

# ROLE OF UNDERGROUND GAS STORAGE FACILITIES OF UKRAINE TO ENSURE RELIABLE AND EFFICIENT GAS CONSUMPTION

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## 1 BACKGROUND

The system of underground gas storage (UGS) of Ukraine consists of 13 underground gas storage facilities (UGSF), as well as its gas transmission system (GTS) and is one of the biggest in the world. UGSF can provide 50% of annual and about 60% of country's daily gas consumption, with their considerable working volume of more than 30 billion cubic meters (bcm), and daily productivity of more than 300 million cubic meters.

Ukraine belongs to the countries with the developed gas industry. The country's gas consumption in 2010 totalled 57.6 bcm against 118.8 bcm in 1990 (when Ukraine took the third place in the world after the USA and Russia).

### Gas Transmission System of Ukraine



Gas consumption in Ukraine, as well as in other countries with the developed gas industry, is irregular during a year. If, for example, in January average annual daily consumption is 150-160%, in July it makes only 40-45%.

The developed and powerful system of underground gas storage facilities (UGSF), which requires effective dispatch control, provided a set of measures aimed at enhancement of reliable and efficient operation of underground gas storage facilities. Enhancement of dispatch services will enable the optimal strategy for interaction of underground gas storage facilities and transmission system (GTS), minimise the emergency situations in the underground gas storage facilities and improve efficiency of UGSF operation.

Underground gas storage is an effective mode of energy collection for short-term or long-term storage. Neither the gas industry nor other energy sector areas have such extent and competitive equivalents.

Natural gas obtains a new important quality and superiority over other forms of energy resources due to capacity of underground gas storage facilities with their unique ability of cost-effective use of resources and constant gas supply to consumers. The underground gas storage facilities are predominant in a global tendency of accumulating energy resources for the steady functioning of economy in case of emergencies.

May 25, 1964 is considered to be the beginning of the underground gas storage in Ukraine - the date when pioneer gas injection in Olyshivske aquifer was carried out in order to create underground gas storage.

Development of underground gas storage in Ukraine can be divided into three periods.

The first period is considered to be 1955-1970 marked by the exploration and experimental operations for creating UGSF based on aquifer formations.

The second period of creating of underground gas storage facilities in Ukraine was in 1969-1985. UGSF were built in depleted gas reservoirs to provide reliable gas supply to the countries of Central and Western Europe and to satisfy growing domestic consumption.

The third stage of underground gas storage facilities development started with the mid-80s of last century and still continues. The most significant work was provided to increase active storage capacity and gas withdrawal conducted in the second half of the 80's. Except the development and putting into operation new storage facilities possible gas withdrawal period in UGSF was decreased from 150-165 days to 100-120 days.

The work, carried out for the last years includes:

- modernisation of drying units and gas-compressor shops,
- measures aimed at a automatic control and efficiency increase of natural gas withdrawal.

Considering operation of Ukrainian UGSF grid by other countries one should mention the unique conditions for continental gas reservation.

