Gas Transmission System Optimization with Natural Gas Transportation

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***Abstract*—** *In connection with the heated political situation to the east of the European Union (EU) borders, there is a growing interest in the discovery of new reserves of natural gas or new suppliers of this fossil fuel. This situation consequently requires new and unconventional ways of solving the storage and transportation of gas in large quantities and over long distances. The following article discusses the methods of storage and transportation of natural gas through the gas network.*

***Keywords*— Natural Gas, Storage Tanks, Pipelines, Compressors Station.**

I. INTRODUCTION

Natural gas consumption is uneven throughout the year, it can fluctuate, and therefore the gas is stored. In addition to natural gas reservoirs and gas pipelines, the gas system consists of several important parts and components.

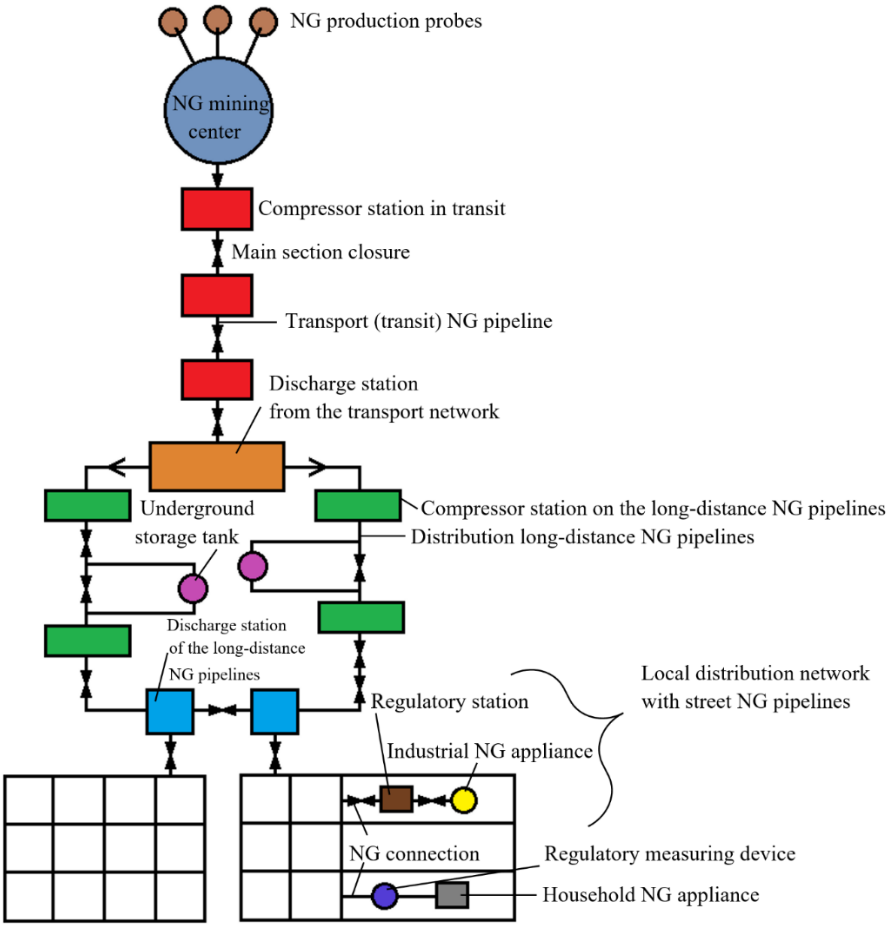

FIGURE 1: Diagram of the transport and distribution natural gas (NG) system [1]

II. NATURAL GAS STORAGE

Natural gas stored in storage facilities meets the requirements of seasonal demand and serves as insurance against unpredictable gas supply interruptions.

The basic storage capacity is used to increase seasonal demand. Baseload facilities can hold enough natural gas to meet long-term seasonal demand requirements.

The turnover rate of natural gas in storage tanks is one year. Natural gas is injected into storage tanks during the summer (outside of the heating season), usually from April to October. Seasonal reservoirs are more voluminous, but their daily output is relatively low and limited.

Tanks are built for all types of heating gases. There are above ground or underground storage tanks of various sizes and types.

