Geographical Distribution of Oil and Natural Gas Deposits - Different Means of Transportation to the Consumption Centers

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Abstracts
Hydrocarbons - oil and gas - are at present the most important energy fuels. Together they accounts for more than 60 % of world-wide total primary energy supply. International Energy Agencies (e.g. IEA 2005) predict a further increase of oil and gas demand. There is a geographical mismatch between resource location and demand that will continue to increase in the future. By these reasons role of transport will rise. Pipeline Transport is an important option.
About 70 % of global conventional oil and natural gas reserves are concentrated inside a so called “Strategic Ellipse” stretching from Middle East to the North of West Siberia. Main consuming regions for in 2004 were North America, Austral-Asia, and Europe, for natural gas North America, CIS and Europe.
About 2,200 Mt (million tons) of crude oil (57 % of global production) was transported across country boundaries in 2004, in part over large distances by tanker or pipeline. Main export region was Middle East followed by Africa and CIS. The share of pipeline transport in the cross border trade achieved about 14 % of traded volumes.
Cross-border trade (not including transit across third countries) of natural gas amounted in 2004 to about 780 G.m³ (billion m³) or about 28 % of global production. About three fourth of this amount was traded by pipeline, about one fourth as liquefied natural gas (LNG).
To secure supply with oil and gas is needed to build new pipelines linking producing and consuming countries. There are several major projects.

Introduction
Hydrocarbons - oil and gas - are at present the most important energy fuels. Together they accounts for more than 60 % of world-wide total primary energy supply. Oil is of extreme importance for transportation, heat production and the chemical industry – whereas natural gas is primarily of importance for heat and electricity production as well as for chemical industry. International Energy Agencies (e.g. IEA 2005) predict a further increase of oil and gas demand (Fig. 1).
There is a geographical mismatch between resource location and demand that will continue to increase in the future. By these reasons role of transport will rise. Pipeline Transport is an important option.
The availability of fuels, taking into account their uneven worldwide distribution, can be broken down into the following elements:
- Geological availability,
- Technical availability,
- Availability of transportation,
- Political availability.
Following will be discussed only the first and third one.

Figure 1: Development of primary energy consumption worldwide (cumulative, not including biomass) and projections of IEA until 2030 (Sources: BP and IEA, 2005)

Crude oil reserves, production and consumption
In terms of global consumption, crude oil is the most important primary fuel, accounting for 36.5% of world primary energy consumption (not including biomass) (BP 2005). Forecasts (e.g. IEA 2005) assume there will be no significant change in the oil’s importance in the next decades.

Table 1: Crude oil in 2004 [Mt]

<table>
<thead>
<tr>
<th>Region/Group</th>
<th>Cumulative production</th>
<th>Production in 2004</th>
<th>Reserves</th>
<th>Resources</th>
<th>Consumption in 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>7,779.0</td>
<td>291.8</td>
<td>2,740</td>
<td>3,625</td>
<td>763.8</td>
</tr>
<tr>
<td>CIS</td>
<td>21,217.3</td>
<td>556.3</td>
<td>15,157</td>
<td>21,080</td>
<td>176.9</td>
</tr>
<tr>
<td>Africa</td>
<td>11,910.0</td>
<td>441.2</td>
<td>14,645</td>
<td>9,878</td>
<td>135.8</td>
</tr>
<tr>
<td>Middle East</td>
<td>37,571.0</td>
<td>1,168.3</td>
<td>100,074</td>
<td>20,510</td>
<td>259.2</td>
</tr>
<tr>
<td>Austral-Asia</td>
<td>10,700.6</td>
<td>379.8</td>
<td>6,036</td>
<td>6,395</td>
<td>1,100.7</td>
</tr>
<tr>
<td>North America</td>
<td>37,112.2</td>
<td>668.1</td>
<td>7,000</td>
<td>13,400</td>
<td>1,122.4</td>
</tr>
<tr>
<td>Latin America</td>
<td>12,869.0</td>
<td>341.9</td>
<td>14,013</td>
<td>7,168</td>
<td>229.9</td>
</tr>
<tr>
<td>WORLD</td>
<td>139,159.2</td>
<td>3,847.4</td>
<td>159,664</td>
<td>82,056</td>
<td>3,789.2</td>
</tr>
<tr>
<td>OPEC</td>
<td>55,329.0</td>
<td>1,570.3</td>
<td>121,372</td>
<td>27,300</td>
<td>325.5</td>
</tr>
<tr>
<td>OPEC-Gulf</td>
<td>35,506.8</td>
<td>1,080.7</td>
<td>98,423</td>
<td>18,800</td>
<td>2,251.9</td>
</tr>
<tr>
<td>OECD</td>
<td>44,875.1</td>
<td>976.6</td>
<td>10,028</td>
<td>17,835</td>
<td>682.0</td>
</tr>
<tr>
<td>EU-25</td>
<td>4,198.1</td>
<td>132.0</td>
<td>1,307</td>
<td>1,580</td>
<td>1,211.8</td>
</tr>
<tr>
<td>Others</td>
<td>380,955.2</td>
<td>1,300.4</td>
<td>28,264</td>
<td>36,921</td>
<td>325.5</td>
</tr>
</tbody>
</table>
The regional distribution of conventional crude oil reserves is very uneven. Inside a so called “Strategic Ellipse” (Fig.2) is located about 71% of global reserves. About 62% of global reserves are in the Middle East, about 13% in North and South America, and about 10% in the CIS countries. OPEC has about 73% of global reserves (of which 61% is in the Persian Gulf region), OECD about 8%, leaving about 17% for the rest of the world (Tab. 1).

