GASEOUS FUELS
TYPES OF GASEOUS FUELS

With regards to the origin:
- natural (natural gas, mine gas, liquid gases),
- synthetic (town gas, coke gas, product of coal gasification, hydrogen)

With regards to the caloric value:
- high caloric (example: with high methane content, HCV = 39 MJ/m$^3$),
- low caloric (example: with high nitrogen content, HCV <= 27 MJ/m$^3$).
Classification of gaseous fuels: standards and parameters

Polish standards

- PN-C-04750:2002 Paliwa gazowe
- PN-C-04753:2002 Wymagania dla gazu ziemnego

Classifying parameters

- Upper caloric value, $J/m^3$
- Upper Wobbe No. $W_s$, $J/m^3$
- Content of major components
Relative density and Wobbe No.

Relative density $d_v$

$$d_v = \frac{\rho_{\text{gas}}}{\rho_{\text{air}}}$$

Upper (lower) Wobbe No. $W_s(W_i)$

$$W_s = Q_s d_v^{-0.5}$$

$$W_i = Q_i d_v^{-0.5}$$
### Families of gases

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name of family of gases</th>
<th>Classifying parameter</th>
<th>Basic applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gas synthesised by industrial methods</td>
<td>UCV</td>
<td>Fuels for industry, mainly in place of generation</td>
</tr>
<tr>
<td>2</td>
<td>Natural gas</td>
<td>Upper Wobe No., $W_s$</td>
<td>Local and national nets, engine fuel</td>
</tr>
<tr>
<td>3</td>
<td>Liquid gases $C_3$-$C_4$</td>
<td>Content of major components</td>
<td>Municipal use, movable stoves, engine fuel</td>
</tr>
<tr>
<td>4</td>
<td>Mixtures of hydrocarbons and air</td>
<td>Upper Wobe No., $W_s$</td>
<td>Local nets, municipal users,</td>
</tr>
<tr>
<td>5</td>
<td>Biogases</td>
<td>-</td>
<td>Gases used in the place of generation</td>
</tr>
</tbody>
</table>
## Family 1: Gases produced by industrial technologies

<table>
<thead>
<tr>
<th>Group</th>
<th>Symbol</th>
<th>$\text{UCV, } H_s, \text{ MJ/m}^3$</th>
<th>Major compounds</th>
<th>Basic applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-caloric</td>
<td>$\text{Sn}$</td>
<td>$&lt; 9.5$</td>
<td>$\text{CO, N}_2, \text{CO}_2, \text{H}_2$</td>
<td>Fuels for industry, mainly in the place of manufacture</td>
</tr>
<tr>
<td>Medium-caloric</td>
<td>$\text{Ss}$</td>
<td>$9.5 \div 28.5$</td>
<td>$\text{CO, H}_2, \text{CH}_4, \text{CO}_2$</td>
<td></td>
</tr>
<tr>
<td>High-caloric</td>
<td>$\text{Sw}$</td>
<td>$28.5 \div 37.9$</td>
<td>$\text{CH}_4$</td>
<td></td>
</tr>
</tbody>
</table>
### Family 2: Natural gas

<table>
<thead>
<tr>
<th>Group</th>
<th>Symbol</th>
<th>Symbol of sub-group</th>
<th>Upper Wobbe No., $W_s$, MJ/m³</th>
<th>Major compounds</th>
<th>Basic applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>With nitrogen</td>
<td>L</td>
<td>Lm</td>
<td>23 ÷ 27</td>
<td>CH₄, N₂</td>
<td>Local fuel, distributed by net</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ln</td>
<td>27 ÷ 32.5</td>
<td>CH₄, N₂</td>
<td>Local fuel, distributed by net</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ls</td>
<td>32.5 ÷ 37.5</td>
<td>CH₄, N₂</td>
<td>Local fuel, distributed by net</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lw</td>
<td>37.5 ÷ 45</td>
<td>CH₄, N₂</td>
<td>Local fuel, distributed by net</td>
</tr>
<tr>
<td>High-caloric</td>
<td>E</td>
<td></td>
<td>45 ÷ 54</td>
<td>CH₄</td>
<td>Gas for national nets, general applications, including engines</td>
</tr>
</tbody>
</table>
Selected parameters of natural gas distributed by net

