INCREASING ROLE OF UNDERGROUND GAS STORAGES FOR RELIABLE SUPPLY OF GAS TO LATVIA, LITHUANIA, ESTONIA, FINLAND AND NW RUSSIA AND PROSPECTS OF DEVELOPMENT OF INCUKALNS UNDERGROUND GAS STORAGE

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ABSTRACT

According to the estimates done by specialists of OAO “Giprospecgaz”, daughter company of OAO “Gazprom”, in their feasibility study regarding regional development of gas supply system in Baltic Countries, Northwest Russia and Finland, needs for natural gas will reach in year 2015 in Latvia $2.8 \times 10^9$ m$^3$, Lithuania $5.25 \times 10^8$ m$^3$, Estonia $1.3 \times 10^9$ m$^3$, Finland $6.071 \times 10^9$ m$^3$ and Russia $39.981 \times 10^9$ m$^3$. Total gas demand of this region in year 2015 will reach $39.98 \times 10^9$ m$^3$, and in year 2020 even $41.76 \times 10^9$ m$^3$. At the same time, due to the fact that natural gas in the region is and according to prognosis will be extensively used for heating purposes, huge difference between gas consumption in summer and winter will remain, and, for example in 2015 monthly consumption of gas in July, according to the forecasts, will be only 36% of the one in January.

In our opinion, potential of Latvian underground gas storages can be well used to meet increasing and changing demands for natural gas in the region and, therefore, Joint Stock Company “Latvijas Gaze”, which owns and operates Incukalns Underground Gas Storage in Latvia, currently with the active gas volume of $2.3 \times 10^9$ m$^3$ (total volume $4.4 \times 10^9$ m$^3$) initiated feasibility study regarding development of regional gas transmission network development and possibilities of utilization of natural underground gas storage potential in Latvia, which was performed by OAO “Giprospecgaz”.

Based on information obtained from each country in the region regarding gas demand for the time period ending in year 2020, OAO “Giprospecgaz” by means of computer modeling of gas flows and assessing few different scenarios, have come up with the proposals on development of gas transmission systems of the region, including countries, Lithuania, Latvia, Estonia, NW Russia and Finland and also developed two step by step different feasible options for expansion of the existing Incukalns Underground Gas Storage. Based on the results of the above feasibility study Joint Stock Company “Latvijas Gaze” have prepared investment plan for the first stage of the Incukalns Underground Gas Storage expansion, however, the main condition to start the whole project is positive decision on construction submarine gas pipeline, connecting Estonian and Finnish gas grids. At present, extensive discussions between “Gazprom”, “Gasum”, “Latvijas Gaze” and “Eesti Gaas” is taking place. What concerns Incukalns Underground Storage, it is advised to increase its capacity due to: 1) existing structure in place with potential for further increase, 2) increase of gas consumption in the region, 3) seasonal unevenness of gas consumption and 4) limited options for development of other storages in the region.

Taking into consideration geological features and gas dynamics of the reservoir, it is estimated that without additional wells active storage volume of Incukalns Underground Gas Storage can be increased to $2.3-2.6 \times 10^9$ m$^3$, and then further to $3.2 \times 10^9$ m$^3$. At the same time, it is expected that the active volume of Nevskoye Underground Gas Storage will be increased to $1.9 \times 10^9$ m$^3$ on 2010 and $2.1 \times 10^9$ m$^3$ in 2015, and Gatchinskoye UGS remain at current volume of $0.2 \times 10^9$ m$^3$ of active gas.