Figure 2: "Strategic Ellipse" and countries with conventional oil reserves >1 Gt (billion tons)

Figure 3: Production and consumption of oil in 2004: Regional distribution
In 2004, the global oil production was at a maximum of 3,847 Mt. The regions with the highest production in 2004 were the Middle East, North America, and the CIS countries. Consumption of oil products increased in 2004 to 3.8 Gt, the ever highest level. Global mineral oil consumption is very unevenly distributed. The OECD countries used about 2.3 Gt, or about 60% of the total oil consumption in 2004, the OPEC countries only about 9%. Consumption was concentrated in North America, Austral-Asia, and Europe. There is a geographical mismatch between resource location and demand (Fig. 3). This mismatch will continue to increase in the future due to increasing demand in Asia and rising dependency on oil from Middle East.

**Natural gas reserves, production and consumption**

Natural gas accounts for about 24% of primary energy consumption, after crude oil and hard coal. Its share has increased in the last several years. This trend is expected to continue in the future.

The global reserves of conventional natural gas are estimated at about 176 T.m³ (trillion m³) at the end of 2004. The regional distribution, like for crude oil, is very uneven. Inside a so called “Strategic Ellipse” (Fig. 4) is located about 69% of global reserves. About 41% of global reserves are in the Middle East, about 32% in the CIS countries and about 8% in Africa. OPEC has about 50% of global reserves (of which 40% is located in the Persian Gulf region), OECD about 9% (Tab. 2). The three counties with major gas reserves – Russia, Iran and Qatar – dispose of more than a half of global gas reserves.

<table>
<thead>
<tr>
<th>Region/Group</th>
<th>Cumulative production</th>
<th>Production in 2004</th>
<th>Reserves</th>
<th>Resources</th>
<th>Consumption in 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>9,468.2</td>
<td>327.8</td>
<td>6,116</td>
<td>7,126</td>
<td>556.4</td>
</tr>
<tr>
<td>CIS</td>
<td>21,493.9</td>
<td>797.1</td>
<td>56,447</td>
<td>96,060</td>
<td>617.5</td>
</tr>
<tr>
<td>Africa</td>
<td>2,195.3</td>
<td>148.1</td>
<td>14,091</td>
<td>11,196</td>
<td>88.7</td>
</tr>
<tr>
<td>Middle East</td>
<td>3,734.0</td>
<td>279.9</td>
<td>72,356</td>
<td>32,540</td>
<td>245.7</td>
</tr>
<tr>
<td>Austral-Asia</td>
<td>5,145.8</td>
<td>324.4</td>
<td>12,941</td>
<td>22,690</td>
<td>367.5</td>
</tr>
<tr>
<td>North America</td>
<td>33,616.7</td>
<td>773.1</td>
<td>7,377</td>
<td>27,300</td>
<td>784.6</td>
</tr>
<tr>
<td>Latin America</td>
<td>2,333.7</td>
<td>130.9</td>
<td>7,095</td>
<td>9,858</td>
<td>117.1</td>
</tr>
<tr>
<td>WORLD</td>
<td>77,987.6</td>
<td>2,781.2</td>
<td>176,422</td>
<td>206,770</td>
<td>2,633.3</td>
</tr>
<tr>
<td>OPEC</td>
<td>7,324.8</td>
<td>459.6</td>
<td>88,290</td>
<td>42,600</td>
<td>316.2</td>
</tr>
<tr>
<td>OECD</td>
<td>42,646.2</td>
<td>1,127.2</td>
<td>15,849</td>
<td>36,036</td>
<td>1,437.5</td>
</tr>
<tr>
<td>EU-25</td>
<td>7,216.2</td>
<td>233.1</td>
<td>3,483</td>
<td>3,355</td>
<td>519.0</td>
</tr>
<tr>
<td>Others</td>
<td>28,016.6</td>
<td>1,194.4</td>
<td>73,023</td>
<td>128,134</td>
<td>1,028.0</td>
</tr>
</tbody>
</table>
Global production of natural gas rose to an absolute high of about 2.8 trillion m³ in 2004. The regions with the highest production are the CIS countries and North America, each with about a third of global production, followed by Europe with an eighth. Global natural gas consumption was on the same level. Most important consumers were USA, Russia, Germany, Great Britain, Canada, Iran, and Italy. The regional geographical mismatch between resource location and demand (fig 3) is somewhat smaller than that for oil.