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gases with nitrogen</th>
<th>Group E high-methane gases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lm</td>
<td>Ln</td>
</tr>
<tr>
<td>Upper Wobbe No., MJ/m³</td>
<td>Lm</td>
<td>Ln</td>
</tr>
<tr>
<td>- nominal value</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>- range of variation</td>
<td>23 ±27</td>
<td>27 ±32.5</td>
</tr>
<tr>
<td>HCV (MJ/m³) no less than</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>LCV (MJ/m³) no less than</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Pressure before the combustor, nominal value, kPa</td>
<td>0.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>
## Family 3: Liquid gases

<table>
<thead>
<tr>
<th>Group</th>
<th>Symbol</th>
<th>Content of major hydrocarbons</th>
<th>Major components</th>
<th>Basic applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical butane</td>
<td>B</td>
<td>$C_4 \geq 95%$ (m/m)</td>
<td>Butane and iso-butane</td>
<td>Portable combustors</td>
</tr>
<tr>
<td>Propane-butane</td>
<td>B/P</td>
<td>$18% \leq C_3 \leq 55%$ $C_4 \geq 45%$ (m/m)</td>
<td>butane propane</td>
<td>Domestic and municipal receivers</td>
</tr>
<tr>
<td>Technical propane</td>
<td>P</td>
<td>$C_3 \geq 90%$ (m/m)</td>
<td>propane</td>
<td>Domestic, municipal, industrial and engines fuel</td>
</tr>
</tbody>
</table>
Liquid gases

Liquid gases are mixtures of hydrocarbons (C₃-C₄) being a side product of crude oil processing.

**LPG - Liquid Petroleum Gas**

Major components of LPG:
- propane (C₃H₈)
- butane (i iso-butane) (C₄H₁₀)
NATURAL GAS
NG
ORIGIN OF NATURAL GAS

The most probably origin of natural gas is organic.
COMPOSITION OF NG

The major compounds of natural gas are:

- methane (CH₄) and its homologous C₃-C₇.

Non-combustible compounds of NG are:

- nitrogen, CO₂, water.

An important compound (pollutant) of NG is:

- H₂S (sulfuretted hydrogen).
OCCURRENCE OF NG

1. Natural gas can exist in the lithosphere:
   - separately
   - or accompany the oil

2. Natural gas can occur:
   - separately,
   - diluted in oil,
   - diluted in water,
   - diluted in rocks (in coal).
### Examples of NG deposits