To provide customers with reliable and secure gas supply, market situation have been analyzed for the region of countries, including Latvia, Lithuania, Estonia, Finland and NW Russia for the time period that ends in year 2020, and the following main conclusions have been drawn:

- need for natural gas will increase;
- seasonal unevenness of gas consumption will remain;
- in order to ensure reliable gas supply for Finnish customers and meet their increasing demands, underground gas storage is advised to be used;
- due to lack of possibility to develop seasonal underground gas storage in Finland and limited options for development of other storages in the region it is advised to use Incukalns Underground Gas Storage in Latvia, which already is used for customers in Latvia, Estonia, NW Russia and, most probably, in the nearest future will be used for Lithuanian customers on commercial terms too;
- for gas supply from Incukalns Underground Gas Storage new submarine gas pipeline shall be built;
- in order to meet increasing demand for gas storage volume, Incukalns Underground Gas Storage have to be expended.

In addition, for increase of gas supply reliability for customers in the Central and Western Europe other potential sites of underground gas storage can be developed in Latvia with the total active capacity of $50 \times 10^9$ m$^3$. 
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It is expected that natural gas consumption in Latvia will increase. The same trend of gas consumption is forecasted in the neighboring countries also. According to the estimates performed by specialists of the OAO “Giprospecgaz” in their feasibility study regarding regional development of gas supply system in Baltic Countries, North-West Russia and Finland, needs for natural gas will reach in year 2015 in Latvia 2.8 $\times 10^{9}$ m$^3$, Lithuania 5.25, Estonia 1.37 $\times 10^{9}$ m$^3$, Finland 6.07 $\times 10^{9}$ m$^3$ and Russia 39.98 $\times 10^{9}$ m$^3$ (BCM). Total gas demand of this region in year 2015 will reach 39.98 $\times 10^{9}$ m$^3$, and in year 2020 even 41.76 $\times 10^{9}$ m$^3$. (see Table 1.) At the same time, due to the fact that natural gas in the region is and according to prognosis will be extensively used for heating purposes, huge difference between gas consumption in summer and winter will remain, and, for example in 2015 monthly consumption of gas in July, according to the forecasts, will be only 36% of the one in January. Needs for natural gas in the countries described above are shown in the Table 1. [2]

<table>
<thead>
<tr>
<th>Consumers</th>
<th>2003</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latvia</td>
<td>1.65</td>
<td>2.20</td>
<td>2.80</td>
<td>3.00</td>
</tr>
<tr>
<td>Lithuania</td>
<td>2.96</td>
<td>4.96</td>
<td>5.25</td>
<td>5.46</td>
</tr>
<tr>
<td>Estonia</td>
<td>0.85</td>
<td>1.10</td>
<td>1.37</td>
<td>1.50</td>
</tr>
<tr>
<td>Finland</td>
<td>5.11</td>
<td>5.62</td>
<td>6.07</td>
<td>6.10</td>
</tr>
<tr>
<td>NW Russia</td>
<td>19.45</td>
<td>22.92</td>
<td>24.49</td>
<td>25.70</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30.02</td>
<td>36.80</td>
<td>39.98</td>
<td>41.76</td>
</tr>
</tbody>
</table>

Table 1. Annual gas consumption volumes

At present, gas to Latvia is supplied in summer by two pipelines of 720 mm diameter and is taken over at the Russian/Latvian border approximately 40 km downstream of the Izborsk compressor station at the Korneti Gas Metering Station. East of Riga, the Incukalns Underground Gas Storage (UGS) facility is linked to the both Izborsk - Riga pipelines. During winter, gas is withdrawn from the underground storage facility, used for Latvian and Estonian consumers and sent also back to Russia [1].

Estonia is receiving gas by two pipelines Izborsk- Tartu-Rakvere (530 mm) through the whole year, and Viresi-Tallinn (720 mm) via Latvia in winter. The same like in Latvia, there the highest monthly consumption (in winter) and the lowest monthly consumption (in summer) differs greatly and reaches even five times.

What concerns Lithuania, gas is supplied only by pipeline Minsk-Vilnius (1220 mm). After commissioning of gas-metering station on Latvian –Lithuanian border it is expected that “Lietuvos Dujos” will receive gas supplies from Incukalns UGS on regular basis (not only in high emergency cases, like it is now). In Lithuania, summer and winter monthly gas consumption difference is about two times.

