EVALUATION OF A RISK LEVEL OF GAS SUPPLY OF THE BALTIC COUNTRIES AND RISK CRITERIA OF UGS

Dr.sc.ing A. Davis, Dr.sc.ing. A. Jesinska, Joint Stock Company “Latvijas gaze”
Prof., Dr. habil. sc. ing. Andris Kreslins, Riga Technical University
Prof., Dr.habil. sc. ing. V. Zebergs, Prof., Dr. habil. sc. ing. N. Zeltins, Institute of Physical Energetics

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1. INTRODUCTION

One of the crucial issues in Europe at the moment is reliable gas supply. This subject became even more important after gas supply interruptions and limitations took place in January of 2009 in some countries of European Union (EU). At present security of supply is on top of the agenda of the European Commission (EC). The most important risk-reducing measures of the gas supply are related to development of a system of gas pipelines (branching and looping of the pipes) and creation of a large-capacity gas storage facilities. The risk management depends on the efficiency of the measures. Latvia and other Baltic Countries (Lithuania, Estonia) has a well-developed gas network that is connected to a gas network of the Russian Federation and high-capacity underground gas storage (UGS) facility. However, the gas networks of the Baltic Countries currently are not connected to the joint EU gas grid, therefore construction of a link between Lithuania and Poland is considered to be very important, but implementation of this project is not started yet. In the future, connection of the Finnish network to the Baltic gas networks is also expected. Finland has shown interest in the use of the Latvian UGS.

2. BACKGROUND

Underground gas storage (UGS) facilities can be used for increase of safety of supply in the Northern Europe. 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 2.35 \( \cdot 10^9 \) m\(^3\) (total volume 4.4 \( \cdot 10^9 \) 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 “Giprospecgaz”.

Following the request of JSC “Latvijas Gaze” specialists of OAO “Giprospecgaz” 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 [1].

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 1.
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 “Giprospecgaz” 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 $2.3-2.6 \times 10^9$ 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 UGS will be increased to $1.9 \times 10^9$ m$^3$ on 2010 and $2 \times 10^9$ m$^3$ in 2015, and Gatchinskoye UGS remain at current volume of $0.2 \times 10^9$ m$^3$ of active gas.

Referring to the feasibility study performed by OAO “Giprospecgaz” specialists [2], 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”.

![Storage volume in year 2015-3200 mio m$^3$](image)

Figure 2. Gas volume increase in Incukalns UGS

3. PROSPECTS FOR DEVELOPMENT OF UGS STORAGES IN LATVIA

Governments of the Baltic Countries are expressed their interested 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 Incukalns 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. In order to facilitate the process, the Government of Latvia decided to co-finance with EC the feasibility study on development of Dobele UGS.

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).

The Baltic States are interested in gas transit through them from Russia to Europe. In doing so, a special role could be played by Latvian UGS facilities (the existing Incukalns UGS as well as potential UGSs that could be successfully built under favourable geological conditions of Latvia). These UGSs might be used most profitably if they were filled with cheaper gas during summer time. Under monopoly conditions and with a single gas supplier from Russia this idea is not fully implemented, however with creation of the Baltic Gas Ring (or others of the kind) this would be quite realistic. Construction of new UGS requires large investments; however these investments might become a profitable money allocation. Besides, it should be remembered that UGSs of large capacity (up to 50 $\times$ 10$^9$ m$^3$) situated in the centre 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 used on a wider scale for traditional purposes (household, industry, etc.) in all Baltic countries.

The Latvian Gas Company has its own UGS (Incukalns UGS) with active capacity of $2.35 \times 10^9$ m$^3$, which is one of the biggest UGS in Europe. Taking into account the distance from gas extraction sites in CIS and Norway, this UGS can play a significant role in gas supply security in North Europe [3]. It also can give profit if during summer time, when gas pipeline from CIS are not overloaded and gas marginal cost is approximately 30% and more cheaper than during winter time, is stored and than in winter extracted and sold. Latvia has unique geological conditions to build UGS. There already exists UGS capacity of $2.35 \times 10^9$ m$^3$, and investigations show that it is possible to build other similar storages with a capacity above $50 \times 10^9$ m$^3$. This can enhance not only the development of the gas supply system around the Baltic Sea but also enhance improvement of gas supply to the whole Europe. Incukalns UGS is located in the central part of Latvia, but in perspective UGS could be spread all over Western part of Latvia.