<table>
<thead>
<tr>
<th>NG deposit</th>
<th>CH₄</th>
<th>C₂H₆</th>
<th>C₃H₈</th>
<th>C₄H₁₀</th>
<th>C₅H₁₂</th>
<th>CO₂</th>
<th>H₂S</th>
<th>N₂</th>
<th>He</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubaczów</td>
<td>89,9</td>
<td>1,6</td>
<td>0,9</td>
<td>0,7</td>
<td>-</td>
<td>0,3</td>
<td>-</td>
<td>6,5</td>
<td>-</td>
</tr>
<tr>
<td>Tarchały</td>
<td>50,37</td>
<td>0,22</td>
<td>0,01</td>
<td>0,02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>47,8</td>
<td>0,00</td>
</tr>
<tr>
<td>Nowa Sól</td>
<td>38,67</td>
<td>16,09</td>
<td>8,35</td>
<td>2,71</td>
<td>0,48</td>
<td>0,5</td>
<td>-</td>
<td>23,2</td>
<td>3</td>
</tr>
<tr>
<td>Dąbrowa</td>
<td>97,80</td>
<td>0,5</td>
<td>0,2</td>
<td>0,1</td>
<td>0,05</td>
<td>0,05</td>
<td>-</td>
<td>1,3</td>
<td>-</td>
</tr>
<tr>
<td>Romazkino</td>
<td>47,4</td>
<td>21,4</td>
<td>14,4</td>
<td>4,5</td>
<td>3,3</td>
<td>0,5</td>
<td>-</td>
<td>8,6</td>
<td>-</td>
</tr>
<tr>
<td>Panhanle</td>
<td>73,2</td>
<td>6,1</td>
<td>3,2</td>
<td>1,6</td>
<td>0,6</td>
<td>0,3</td>
<td>-</td>
<td>14,3</td>
<td>-</td>
</tr>
<tr>
<td>Texas</td>
<td>39,56</td>
<td>6,17</td>
<td>2,89</td>
<td>2,2</td>
<td>2,28</td>
<td>4,5</td>
<td>42,4</td>
<td>-</td>
<td>0,7</td>
</tr>
<tr>
<td>Alaska</td>
<td>95,5</td>
<td>0,05</td>
<td>0,01</td>
<td>-</td>
<td>-</td>
<td>0,01</td>
<td>-</td>
<td>0,43</td>
<td>-</td>
</tr>
<tr>
<td>Wyoming</td>
<td>28,8</td>
<td>6,35</td>
<td>3,35</td>
<td>2,84</td>
<td>3,4</td>
<td>42,0</td>
<td>1,11</td>
<td>4,09</td>
<td>-</td>
</tr>
<tr>
<td>Wenezuela</td>
<td>70,9</td>
<td>8,2</td>
<td>8,2</td>
<td>6,2</td>
<td>3,7</td>
<td>2,8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kanada</td>
<td>71,8</td>
<td>-</td>
<td>13,9</td>
<td>13,94</td>
<td>-</td>
<td>0,3</td>
<td>-</td>
<td>12,4</td>
<td>-</td>
</tr>
<tr>
<td>Libia</td>
<td>70</td>
<td>15</td>
<td>9</td>
<td>3,5</td>
<td>1,0</td>
<td>-</td>
<td>-</td>
<td>2,0</td>
<td>0,6</td>
</tr>
<tr>
<td>Algeria</td>
<td>86,9</td>
<td>9,0</td>
<td>2,6</td>
<td>1,2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0,3</td>
<td>-</td>
</tr>
</tbody>
</table>
### Acronyms for natural gas

1. Natural gas \(\textit{NG}\)
2. Natural gas in net: \(E, L\)
3. Compressed natural gas: \(\textit{CNG}\)
4. Liquid Natural Gas: \(\textit{LNG}\)
5. (Low caloric natural gas) \(\textit{LCNG}\)
MINE-METHANE

• In some hard coal deposits methane is absorbed in coal under great pressure.
• Mine-methane is obtained in the process of de-methanization of coal mines.
• The methane content in coal depends on the coal field features and could be in the range of: 0-200 m$^3$/Mg$_{coal}$.
• The mine-methane comprises:
  - 96% CH$_4$,
  - 3% N$_2$
  - other compounds.
MINE-METHANE

• During mining pressure in the coal field drops and the absorbed gases undergo desorption and evolve.

• To make the process of de-methanization more effective the coal field is shaked using explosives.

• Mine-methane is collected in the steel pipelines and transported from the mine.

• Due to the processing applied the mine-methane has a considerable content of air: 20-50% air.