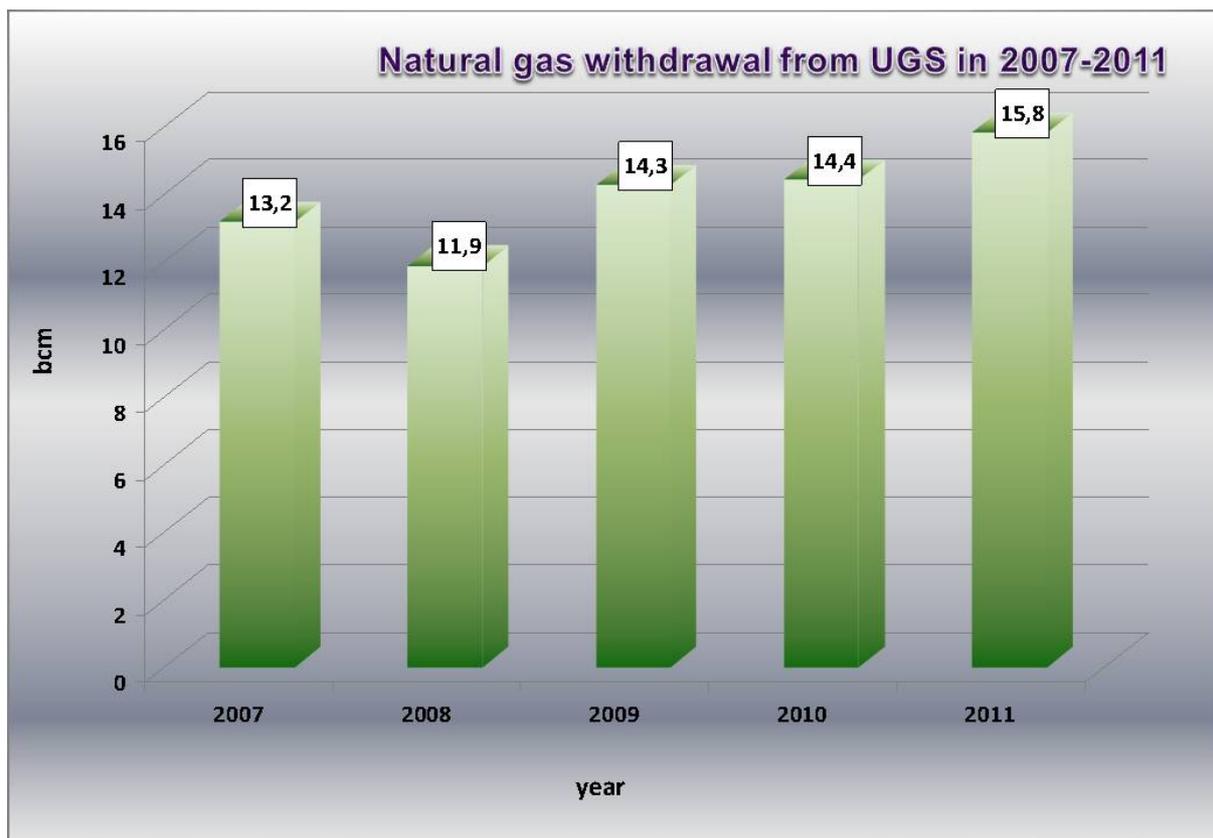
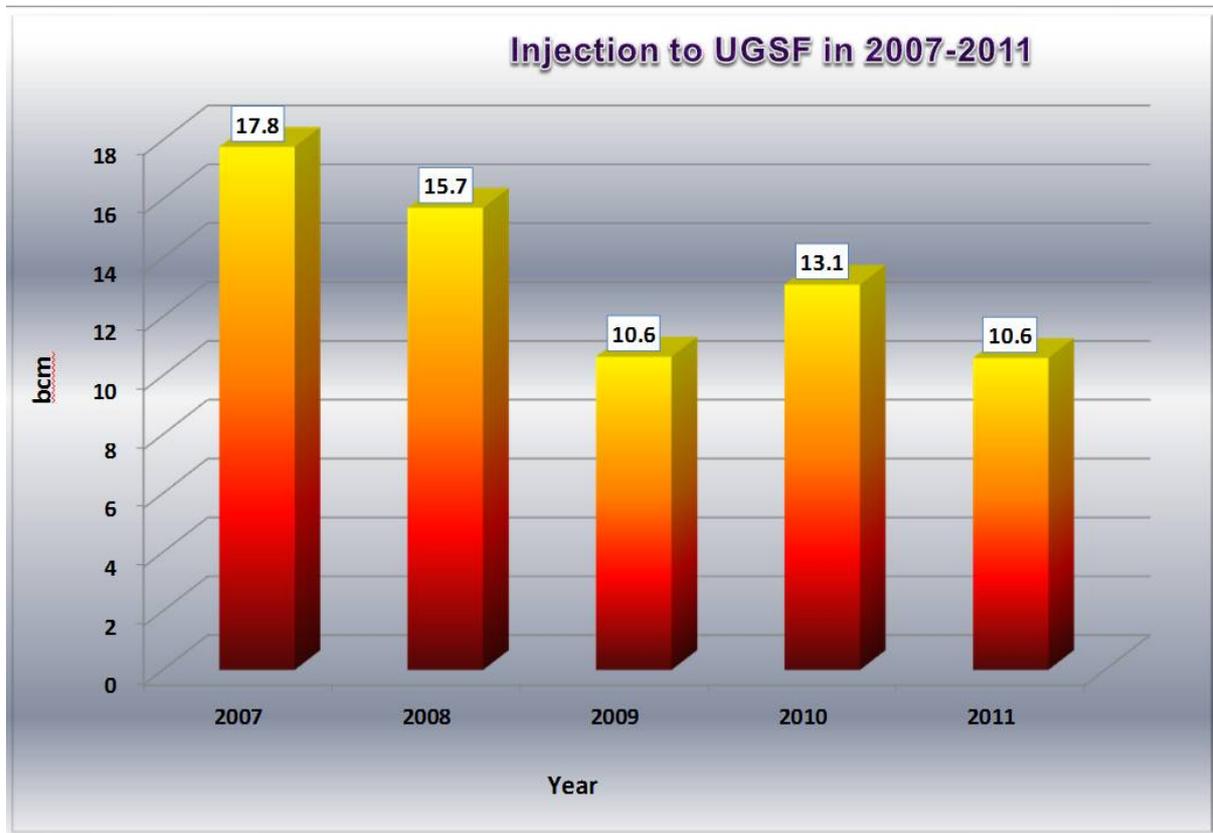
The system of dispatch control of underground gas storage facilities is a complex of measures directed at reliability enhancement and optimality of UGSF operations. Design and implementation of dispatch control system gives an opportunity to find optimal strategy of interoperation between underground gas storage facilities (UGSF) and gas transmission system (GTS), to minimise contingencies at underground storage objects as well as to enhance operation reliability of gas storage facilities.