Natural gas, like most other commodities, can be stored indefinitely. Exploration, extraction, and transportation of natural gas take time. Natural gas, which is transported to its destination and is not always used for immediate consumption, is injected into underground reservoirs. Consumption is significantly higher during the winter, as natural gas is mainly used for heating.

Strategically, underground storages of natural gas are used for seasonal regulation, which means compensating for increased gas consumption in the winter season by extracting it from storage tanks in which gas is stored in the summer season, when consumption is lower. They are efficient from a financial point of view because the purchase of gas takes place during the period when gas prices are lower, its storage and subsequent extraction during the period of higher prices. At the same time, they ensure the safety of deliveries in case of production or transport disruptions. These reservoirs have a large storage capacity, but a smaller daily output.

Tanks that are used for peak loads are designed to have high performance in a short time, which means that natural gas can be quickly withdrawn from the tank if needed. Peak load devices are designed for sudden increases in short-term demand. These devices are not as bulky as baseload devices, but they can deliver a smaller amount of gas faster and in less time than baseload devices. In contrast to seasonal reservoirs, these reservoirs can be refilled to their maximum capacity during the winter period.

Geological structures suitable for the creation of underground reservoirs must mainly meet the following geological-deposit criteria:

- Gas Tightness of The Formation,
- Effective Porosity,
- Size of Usable Cubic Capacity,
- Storage Depth.

On a global scale, the most used type for the creation of underground reservoirs are the natural gas and oil extracted deposits. If such sites are not available, storage tanks are built in watered layers of the so-called aquifer type. These types of reservoirs have a large storage capacity but a smaller daily output and are referred to as seasonal reservoirs.

Peak reservoirs are most often established in salt caverns (cavities), which are created by treating part of the salt deposit with water. Less often, other underground cavities are used for this purpose, such as abandoned coal or ore mines or artificially cut caverns.

With underground reservoirs, we recognize the prospective need for the stored amount of gas, i.e., the required storage capacity and the ready mining capacity.

The most common form of underground reservoirs is porous (Figure 2). These are mostly extracted deposits of oil or natural gas that are used to re-storage the gas, leaving an underground formation geologically capable of holding natural gas.