• Production of mine-methane in Poland: ~ 200 mln m³/y.
Mine methane resources $ \times 10^6 \text{m}^3$

<table>
<thead>
<tr>
<th>Wyszczególnienie</th>
<th>Zasoby wydobywalne</th>
<th>Zasoby przemysłowe</th>
<th>Emisja z wentylacją</th>
<th>Wydobycie</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Excavable resour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bilansowe balance</td>
<td>pozabilans. off-balance</td>
<td>Industrial resources</td>
<td>Emission from ventilation</td>
</tr>
<tr>
<td>ZŁOŻA UDOKUMENTOWANE OGÓŁEM: 44 złóż</td>
<td><strong>84 534.57</strong></td>
<td><strong>24 579.60</strong></td>
<td><strong>3 257.22</strong></td>
<td><strong>146.44</strong></td>
</tr>
<tr>
<td></td>
<td>of which, in the areas of exploited coal deposits: 28 deposits</td>
<td><strong>24 569.39</strong></td>
<td><strong>3 784.37</strong></td>
<td><strong>2 087.66</strong></td>
</tr>
<tr>
<td>z czego w pokładach poza zasięgiem eksploatowanych złóż węgla: 19 złóż</td>
<td><strong>59 965.18</strong></td>
<td><strong>20 795.23</strong></td>
<td><strong>1 169.56</strong></td>
<td>-</td>
</tr>
<tr>
<td>of which, in the areas outside exploited coal deposits: 19 deposits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Use of coal-methane MPW

In Poland coal mines used approx. 60% of coal methane.
Hydrates are crystalline structures consisting of combined water and gas molecules. Most widespread in environment are methane hydrates. Normally they are in the form of water ice and give off methane when heated. The content of methane is as high as 164 m$^3$ CH$_4$ in 1 m$^3$ of hydrate.

Deposits of hydrates are located on continental slopes under oceans and also in the permafrost regions. Global resources of hydrates are estimated by some even at $10^{16}$ m$^3$ of methane (in comparison, resources of natural gas are estimated at over $3*10^{14}$ m$^3$). Due to climatic and geological conditions excavation of hydrates is not cost-effective nowadays.
EXAMPLES OF HYDRATES

\[ \text{CH}_4 \cdot 6\text{H}_2\text{O} \]

\[ \text{C}_2\text{H}_6 \cdot 7\text{H}_2\text{O} \]
BURNING OF HYDRATES
HYDRATES DEPOSIT AT THE SEA BOTTOM

COMBUSTION AND FUELS
CONDITIONS OF HYDRATES FORMATION

- Methane + ice
- Methane + water
- Methane hydrate + ice
- Methane hydrate
OCCURRENCE OF HYDRATES IN THE WORLD

COMBUSTION AND FUELS
SYNTHETIC GASES
Town gas (also: low-temperature or lighting gas) is obtained at low- and medium temperature coal gasification.

Town gas composition (an example):

55% $H_2$, 25% $CH_4$, 8% CO, 7% $N_2$ i $O_2$

LCV of town gas:

~17.5 MJ/m$^3$
Coke gas is obtained at the high-temperature coal gasification.

Composition and properties:

Similar to the properties of town gas

Gas from iron making processes also has similar properties.
# PRODUCT OF COAL GASIFICATION

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Coal</th>
<th>Refinery coke</th>
<th>NG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The process</strong></td>
<td>Gasification method</td>
<td>Gasification method</td>
<td>Steam conversion</td>
</tr>
<tr>
<td></td>
<td>Koppers–Totzek</td>
<td>Lurgi</td>
<td>Shell</td>
</tr>
<tr>
<td><strong>Pressure, MPa</strong></td>
<td>0,105</td>
<td>2–3</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>Composition % vol.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{H}_2$</td>
<td>28,7</td>
<td>40,2</td>
<td>45,9</td>
</tr>
<tr>
<td>CO</td>
<td>57,0</td>
<td>20,6</td>
<td>48,6</td>
</tr>
<tr>
<td>$\text{CH}_4$</td>
<td>0,1</td>
<td>10,7</td>
<td>0,5</td>
</tr>
<tr>
<td>$\text{C}_2+$</td>
<td>–</td>
<td>1,0</td>
<td>–</td>
</tr>
<tr>
<td>$\text{N}_2$</td>
<td>1,4</td>
<td>0,3</td>
<td>0,2</td>
</tr>
<tr>
<td>$\text{CO}_2$</td>
<td>12,6</td>
<td>26,9</td>
<td>4,0</td>
</tr>
<tr>
<td>$\text{H}_2\text{S}$</td>
<td>0,2</td>
<td>0,3</td>
<td>0,8</td>
</tr>
<tr>
<td>Ratio $\text{H}_2$/CO</td>
<td>0,5</td>
<td>1,95</td>
<td>0,94</td>
</tr>
</tbody>
</table>
HYDROGEN

Hydrogen as a fuel of the future:

- environmental friendly,
- high caloric value,
- Fuel cells applications.