## 2 AIMS

The main purpose of this report is to dwell upon the significant role of underground gas storage ensuring the reliable and efficient gas supply to consumers in Ukraine, as well as to provide reliable Ukraine-Europe transit of gas, especially in case of emergency.

UGSF equilibrates seasonal gas consumption, creates necessary gas supply in order to make the system more reliable and to provide stable functioning of gas transmission system

including gas industries and gas pipes of the populated areas. UGSF also reduces expenditures on linear part and compressor stations.



Due to the slight changes in the daily gas production and annual gas import, in spring-summer season there is a considerable surplus of gas which is injected into UGSF, and in autumn and winter this gas is withdrawn from the storages and is supplied to the market to satisfy the excess demand.

The efficient UGS operation requires systematic analysis of dynamic responses, development and implementation of optimisation methods for storage facilities within unified gas transmission system providing actual and accumulative capacity of storage facilities. To operate the system efficiently it is necessary to develop and organize the modernisation of GTS, interoperation between GTS and UGSF aimed at maximum use of their energy saving potential.

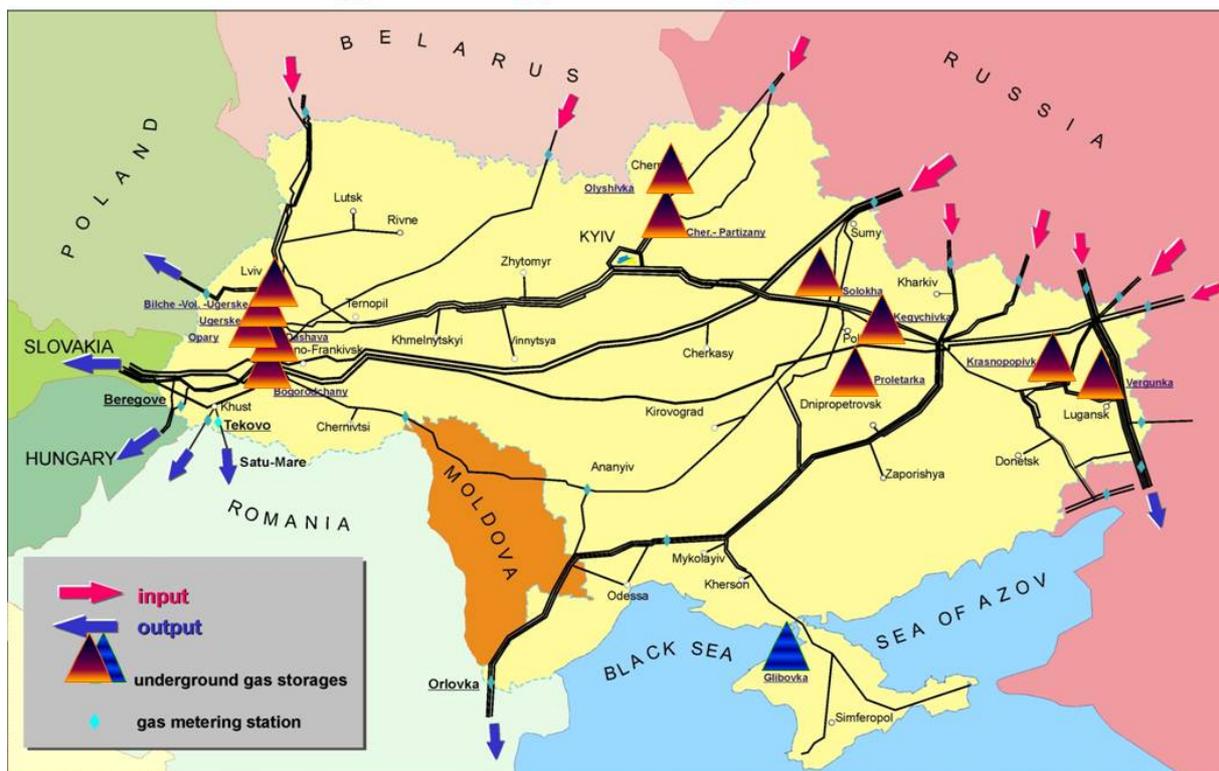
### 3 METHODS

Underground gas storing is a highly effective process that provides constant supply of natural gas from main gas pipes for engineering and economic interest amid variable market demand depending on weather conditions, in case of long-lasting supply interruption or its significant reduction caused by considerable damage or natural calamity, environmental problems etc.