For NW of Russia gas is supplied by pipeline systems Grazovec-Leningrad, Serpuhov-Leningrad and Belousovo-Leningrad from Nadim-Pur-Tazovsk region of Tymen Oblast.
Gas to Finland is supplied by pipeline Leningrad-Viborg- Russian border. Both, in Finland and in NW Russia, similar to three Baltic Countries, gas consumption in winter months comparing to summer months differ at least two times.

In order to meet changing demands of customers in this particular region, currently there are three underground gas storages in operation: Incukalns UGS in Latvia and Nevskoye and Gatchinskoe in Russia.

2. Aims of developing Latvian underground gas storages

In our opinion, potential of Latvian underground gas storages can be well used to meet increasing and changing demands for natural gas in the region and, therefore, Joint Stock Company “Latvijas Gaze”, which owns and operates Incukalns Underground Gas Storage in Latvia, currently with the active gas volume of $2.3 \times 10^9 m^3$ (total volume $4.4 \times 10^9 m^3$) initiated feasibility study regarding development of regional gas transmission network and possibilities of utilization of natural underground gas storage potential in Latvia, which was performed by OAO “Giprosgpegaz”.

Following the request of JSC “Latvijas Gaze” specialists of OAO “Giprosgpegaz” have performed analysis of natural gas demand in Baltic Countries: Latvia, Lithuania, Estonia and Finland and NW Russia based on the information obtained from the gas companies of particular countries [2].

The compiled results show that the unevenness of the monthly consumption and, in particular, difference in natural gas consumption in summer and winter months will remain high, as presented on the following Figure 2.
In order to meet changing demands of consumers, the capacity of the underground gas storages in the region have to be increased. Following the suggestions of OAO “Giprosgaz” specialists, it is advised to increase Incukalns UGS capacity due to

- existing structure in place with potential for further increase;
- increase of gas consumption in the region;
- seasonal unevenness of gas consumption;
- limited options for development of other storages in the region.

Taking into consideration geological features and gas dynamics of the reservoir, it is estimated that without construction of additional wells active storage volume of Incukalns UGS can be increased to 2.3-2.6 \(10^9\) m\(^3\) and then further to 3.2 \(10^9\) m\(^3\). At the same time, it is expected that the active volume of Nevskoye UGS will be increased to 1.9 \(10^9\) m\(^3\) in 2010 and 2 \(10^9\) m\(^3\) in 2015, and Gatchinskoye UGS remain at current volume of 0.2 \(10^9\) m\(^3\) of active gas.

Referring to the feasibility study performed by OAO “Giprosgaz” specialists [3], gas from Incukalns UGS can be delivered to Finnish customers, first, by pipeline Viresi-Tallinn and, following, by pipeline Tallinn-Helsinki with the length of 111 km, including 63 km submarine pipeline, which has to be constructed. In order to meet estimated demand in Finland, the diameter of pipeline shall be 700 mm with submarine part 500 mm, and two compressor stations, one in Latvia and one in Estonia, and one reception terminal in Finland also shall be built. The total estimated annual volume to be delivered to Finland in 2015 may reach 750 Mio m\(^3\).

In order to deliver estimated annual gas volumes for meeting customer needs in Lithuania, which is set on the level of 200 Mio m\(^3\) for years 2015-2020, the looping to gas pipeline Iecava-Liepaja shall be built with diameter 500 mm and length of 75 km.

It is estimated that Estonian customers in time period of 2015-2020 may need 600 Mio m\(^3\), which will be delivered by pipeline Viresi-Tallinn through the gas metering station “Karksi”.

Figure 2. Unevenness of natural gas consumption in year 2015
3. Prospects for the Latvian UGS development

Governments of Baltic Countries are expressing their interest in gas transit through them from Russia to Europe. In such case, a special role could be played by the Latvian underground gas storage (UGS) facilities (the existing Inchukalns UGS as well as potential UGSs that could be successfully built utilizing favorable geological conditions in Latvia)[5]. These UGSs might be used most profitably if they were filled with cheaper gas during summer time, but gas used in winter.