Hydrogen is produced on the industrial size by reforming of natural gas (methane). Reforming means acting of water steam on natural gas in the presence of nickel catalyst at the temperature approx. 800 °C.
SOURCES OF HYDROGEN

1. Hydrogen doesn’t occur in nature

2. Hydrogen is manufacturing on the industrial scale from natural gas

3. The process is called reforming:

   Reforming of NG with steam in the presence of nickel catalyst.
BASIC PARAMETERS OF GAS

1. Composition
2. HCV \( (Q_s) \) and LCV \( (Q_i) \), MJ/m\(^3\)
3. Density \( \rho \), kg/m\(^3\) and dimensionless density \( d_v \)
4. Wobbe No., \( W_b \)
5. Temperature of dew point and moisture
6. Explosibility limits, %
7. Stoichiometric air
8. Octane number (ON).
Dimensionless density and Wobbe NO

Dimensionless density \( d_ν \)
\[
d_ν = \frac{\rho_{\text{gas}}}{\rho_{\text{air}}}
\]

Wobbe No. \( W_b \)
\[
(W_b = Q_s d_ν^{-0.5})
\]
OCTANE NUMBER (ON)

Octane number ON is the measure of “engine knocks” resistance of a given fuel.

ON of a particular fuel blend is determined under specific operating conditions in a CFR single cylinder engine at variable CR.

CFR - Co-operative Fuel Research

CR - compression ratio

The reference fuel: mixture of iso-octane and n-heptane:
 iso-octane has ON = 100
 n-heptane has ON = 0

ON = content of iso-octane in %.
## SELECTED PARAMETER of SOME HYDROCARBONS

<table>
<thead>
<tr>
<th>Name</th>
<th>Molar mass</th>
<th>Density</th>
<th>LCV</th>
<th>Air/gas</th>
<th>Explosibility limits (in air)</th>
<th>$t_{\text{boil}}$</th>
<th>ON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/m$^3$</td>
<td>MJ/m</td>
<td>m$^3$/m$^3$</td>
<td>%</td>
<td></td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Metan</td>
<td>16,05</td>
<td>0,716</td>
<td>35,8</td>
<td>9,5</td>
<td>4,7 – 14,8</td>
<td>– 161,6</td>
<td>100</td>
</tr>
<tr>
<td>Etan</td>
<td>30,07</td>
<td>1,356</td>
<td>64,2</td>
<td>16,7</td>
<td>3,2 – 12,5</td>
<td>– 88,6</td>
<td>104</td>
</tr>
<tr>
<td>Propan</td>
<td>44,09</td>
<td>2,004</td>
<td>92,7</td>
<td>23,8</td>
<td>2,5 – 9,5</td>
<td>– 42,1</td>
<td>100</td>
</tr>
<tr>
<td>i-butanol</td>
<td>58,12</td>
<td>2,668</td>
<td>121,9</td>
<td>31,0</td>
<td>1,8 – 8,4</td>
<td>– 11,7</td>
<td>99</td>
</tr>
<tr>
<td>n-butanol</td>
<td>58,12</td>
<td>2,703</td>
<td>122,5</td>
<td>31,0</td>
<td>1,5 – 8,4</td>
<td>+ 0,5</td>
<td>92</td>
</tr>
<tr>
<td>i-pentan</td>
<td>72,15</td>
<td>3,457</td>
<td>152,3</td>
<td>38,1</td>
<td>1,3 – 7,8</td>
<td>+ 27,8</td>
<td>90</td>
</tr>
<tr>
<td>n-pentan</td>
<td>72,15</td>
<td>3,457</td>
<td>153,1</td>
<td>38,1</td>
<td>1,3 – 6,9</td>
<td>+ 36,1</td>
<td>64</td>
</tr>
<tr>
<td>n-heksan</td>
<td>86,17</td>
<td>3,850</td>
<td>183,3</td>
<td>45,3</td>
<td>1,0 – 6,0</td>
<td>+ 68,7</td>
<td>62</td>
</tr>
<tr>
<td>n-heptan</td>
<td>100,20</td>
<td>4,459</td>
<td>217,6</td>
<td>52,7</td>
<td>1,0 – 6,0</td>
<td>+ 98,4</td>
<td>0</td>
</tr>
</tbody>
</table>