Ukrainian UGS have favourable location as they are situated in the centre of Europe at 3000-3500 km distance from the main regions of natural gas production. Favourable geologic conditions make the underground gas depositories system a strategic, necessary, reliable, competitive and multi-functional one against the increasing demand for UGS in the neighbouring countries.

There are four regional complexes of UGSF in Ukraine.

## Underground gas storage in Ukraine



The Western complex, created in Carpathian region within the system of transcontinental, international and national gas pipes, comprises five UGSF: Bilche-Volytsko-Ugerske, Ugerske, Dashavske and Oparske. The underground gas storage facilities of the complex are joined through the gas pipes system that provides favourable conditions for gas flows redistribution and satisfaction of local and distant consumers' gas demands. The complex gives an opportunity to accumulate necessary gas reserves to complete operational and strategic tasks.

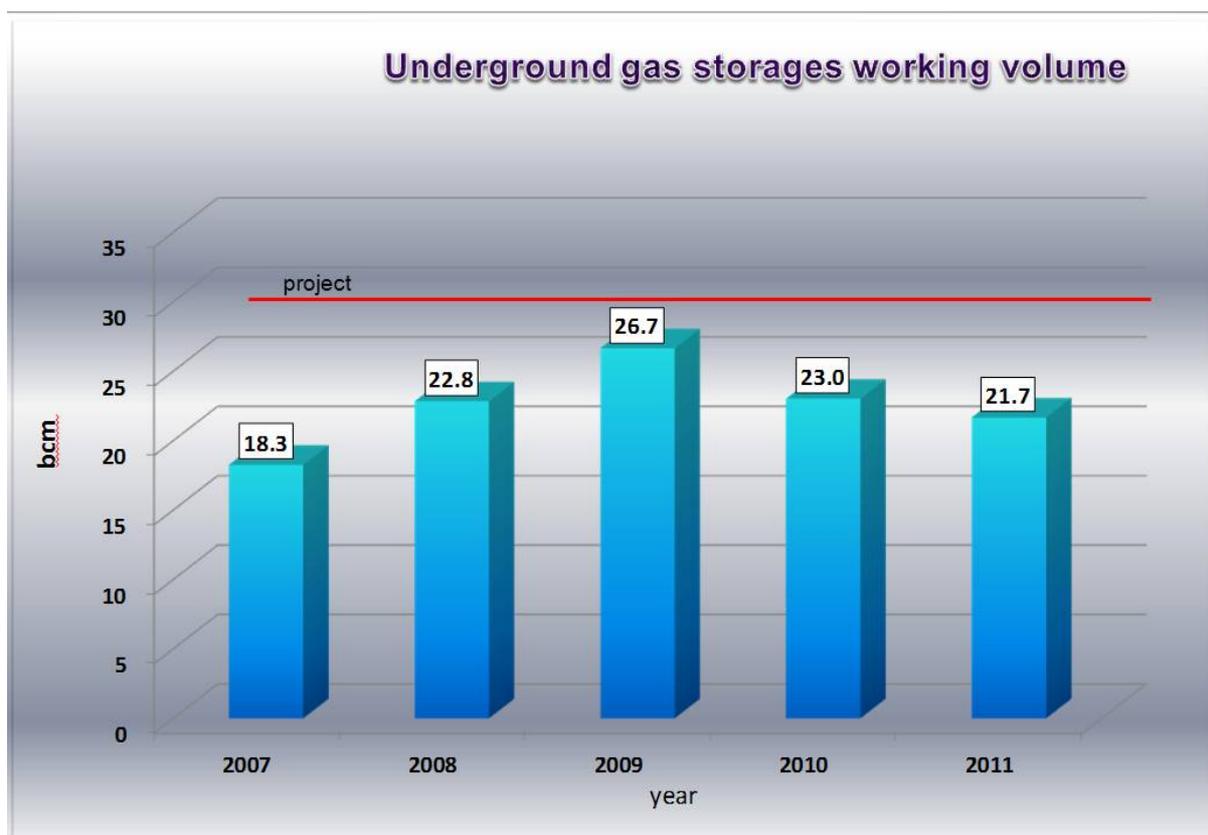
The Central complex, which includes four UGSF (Chervonopartyzanske, Olyshivske, Solokhivske and Kegychivske), created within Kyiv's main gas pipe system, ensures reliable gas supply to Kyiv and the number of regions of Central Ukraine. UGSF are joined by the gas pipe system that allows to regulate the pumping capacity and taking of gas within the framework of the complex.

