>
<td>19,1</td>
<td></td>
</tr>
<tr>
<td>Far East</td>
<td>74,7</td>
<td>21,45</td>
<td>38,68</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>19,92</td>
<td>0,54</td>
<td>33,01</td>
<td></td>
</tr>
<tr>
<td>Middle East</td>
<td>100,25</td>
<td>10,8</td>
<td>59,15</td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td></td>
<td>9</td>
<td>449,63</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>297.29</strong></td>
<td><strong>125,19</strong></td>
<td><strong>1093,31</strong></td>
<td></td>
</tr>
</tbody>
</table>

* All on-going planned projects till 2023

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Regasification capacity: operating and planned

Mmty

- Africa
- Australasia
- C.I.S.
- Europe
- Far East
- Latin...
- Middle East
- North...

- Operating Capacity
- Under Construction Capacity
- Planned Capacity *

* All on-going planned projects till 2020

IHS January 2014
Regasification capacity: operating and planned

<table>
<thead>
<tr>
<th>Region</th>
<th>Operating Capacity</th>
<th>Under Construction Capacity</th>
<th>Planned Capacity *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td>11,54</td>
</tr>
<tr>
<td>Australasia</td>
<td></td>
<td></td>
<td>1,17</td>
</tr>
<tr>
<td>C.I.S.</td>
<td></td>
<td></td>
<td>9,07</td>
</tr>
<tr>
<td>Europe</td>
<td>137,08</td>
<td>3,49</td>
<td>121,74</td>
</tr>
<tr>
<td>Far East</td>
<td>379,12</td>
<td>20,46</td>
<td>249,35</td>
</tr>
<tr>
<td>Latin America</td>
<td>41,64</td>
<td>1,7</td>
<td>76,66</td>
</tr>
<tr>
<td>Middle East</td>
<td>17,41</td>
<td></td>
<td>14,77</td>
</tr>
<tr>
<td>North America</td>
<td>83,95</td>
<td></td>
<td>17,45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>659,2</strong></td>
<td><strong>25,65</strong></td>
<td><strong>501,75</strong></td>
</tr>
</tbody>
</table>

* All on-going planned projects till 2020

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Overland transport of LNG: By road trucks and railcars

- LNG is transported by road truck in many countries
- Trucked LNG has many small-scale uses:
  - Domestic and commercial piped gas supply from satellite re-gasification terminals located in places remote from pipelines
  - Small industrial users (electric power, engine tests, glass, paper)
  - Commercial users (trains, buses, ferries, institutions)
  - Supply to peak-shaving plants
  - Supply to pipeline network during repairs or maintenance
4. Underground Gas Storage

Source: WOC2 database, (Cedigaz, IHS Cera)

- Types of UGS,
- per countries: distribution, WGV, maps
- per type: distribution, WGV,
- TPA
- Projects

- ? Strategic LNG storage
UGS Working Gas Volume by regions

UGS in the World
Working Gas Volume Distribution by Regions (bcm)

- Asia: 138.1 bcm (38%)
- Europe: 113.6 bcm (32%)
- Asia Pacific: 98.7 bcm (28%)
- CIS: 4.0 bcm (1%)
- L. America & Caribbean: 3.0 bcm (1%)
- Middle-East: 1.4 bcm (0.1%)
- North America: 0.1 bcm (0%)

Total: 358.8 bcm
UGS Working Gas Volume by storage type

UGS in the World
Working Gas Volume Distribution by Storage Types (bcm)

Total = 358,8

- Aquifer: 45,7 (13%)
- Gas Field: 272,7 (76%)
- Oil Field: 18,2 (5%)
- Rock Cavern: 0,1 (0%)
- Salt Cavern: 22,2 (6%)
UGS Working Gas Volume distribution in Europe

UGS in Europe
Working Gas Volume Distribution by Storage Types (bcm)

Total = 98,7

- Aquifer: 68,1 bcm (69%)
- Gas Field: 16,9 bcm (17%)
- Oil Field: 12,7 bcm (13%)
- Rock Cavern: 0,1 bcm (1%)
- Salt Cavern: 0,1 bcm (1%)
Specific Working Gas Volume and No. of UGS by Countries

excluding long-term strategic reserves in Russia

No. of UGS Facilities

Specific Working Gas Volume (bcm/UGS Facility)
Age of UGS facilities

Age of storages

No. of UGS Facilities

- Abandoned mine
- Aquifer
- Gas Field
- Oil Field
- Rock Cavern
- Salt Cavern

<table>
<thead>
<tr>
<th>Period</th>
<th>Abandoned mine</th>
<th>Aquifer</th>
<th>Gas Field</th>
<th>Oil Field</th>
<th>Rock Cavern</th>
<th>Salt Cavern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900-1930</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1930-1940</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1940-1950</td>
<td>45</td>
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<td></td>
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</tr>
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<td>1950-1960</td>
<td>10</td>
<td></td>
<td>73</td>
<td></td>
<td></td>
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</tr>
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<td>1960-1970</td>
<td>30</td>
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<td>58</td>
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<td></td>
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<td>1970-1980</td>
<td>6</td>
<td>11</td>
<td></td>
<td>80</td>
<td></td>
<td></td>
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<td>1980-1990</td>
<td>14</td>
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</tr>
<tr>
<td>1990-2000</td>
<td>12</td>
<td>2</td>
<td></td>
<td>58</td>
<td>4</td>
<td></td>
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<tr>
<td>2000-2012</td>
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</table>
UGS Working Gas Volume by operators

UGS Working Gas Volume by Storage operators (Bcm)
Development of new storage capacity compared to the storage capacity in the previous triennium (bcm)
UGS planned Working Gas Volume

UGS in the World
Reported Planned Working Gas Volume Distribution by Regions (bcm)