### COMBUSTION AND FUELS
ADVANTAGES OF GAS

- high efficiency of heat and power generation,
- storage is not required,
- good stability of LCV and flame temperature,
- gas flame is easy to control,
- gas burners and boilers are apt for automation,
- design of gas furnaces is relatively simple,
- smokeless burning,
- no ash, no SO$_2$ emission, easy control of NO$_x$,
- the smallest emission of CO$_2$ of all of fossil fuels.
APPLICATIONS OF GAS

Metallurgy:
- heating furnace and flatten workshops,
- thermal processing and forges.

Building materials manufacturing:
- glass, cement and ceramic.

Electrical power generation
- internal engines (piston engines and gas turbines),
- fuel cells and MHD generators.

Chemical technology: syngas production necessary for:
- ammonia NH$_3$ 90 mln Mg/y
- methanol CH$_3$O 20 mln Mg/y
- hydrogen H$_2$ 200 bln m$^3$/y)

In petrochemistry
RESERVES AND PRODUCTION OF NG

Reserves of NO: 146 000 bld m$^3$.

Total reserves of NG: 338 000 bld m$^3$.

NG reserved in the world (in bld m$^3$):

- Russia, Eastern Europe - 56 738,
- Asia - 44 809,
- Africa - 9 785,
- Oceania - 13 328,
- North America - 7 306,
- South America - 7 763,
- West Europe - 8 295.

The World production of NG: 2106 bln m$^3$

Duration (reserves): 63 years
Total reserves of NG

situation at 01.01.1996, source IGU-20 World Gas Conference, Copenhagen 1997
Prognosis of NG consumption

situation at 01.01.1996, source IGU-20 World Gas Conference, Copenhagen 1997
RESERVES AND PRODUCTION of NG in POLAND

Reserves: 153 bld m$^3$.
Total reserves: 605 bld m$^3$.
(Total reserves in Baltic shelf: 7 bln m$^3$)
Including gas diluted in crude oil: 10 bln m$^3$)

Production and import of NG in Poland:
The total use of NG: approx. 10 bld/rok
- municipal sector: 5,5 (57%) bld m_p$^3$;
- industrial sector: 4,2 (43%) bld m_p$^3$;
(index p: calculated for high-methane gas, $Q_s = 39$ MJ/m$^3$).

COMBUSTION AND FUELS
Storage of NG in Poland

- Existing reservoirs
- Planned reservoirs in deposits of gas
- Existing reservoirs abroad
- Planned reservoirs in deposits of salt

Quantity of stored NG ($\times 10^9$ m$^3$)

- 1995: 0.3
- 1997: 0.1
- 2000: 1.0
- 2005: 0.4
- 2010: 0.8
- 2015: 3.1

Storage capacity increases over time, with a significant rise in 2010.
GAS DISTRIBUTION IN POLAND (1970)

- **High-methane natural gas (97% CH₄)**
- **High nitrogen natural gas (68% CH₄)**
- **Coke gas**
- **Borders of gas distribution regions**
Use of NG in Poland

1 cm = 0.3 mld m^3n

- **black**: household
- **light**: industry
- **dark**: commercial
Supply sources of gas in Poland