One of the largest and most investigated prospective UGS is situated at Dobele. The peculiarities of the geological structures in Latvia is creating unique favourable conditions for setting up other underground gas storages. The lower part of the sedimentary rocks contain Middle Cambrian limestone strata with a good satisfactory collector capacity practically everywhere. A thick water-impermeable clay and carbonate stratum covers this layer. The existing Incukalns UGS in Latvia is the only one in the Baltic States. The depth of this Middle Cambrian collector is form 700 to 1,700 m. The designed capacity of this collector for the next 20 years is $4 \times 10^9$ m$^3$ (the active capacity is $2.3 \times 10^9$ m$^3$). In the future, development of the Dobele UGS is highly possible. Approximately 20 wells have been bored already, and the total capacity of this storage is estimated at $16 \times 10^9$ m$^3$. At present, the existing Incukalns UGS with a capacity $2.35 \times 10^9$ m$^3$ performs only a limited number of functions. In the summer period gas from Russia is stored for all customers in Latvia for winter (about 85% of annual consumption). In the wintertime the gas pipe to Latvia from Russia is closed. In this way, during the maximum gas consumption in winter the Russian gas pipes are freed for
other customers. For Latvia they are used only during summer as an extra means of gas transportation. If the additional gas transportation were calculated at marginal costs, the transportation cost of gas in long-distance pipelines (from Russia is approximately 3,000 km) would be 30–40% of its total cost. Unfortunately, under the monopoly of gas supply (only from Russia) these cost benefits are limited.

4. ROLE OF UNDERGROUND GAS STORAGE

As integral part of energy supply system, the UGS can perform several important functions:

• To increase gas supply safety (in case of pipeline damage);
• To reduce needs for capacity of the major gas pipelines;
• To control gas supply mode related to the changing weather conditions;
• To enhance development of electricity production.

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 in order to meet their increasing demands, it is advised to use underground gas storage;
- 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 suggested to use Incukalns Underground Gas Storage in Latvia, which already is utilized for customers in Latvia, Estonia, NW Russia and Lithuania;
- 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.

Picture 2. Gas network of the Baltic Countries
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 $5 \times 10^9$ m$^3$ [6].

**5. LEVEL ESTIMATION OF SECURITY OF SUPPLY**

The assessment of the energy security level for a separate region (a state) can be performed using indicators that quantitatively characterize the existing safety threat and its degree based on:

- comparison of the current and expected values of indicators with some pre-defined threshold (limiting) levels;
- determination of the qualitative state of energy security that could be characterized as normal (N) and critical (C).

The indicators that can be used for estimation of the energy security in a region and the threshold levels are determined based on the expert estimation. Most of these indicators are used in the international practice. For reserve of boiler-furnace fuel, natural gas and heavy fuel oil indicators of N=90, C=30 (in days) are used very often.

**6. EVALUATION OF THE RISK CRITERIA**

In order to evaluate the reliability of the gas supply in the first approximation, the following often-used criteria can be applied:

- the probability of an emergency situation (q);
- the probability of a working condition (p).

The emergency situation coefficients ($\chi_a$) for individual elements of the gas supply system are determined according to the statistical data of the emergency situation. Thus, the emergency situation coefficient for a gas power plant is $\chi_a = 0.05 - 0.10$, depending on capacity of the power plant (200 – 20 MW).

<table>
<thead>
<tr>
<th>Capacity of plant (MW)</th>
<th>Number of units</th>
<th>Probability of emergency situation $\chi_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>4</td>
<td>0.05</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>0.04</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 1. The emergency situation coefficient for a gas-fired power plant

Theoretically the UGS and the gas pipeline system can be regarded as parallel-connected gas supply elements. In such a case the probability of an emergency situation is:

$$\chi_a = \chi_1 \times \chi_2$$  \(^{(1)}\)

where

- $\chi_1$ is the probability of an emergency situation for the first gas supply element (the UGS);
- $\chi_2$ is the probability of an emergency situation for the second gas supply element (the gas pipeline system).

Even at a very high probability of an emergency situation ($\chi_2 = 0.2$) for the gas pipeline system from Russia, the UGS is used with a very low probability of an emergency situation ($\chi_1 = 0.001$), the total probability of an emergency situation for the gas supply $\chi_a$ will be low too ($\chi_a = \chi_1 \times \chi_2 = 0.001 \times 0.2 = 0.0002$), but the probability of a working condition:

$$p = 1 - q$$  \(^{(2)}\)

will be sufficiently high ≥ 0.999.
The result proves efficiency of the UGS in the respect of gas supply security, i.e., uninterrupted gas supply to the Baltic consumers.

CONCLUSIONS

1. A very important risk-reducing measure of gas supply is development of a gas pipeline system, which includes UGS. 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 of submarine gas pipeline, connecting Estonian and Finnish gas grids.

2. In order to minimise the gas supply risk in Latvia, underground gas storage facilities will be created. For existing 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.

Taking into consideration geological features 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 gas supply reliability for Europe.

REFERENCES