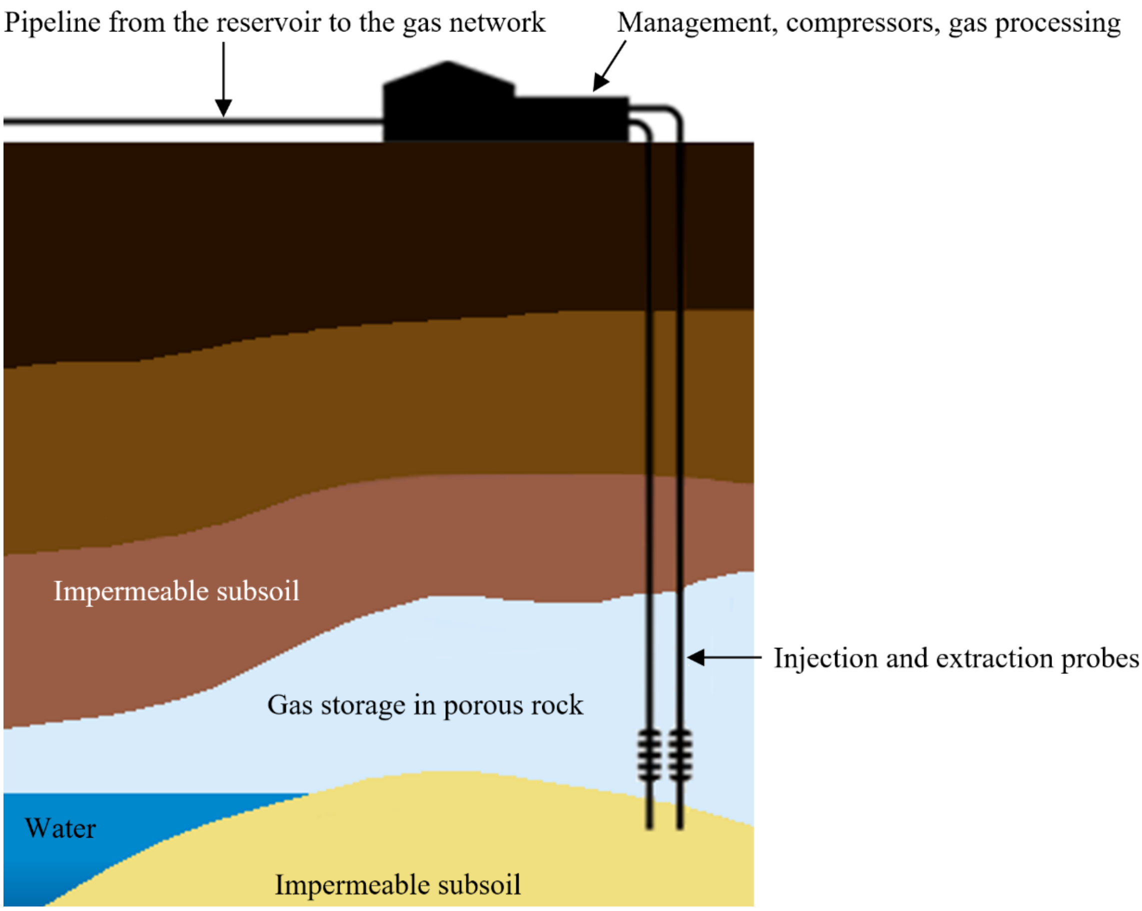

FIGURE 2: Porous NG storage [2]

Exhausted deposits are attractive also because their geological characteristics are already well known. The gas is stored in porous rocks, which are most often formed by sandstone and various consolidated sands containing clay.

III. TRANSIT SYSTEM OF NATURAL GAS

As already mentioned, the discovery of large-capacity natural gas deposits on various continents and the appreciation of the importance of natural gas in its wide range of uses as an energy source and raw material laid the foundations for transportation systems.

The basic characteristics of the natural gas transmission system are:

- Verified Large-Capacity Gas Deposits,
- Transportation of Large Quantities of Gas (on the order of billions m^3 per year),
- Large Diameter Pipes Consisting of Several Lines (approx. 900 to 1,400 mm),
- High Operating Transport Pressures (5 to 7.5 MPa),
- Long Linear Lines Connecting the National Gas Systems of the Individual States of the Continent (Thousands of km).

In terms of the relevant legislation, the transport NG network is characterized as a network of compressor stations and a network of mainly high-pressure gas pipelines, which are connected to each other and serve to transport NG in a defined area, in addition to the extraction network and storage and high-pressure NG pipelines, which serve primarily to transport NG in parts of the defined area.

The natural gas transportation system consists of:

- Border Discharge Stations,
- Pipelines,
- National Discharge Stations,
- Compressor Stations.

IV. PIPELINES

At the beginning of the transportation chain, when it is necessary to transport large volumes of natural gas over long distances, natural gas is most often transported in two basic ways: gas pipelines or in tankers in the form of liquefied gas.

By gas pipeline, we understand the system of pipes through which we transport natural gas from the place of extraction to the place of consumption. As the consumption of natural gas grew in the past, deposits near large cities were gradually exploited, so it was necessary to transport natural gas over greater distances and in larger volumes. Long-distance gas pipelines are run not only on land, but also on the seabed, which makes it possible to transport natural gas also from other continents.

There are several types of gas pipelines:

- Transit Transmission Lines,
- Distribution (Connecting) Transmission Lines.

The task of transit transmission lines is to transport a large amount of heating gases, usually natural gas, from mining deposits over distances of several hundred kilometers to the area of main consumption. National or interstate transmission lines usually have a pipe diameter of over 500 mm and an operating pressure of over 5 MPa.

Distribution (connecting) long-distance lines ensure gas transport from the main transit arteries to individual gas-supplied areas and interconnected and circularized ensure smooth gas supply to customers. As a rule, they are built under 500 mm pipe diameter and under 5 MPa operating pressure, their lengths are usually a few hundred kilometers at most. Depending on the operating pressure, they can create separate distribution circuits.