- Year consumption of gas in Poland is $13,5 \times 10^9$ m$^3$ (2007).
- 1/3 of demand is covered by domestic production.
- 2/3 of demand are covered by import.
- Most of gas is received from Ukraine through border crossing point in Drozdowicze.
- About $2.8 \times 10^9$ m$^3$ of gas flows in by Yamal pipeline.
- Gas also comes to Poland from Byelorus.
- And through border crossing point in Zgorzelec (west of Poland).
- In underground storage tanks there are almost $2 \times 10^9$ m$^3$ of gas.
Supply sources of gas in Poland

Sources of gas for PGNiG

- Norway: 4%
- Germany: 3%
- Russia: 41%
- Domestic production and purchase: 32%
- Central Asia: 20%

Suppliers:
- Gazprom: 6.2 (67%)
- RosUkrEnergos (Grupa Gazpromu): 2.3 (24.5%)
- VNG (Niemcy): 0.8 (8.5%)

Sources of gas:
- Domestic deposits: 4.3 (31.6%)
- Import: 9.3 (68.4%)

Industrial consumers of gas (%):
- Others: 28.9
- Nitrogen industry: 28.9
- Heating plants: 7%
- Refineries: 10%
- Food industry: 8.4

Consumers of gas (%):
- Household: 28.1
- Agriculture: 60.5
- Commercial: 10.2
- Steelworks: 7.8
- Glassworks: 8

Data from 2007 x 10^9 m³/year
Directions of gas import into Poland

Yamal Pipeline, other pipelines, existing, planned.
Gas supply to Europe

Gazprom’s export to Europe

<table>
<thead>
<tr>
<th>Year</th>
<th>Export (10^9 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'90</td>
<td>117,4</td>
</tr>
<tr>
<td>'95</td>
<td>129,0</td>
</tr>
<tr>
<td>'00</td>
<td>156,1</td>
</tr>
<tr>
<td>'05</td>
<td>161,5</td>
</tr>
<tr>
<td>'06</td>
<td>161</td>
</tr>
<tr>
<td>'07</td>
<td>157,7</td>
</tr>
<tr>
<td>'08</td>
<td></td>
</tr>
</tbody>
</table>

Gas supply sources to EU-15 in percents

- Russia: 33%
- Norway: 25%
- Algeria: 21%
- Others: 21%

Source: Gazprom

Source: Opracowanie Ośrodka Studiów Wschodnich
480 x 10⁹ m³ of gas is used in Europe each year
47,57 x 10₁² m³ have the gas resources in Russia

Participation of gas imported from Russia in total use of gas for:
- European Union 23.5%
- old members of EU 17.6%
- new members of EU 73.5%
- Ukraine & Belarus 73.3%

Pipelines from Russia to Europe
- existing
- planned

Gas connection between Europe and Eastern Europe and Asia
Natural gas prices in USA

NYMEX Natural Gas Futures Close (Front Month)

$ / MMBTU

Jan. 2, 2008 - Jan. 6, 2009

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(479) 293-4081
Natural gas prices in Europe

Gas prices in Poland for individual consumers of high-metane natural gas (E group) in tariff-group E

1,14 zł / m³

Gasprom
Gazprom charges Europe around $378 per 1,000 cubic metres (tcm)

and prices may rise to $400, a Gazprom source told Reuters, implying a huge price spike for Ukraine, which pays $179.5 per tcm for the Central Asian gas it is buying from Gazprom this year.
DEPOSITS OF NATURAL GAS
DEPOSITS OF CRUDE OIL
DEPOSITS OF OIL & GAS
BORDERS OF GEOLOGICAL UNITS
NON-PROSPECT REGIONS
REACH OF ROTLIEGEND
CONGLOMERATE
SANDSTONE
MUDDSTONE AND SHALE WITH SANDSTONE INSERT
NG FIELDS IN POLAND AND CONCESIONS

According to PGNiG
Oil-fields in the Baltic shelf in Poland