- Asia: 64.7 bcm, 54%
- Asia Pacific: 24.7 bcm, 21%
- CIS: 12.4 bcm, 10%
- L.America & Caribbean: 11.7 bcm, 10%
- Middle-East: 3.1 bcm, 3%
- North America: 2.1 bcm, 2%
- Europe: 3.1 bcm, 3%

Total: 188.6 bcm
UGS distribution worldwide
UGS distribution in Europe
UGS distribution in CIS
UGS distribution in North America

Legend
- Gas Field
- Oil Field
- Aquifer
- Salt Cavern
5. Distribution

- Grids & networks (characteristics)
- Companies ?
- Gas quality
- Smart grids
- TPA

Source: Woc4 and national websites
6. Utilisation

- Industrial uses
- Domestic and commercial uses
- Natural gas vehicles (SG 5.3)
- LNG vehicles

Source: WOC5
Evolution of consumption by region (Bcf) 2000 - 2011

Source: DOE Energy Information Agency
Demand Evolution of Asian Countries (Bcf) 2000-2011

Source: DOE Energy Information Agency
Growing Global Demand for Gas

Gas overtakes coal before 2030 and meets one quarter of global energy demand by 2035—demand grows by 2% annually, compared with just 1.2% for total energy

Gas: Convenient & Efficient Source of Energy Economic and Clean

- Easy handling, lower installation and maintenance cost
- Good controllability of processes and high efficiency
- Direct heating or drying of products or materials
- Clean and environment-friendly
- Less CO₂ emission rights needed (where applicable)
Gas: The Efficient Source of Energy (examples)

Green houses – use

↑ Boiler house in green house. Gas use temperature dependent.

↔ Assimilation illumination
+ Use of CO₂ from exhaust gases as fertiliser
Residential: Efficient and environmentally friendly fuel for heating, hot water and cooking

- Clean and easy handling once infrastructure is present
- Low installation cost vs. other fuels
- High efficiency heating equipment available
- High comfort factor
- Individual heating systems in apartment blocks

† High efficiency heating system (hot water boiler) with storage vessel
† High efficiency heating system
LNG as automotive fuel for heavy vehicles

- **LNG is used in increasingly many places for road transport fleets**: Buses, Dust Carts, Chilled Container Transporters – it gives good engine performance and a vehicle range comparable with other fuels.

- **LNG is suitable to fuel high-consumption transport** where space for the LNG storage is readily available: e.g. trains and sea ferries.

- **LNG is less-suitable for small privately-owned vehicles** because of more complex procedures and more expensive fuelling stations with special requirements regarding their location.

- **Heavy vehicles do not lend themselves to be run on electric power.**
LNG as automotive fuel for heavy vehicles

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Natural gas for road transport

Natural gas is the cleanest fossil fuel

Source: Gasunie ‘Natural gas, part of an efficient sustainable energy future, The Dutch case’, Feb 2010
7. Gas markets

- See trading aspect: LT contracts, open-season
- Industrial aspect: Power generation, Industry
- Markets lists or map

Source: PGCE, SGE1, Total G&P
8. Environmental impact

*Source: PGCA, life cycle analysis*

- Life Cycle Analysis approach
- Impact effect for each step of the chain (including uses)
- Greenhouse gases and others emissions
- Water management
- Energy efficiency (for all the chain)
- Gas advocacy
Natural Gas with or w/o CCS: Cleanest fossil fuel for power generation

Metric Tons CO₂ per MWH

0
0.25
0.5
0.75
1

GHG Emissions

Solar
Nuclear
Wind (0)

"Clean" Natural Gas* (0.04)

"Clean" Coal* (0.09)

Natural Gas (0.35)

Oil (0.80)

Coal (0.85)

* With CCS

Source: IGU based on CERA
Natural Gas fired generation:
Smallest ecological footprint for power generation

Land use in acres to have 1,000 MW of capacity

Source: based on data from Union Gas Ltd.
Gas: Cleanest Fossil Fuel
Lowest emission of CO2

Emission of CO₂
(in kg CO₂/MWh)

- Lignite-fired power: 1,200 (340%)
- Hard coal-fired power: 850 (230%)
- Gas-fired CCGT: 350 (100%)

Source: US Department of Energy (DOE), US Energy Information Administration (EIA)
Particulate emissions from heating systems

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Emissions (mg/kWh)</th>
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<tbody>
<tr>
<td>Natural gas</td>
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<td>Heating oil</td>
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<tr>
<td>Lignite*</td>
<td>306</td>
</tr>
<tr>
<td>Hard coal**</td>
<td>554</td>
</tr>
</tbody>
</table>

* Emissions based on use of briquettes and lignite from the Rhineland-area in Germany
** Emissions based on use of briquettes

LUWB Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg; Average emission factors for small and medium combustion installations without exhaust gas after treatment. Status: 2006, BGW; Source: www.asue.de
Steps of the natural gas chain modeled with the main trade movements in Europe

1 MJ of distributed NG
Results on the whole life cycle, including the final use

First example:

Electricity production: CCGT

The final use is not necessarily the only significant contributor to all the impacts
Results on the whole life cycle, including the final use

Differences observed between the 3 final uses:
mainly linked to the efficiency of the conversion process and to the type of combustion
Results: focus on the upstream chain

Different contributions of each step to the 3 impacts

- Climate change
- Acidification
- Non renewable energy depletion
Comparison of the repartition of GHG emissions along the upstream chains

GHG emissions ranging from 1 to 4 depending on the NG supply chain.
Sur distribution

Renewable gases (or Bio gases)
- trends, new installations, new methanation techniques

Hybrid solutions
- gas heat pumps, solar plus gas

Source: PGCF, WOC5