Construction of new UGSs requires large investments, however these investments might become a profitable money allocation. Besides, it should be remembered that UGSs of a large capacity (up to $50 \times 10^9$ m$^3$) situated in the center of Europe would improve security of gas supply, especially if one takes into account the huge distances from the gas fields of Russia (3000 - 4000 km). Gas as highly efficient fuel can be utilized in a wider scale for traditional purposes (household, industry, etc.) in all Baltic Countries, especially taking account of their only partial coverage with gas pipelines.

The Joint Stock Company “Latvijas Gaze” in Latvia has its own UGS (Inchukalns UGS) with active capacity $2.2 \times 10^9$ m$^3$ [4] and it is one of the biggest UGS in the Europe (see Table 2). Bearing in mind distance from gas extraction places in CIS and Norway, this UGS can play a significant role in gas supply security in North Europe. It also can give profit if during summer time, when gas pipeline from CIS are not overloaded and gas marginal cost is approximately 30% or even more cheaper than during winter time, is stored and than in winter extracted and sold.

Latvia has unique geological conditions for building of UGS. There already exists UGS capacity of 2.3. $10^9$ m$^3$, and investigations show that it is possible to develop other similar storage sites with a total active capacity above 50. $10^9$ m$^3$. The existence of beneficial geological conditions in Latvia was proved once again by feasibility study performed by Baltic Energy Corporation and CMS Gas Transmission and Storage Company (USA) in 1997. These conditions can enhance not only the development of the gas supply system around the Baltic Sea, but also promote the improvement of gas supply reliability for the whole Europe [7]. The Inchukalns UGS is located in the central part of Latvia, but in perspective UGS can be spread all over the territory of Latvia, but especially in western part of Latvia.
Table 2: The UGS capacities in Eastern Europe ($10^9$ m$^3$)

<table>
<thead>
<tr>
<th>Country</th>
<th>Existing</th>
<th>Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latvia</td>
<td>2.3</td>
<td>50 (8 UGS)</td>
</tr>
<tr>
<td>Poland</td>
<td>0.56</td>
<td>5.23</td>
</tr>
<tr>
<td>Slovakia</td>
<td>1.60</td>
<td>1.62</td>
</tr>
<tr>
<td>Hungary</td>
<td>1.92</td>
<td>2.52</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2.01</td>
<td>1.20</td>
</tr>
<tr>
<td>Romania</td>
<td>0.57</td>
<td>1.45</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0.60</td>
<td>0.60</td>
</tr>
</tbody>
</table>

One of the largest and well-investigated perspective UGS is situated at Dobele. The peculiarities of the geological structure in Latvia create unique favorable conditions for setting up an underground storage. The lower of the sedimentary rocks contains Middle Cambrian limestone strata with a good collector capacity practically all over the territory of the country. A thick water-impermeable clay and carbonate stratum covers this layer (see Fig. 4).
The existing Inchukalns UGS in Latvia is the only one in the Baltic States. The depth of this Middle Cambrian collector (reservoir) is 620 to 760 m. The present capacity of this collector is $4.4 \times 10^9$ m$^3$ (the active capacity - $2.3 \times 10^9$ m$^3$), average porosity over 20%, average gas permeability 460 milidarcies. What concerns potential Dobele UGS, 20 wells have been drilled already at this site, and the working capacity of this storage is estimated at $10^9$ m$^3$.