Figure 4: „Strategic Ellipse“ and countries with natural gas reserves >1 T.m³

Figure 5: Production and consumption of natural gas in 2004: Regional distribution
Transport of oil and natural gas

About 2,200 Mt of crude oil (57 % of global production) was transported across country boundaries in 2004, in part over large distances by tanker or pipeline. Main export region was Middle East with exports of 824 Mt (39 % of total exports) by tanker followed by Africa with 344 Mt by tanker too and CIS with 323 Mt with predominately pipeline transport to Europe. The share of pipeline transport in the cross border trade achieved about 14 % of traded volumes. Pipeline transport is of more importance in intra-country transport. Major trade movement of oil and petroleum products are shown in figure 6. For crude oil, there is a single global market with nearly uniform prices.

Figure 6: Major oil trade movements in 2004 [Mt]

Because the gas producing region is usually not the same as the consumer region, natural gas must be transported over long distances. It can be transported by pipeline or as liquefied natural gas (LNG) in special tankers. Transport costs for natural gas are significantly higher than those for crude oil or hard coal due to the lower energy density of natural gas (Fig. 7). This is a competitive disadvantage, especially when the fields are very far from the markets. Whether natural gas is used depends on the economic and political conditions in the consumer country, and increasingly on environmental requirements. In contrast to oil with a single world market for natural gas exist four main regional markets in which producers and distributors have long-term contracts: the European market, with the main exporters Russia, North Africa, Norway, and the Netherlands; the North American market (NAFTA); the Asian LNG dominated market, characterized by large distances between the main consumers (mainly Japan, South Korea, and Taiwan)
and the producing countries (mainly Indonesia, Malaysia, and Brunei); and the South American market, which has been developed in the last years.

Figure 7: Transport costs for natural gas and oil in US$/boe after HATAMIAN (1998), for coal after Verein deutscher Kohleimporteure (Jahresbericht 1998)

Figure 8: Major natural gas trade movements in 2004

Cross-border trade (not including transit across third countries) of natural gas amounted to about 780 G.m³ (about 28 % of global production) in 2004. About three
fourth of this amount was traded by pipeline, about one fourth as liquefied natural gas (LNG). Inter-regional gas trade was at about 430 G.m³ in 2004. By predictions of the IEA (IEA 2004) in the period to 2030 the inter-regional trade of natural gas will triple to 1 265 G.m³. More than 50 % of all inter-regional gas trade will be than as LNG.

**Major Pipeline Projects**

To secure supply with oil and gas needed to build new pipelines linking producing and consuming countries.

Oil pipeline projects are important especially for the transport of oil from the Caspian Region and Russia to world market. Some important projects finished in last years, are under construction, in planning or under considerations (Fig. 9 and 10) e.g.

- Caspian Pipeline Consortium (CPC) pipeline, went on stream in October 2001 to transport oil from super-giant Tengiz oil field in Kazakhstan to the Russian port of Novorossiysk on the Black Sea coast,
- Baku-Tbilissi-Ceyhan (BTC) pipeline, filled now, for the transport of Azerbaijan oil to the Turkish port Ceyhan on the Mediterranean Sea,
- Kazakhstan – China pipeline for the transport of Kazakh and Russian oil to Western China continued in China to the Eastern regions (Fig. 9),
- Eastern Siberia – Pacific Ocean (ESPO) pipeline for transport of Siberian oil to the Pacific coast for export of oil to Southeast Asia and North America with a possible extension to China (Fig. 10).

Figure 9: Oil pipeline network in the Caspian Region (REMPPEL 2004 updated)
Figure 10: Russian oil pipeline network (REMP 2002 updated)

To guarantee the rising demand for natural gas, new pipelines have to be built and new natural gas fields developed. This will require considerable capital investment over a long time.

Several natural gas pipelines are under construction or are planned.

Of importance for Europe (Fig. 11) is e.g.

- Yamal-Europe pipeline, linking the giant gas fields on the Yamal Peninsula with consumers in Europe,
- North European Gas Pipeline (NEGP) for direct supply of Russian gas to Germany though Baltic Sea,
- Medgaz pipeline, linking Algeria with Spain,
- Green Stream project, linking Libya with Italy via Sicilia,
- Gasli pipeline from Algeria to Italy via Corsica and Sardinia and
- Nabucco project, linking Iranian and Azerbaijan gas networks with Western Europe.

In other regions major natural gas projects are under construction, in planning or under consideration, e.g.

- the Baku–Tbilissi–Erzurum (BTE) pipeline to transport Azerbaijan natural gas to Turkey,
- the pipeline from Eastern Siberia (Kovykta field) to China,
- Trans Sahara Pipeline from Nigeria to North Africa and Europe,
- pipeline from Alaska to US mainland and
- South American Gas Pipeline Project.
Despite construction of new pipelines the reconstruction and modernization of older pipelines is of importance.

Conclusions

The Demand on oil and natural gas will continue to increase according to different forecasts.

The geographical mismatch between resource location and demand regions will further rise.

For this reason, the importance of transport options for oil and natural gas will increase.

From different transport options, pipeline transport is important especially for onshore transport, for natural gas on distances up to 5,000 km.

To provide security for rising oil and natural gas demand construction of new and reconstruction of older pipelines are needed.

Pipeline security will be an important issue.
References


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