An important part of the transit transmission lines are route closures (Figure 2), which are placed approximately every 20-25 km. They enable possible stopping of the gas flow on individual sections of the gas pipeline. When the transported amount of gas drops, the valve closes automatically and closes the section. Other functions of the route closures are, for example, the depressurization of the gas pipeline, the release of gas between gas pipeline sections and eventual cleaning of gas pipeline sections.

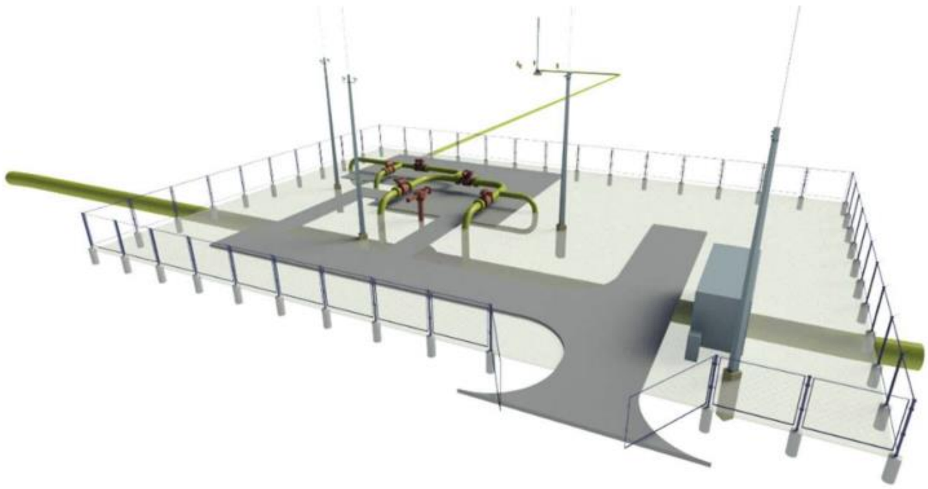

FIGURE 3: Route closure [3]

V. COMPRESSOR STATIONS

As a rule, the extraction technology from deposits does not allow using the deposit pressures to transport large quantities of natural gas through long-distance transit pipelines to places of consumption.

When transporting natural gas through long-distance gas pipelines, pressure losses occur. These losses are caused by the friction of the gas both against the walls of the pipe and by the internal friction of the individual parts of the gas against each other. Pressure losses must be compensated to deliver the gas to the designated location. Compressor stations as part of gas pipelines serve this purpose - they increase gas pressure. For safety and operational reasons, they are built outside cities and towns.

The station consists of a system of interconnected devices that can be divided into two groups:

- Equipment serving its own gas compression and gas treatment equipment (compressors, compressor drives, pipelines, filters, gas coolers),
- Service facilities (energy and oil management, firefighting equipment, laboratories, and workshops).

Compressors used in the gas industry are divided into two basic groups:

- Reciprocating Compressors,
- Turbo Compressors.

Reciprocating compressors work based on the change in the volume of the working space (cylinder).

Turbochargers are high-speed machines in which the pressure increases due to the increase in the velocity of the gas flowing between the rotor blades.

The largest compressor station in the territory of the European Union is the Veľké Kapušany compressor station (Figure 4), located in Slovakia. The technical capacity at the entry point in Veľké Kapušany is 220 million cubic meters of natural gas per day. [4]

Gasification in Slovakia began in 1951, when the first gas pipeline was built on the territory of today's Slovakia, which was 38 kilometres long. Between 1970 and 1973, a parallel transit pipeline with a huge annual capacity of 28 billion m3 was built to transport gas to Germany. Currently, up to 94% of the population in Slovakia has access to natural gas.

FIGURE 4: Largest EU compressor station in Slovakia [5]

VI. CONCLUSION

The costs of construction, operation, or modernization of the gas network together with natural gas storages represent a significant investment for their developer or operator. The time required for construction plays an equally important role. It is therefore necessary to carefully consider the use of currently existing networks as well as storage facilities as well as the construction of new ones.

New deposits and new forms of natural gas transportation, as well as the search for new sources of energy, could bring about a stable operation of the world economy again in the future without deepening the ongoing climate change.

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