The existing Inchukalns UGS with a capacity of $2.3 \times 10^9$ m$^3$ at present is used in the following manner. In the summer period gas received from Russia is injected into the storage, but in winter withdrawn from the storage and used for consumers in Latvia (about 85% of annual consumption in winter), returned back to Russia and delivered to Estonia. There are no gas supplies by pipelines for Latvian consumers from Russia in winter. In such a way, more scarce pipeline capacities in Russia in winter can be used for gas transportation to the Central and Western Europe. If the additional gas transportation were calculated at marginal costs, the transportation cost of gas in long-distance pipelines (approximately 3000 km) would be 30-40% of its total cost.

The UGS certainly performs all the necessary functions for increase of the reliability of gas supply. In order to meet accepted reliability standards, volume of approximately 15 days of maximum gas consumption should be kept in long distance pipelines, the volume that the existing UGS can fully ensure not only for Latvia, but also for the entire Baltic region. In addition, we would like to stress that in harsh conditions of present winter Latvia due to its underground gas storage was among these very few countries in Europe that had no necessity to limit any gas consumption.

Changes in the weather conditions effect both the variations of gas consumption in each season of the year and long-term variations (in the series of warm and cold winters). Seasonal variations are rather stable, therefore a reserve of about 40% of the annual gas consumption is necessary in the climate zone of Latvia to compensate the variations of gas consumption for heating. Considering the comparably high specific weight of heating in Latvia where practically no heavy industry is developed the total amount of the reserves for the compensation of seasonal variations may be 24-28% of the annual gas consumption (see Table VI). It means that the perspective UGS with the capacity of $50.10^9$ m$^3$ could ensure these variations in the North European region with the consumption of about 150-200.$10^9$ m$^3$ a year.
An all round estimation of the use of UGS in the gas supply system is connected with the solution of several economic problems. So, it is rather complicated to calculate the compensation of variations in the daily, seasonal and annual gas consumption by means of UGS in terms of profit.

<table>
<thead>
<tr>
<th>The group of the consumer mode</th>
<th>Specific weight (%)</th>
<th>Long-term deviations (%)</th>
<th>The amount of reserves against the yearly fluctuation of consumption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers using gas for heating</td>
<td>85</td>
<td>20</td>
<td>17,0</td>
</tr>
<tr>
<td>Consumers using gas for technological purposes</td>
<td>15</td>
<td>5</td>
<td>7,5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>-</td>
<td>24,5</td>
</tr>
</tbody>
</table>

Table 3. The amount of the reserves needed for the compensation of long-term gas consumption fluctuations in Latvia.

As described above the UGS potential in Latvia (capacity more than 50, $10^9$m$^3$) can provide reserve capacity for the large region with annual consumption of 150-200, $10^9$m$^3$. It could have a great importance for the Baltic See Pipeline project connecting Russia with Germany for purpose of improvement of reliability of gas supply that at present due to the latest developments in gas industry is considered the highest priority of EU energy policy. This pipeline is shown in Fig. 5 with doted line crossing the Baltic Sea. In latest project options, branch lines to Kaliningrad, Sweden and Poland etc. are considered. In case branch pipeline to Latvia would be constructed and Latvian UGS potential used, gas supply security for Europe would be improved considerably because possible disruptions on gas pipelines on the long route of more than 3000 km from gas deposits to the Finnish Bay where the Baltic Sea pipeline starts would not influence gas supplies (see Fig.5.).

Figure 5. Prospects of the developing gas supply system and number of defects in the main pipelines 2000-2003 years
4. Method of gas supply systems optimization

Based on information obtained from each country of the region regarding gas demand for the time period ending in year 2020, OAO “Giprospecgas” by means of computer modeling of gas flows and assessing few different scenarios, have come up with the proposals on development of gas transmission systems of the region, including countries, Lithuania, Latvia, Estonia, NW Russia and Finland and also developed two step-by-step feasible options for expansion of existing Incukalns Underground Gas Storage.

However, the possibilities of utilization of Latvian UGS potential with the total active capacity over 50. $10^9$ m$^3$ are not explored sufficiently, but it can be important for the whole Europe as explained above. It is particularly complicated to estimate feasibility of increase of gas supply reliability. As we can see in Fig.5 number of disruptions on main gas pipelines are considerable and the problem of improvement of gas supply reliability for Europe is becoming more and more important.

The calculation of the profit gained from raising the reliability of gas supply by means of UGS is not so simple either, considering the possibility to supply the consumers with gas from several points, including, case of a system of gas pipes with closed circuits or several sources of gas etc [6]. As mentioned above, UGS may yield great economical effect by reducing the carrying capacity of the main gas pipes (during the maximum consumption). In a general way one can write that the profit from the gas supply system using the UGS will be higher:

$$P_{GSS} < P_{GSS+UGS};$$

or

$$P_{GSS} < P_{GSS} + \Delta P_1 + \Delta P_2 + \ldots + \Delta P_n,$$

where:

- $P_{GSS}$ - the profit from the gas supply system without UGS;
- $P_{GSS+UGS}$ - the profit from the gas supply system with UGS;
- $\Delta P_1 + \Delta P_2 + \ldots + \Delta P_n$ - extra profits from the use of UGS due to various effects from the use of UGS.

Thus, to compensate the daily variations in the gas consumption, UGS may replace over-ground high-pressure boilers. For compensation of seasonal variations, UGS may replace over-ground oil tanks, and so on. In addition, if the construction and utilization costs of the UGS will be lower, consequently, the gas supply system may give extra profit. In the same way it refers to the other aspects of the use of UGS in the gas supply system yielding additional profit. Greater problems here are related to improvement of the calculation theories and procedures in order to estimate to a full extent the profit from the UGS. This may define the perspectives for development of the Latvian UGS when creating the North European system of gas supply [7].

5. Results

Based on the results of the above feasibility study Joint Stock Company “Latvijas Gaze” have prepared investment plan for the first sage of Incukalns Underground Gas Storage expansion, however, the main condition to start the whole project is positive decision on construction of submarine gas pipeline, connecting Estonian and Finnish gas grids. At present, extensive discussions between “Gazprom”, “Gasum”, “Latvijas Gaze” and “Eesti Gaas” is taking place. What concerns Incukalns Underground Storage; it is advised to increase its capacity due to

- existing structure in place with potential for further increase;
- increase of gas consumption in the region;
- seasonal unevenness of gas consumption;
- limited options for development of other storages in the region.
Taking into consideration geological features and gas dynamics of the reservoir, it is estimated that without construction of additional wells active storage volume of Incukalns Underground Gas Storage can be increased to 2.3-2.6 \(10^9\) m\(^3\), and then further to 3.2 \(10^9\) m\(^3\).

Further study is required regarding utilization of perspective 50 \(10^9\) m\(^3\) UGS capacity in Latvia that can help to solve the increasingly important problem of reliability of gas supply to Europe...

6. Summary

To provide customers with reliable and secure gas supply, market situation have been analyzed for the region of countries, including Latvia, Lithuania, Estonia, Finland and NW Russia for the time period that ends in year 2020, and the following main conclusions have been drawn:

- need for natural gas will increase;
- seasonal unevenness of gas consumption will remain;
- in order to ensure reliable gas supply for Finnish customers and meet their increasing demands, underground gas storage is advised to be used;
- due to lack of possibility to develop seasonal underground gas storage in Finland and limited options for development of other storages in the region it is advised to use Incukalns Underground Gas Storage in Latvia, which already is used for customers in Latvia, Estonia, NW Russia and, most probably, in the nearest future will be used for Lithuanian customers on commercial terms too;
- for gas supply from Incukalns Underground Gas Storage new submarine gas pipeline shall be built;
- in order to meet increasing demand for gas storage volume, Incukalns Underground Gas Storage has to be expended.

Initial calculations show that there are certain perspectives to incorporate new perspective UGS capacities in Latvia (total capacity over 50 \(10^9\) m\(^3\)) into European gas supply system especially due to insufficient gas supply security to Europe.

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