The Eastern complex, comprising Krasnopopivske and Verhunske UGSF, created within the Donbas gas pipe system, provides reliable gas supply to consumers of Donbas region.

The Southern complex is created in Prydniprovskiy region near the Crimean peninsula. The complex comprises Proletarske and Glibivske UGSF. The Southern UGSF provides reliable national gas supply and transit gas deliveries through southern regions of Ukraine to Moldova, Turkey and Balkan countries.

Ukrainian underground gas storage facilities, particularly those in Western region, are connected with transit pipelines to ensure reliable gas supply not only to domestic consumers but also the gas transit to European countries.

In a fall-winter period the western UGSF are used to regulate transit deliveries on the western border of Ukraine not only through the irregular gas supply from Russia as a result of possible breakdown of transcontinental gas pipelines or a sharp temperature drop, but also for indemnification of part of transit gas, used in the east regions of Ukraine in this time of year.



System of dispatch control of underground gas storage facilities is based on hydraulic connection of underground gas storage objects and integration of operation model of the system “UGSF layer – main gas pipeline”.

Main trends in efficient UGSF operation in GTS is increase in working volume using idle horizons, increasing daily yield. Investigation of the efficiency is provided to substitute cushion gas with inert gas in sufficiently non-uniform layers. There is increase in throughput capacity in ‘bottlenecks’ of the layer-gas-main pipeline system and optimisation of gas withdrawal and injection processes as well as automation of control for production well operation and gas flow in the layer-gas-main pipeline system. Development and implementation of energy-saving technologies and related technological solutions facilitate the innovations, development of software-hardware systems for the needs of modelling, optimization and control.

#### 4 RESULTS

The underground gas storage facilities of Ukraine have operated as usual for decades. But the situation in January 2009 provoked the necessity of the autonomous mode of functioning of GTS, when the import of gas was completely stopped. The natural gas from UGSF of the Western region was transported in the reverse direction to the consumers in Central and Eastern regions of Ukraine.

At that period the temperature in south-eastern region of Ukraine descended to 27 degrees below zero. The volume of domestic production and gas reserves in underground gas storage facilities of this region was not enough for the minimal gas supply to consumers. Meanwhile, the Pre-Carpathian underground gas storage facilities, whose active volume is about 80% of the Ukraine’s UGSF, had sufficient natural gas resources that significantly exceeded the needs of the region and were not used for transit supply regulation. In a day an unprecedented gas transmission system’s reverse was made - gas from the western underground gas storage facilities was directed to the southern and eastern regions of Ukraine.

Ukraine's gas transmission system’s peculiarity is its branch system. Transit pipelines have multiple parallel lines that are interconnected at the compressor shop stations and are connected with the help of pipeline jumpers. It provides the system with high flexibility and reliability in natural gas supply to consumers, that made it possible to turn gas flows from west to east and south, traditionally directed from east to west.

Due to the high qualification of the personnel of dispatching centre the scheme of gas supply from west to east has been successfully implemented and communal households even in the remotest parts of Ukraine had no problems with the supply of gas and heat. Of course, in this emergency situation industrial gas consumers were somehow limited, but most of them launched the reserve fuel.

It should be noted that in that emergency situation some gas from Ukraine’s UGSF was served even to Moldova, that had no other sources of gas. The possibility of gas supply from Ukraine’s UGSF to Bulgaria was also regarded.

During the reverse mode of transmission system every gas pipeline was tested for integrity and reliability. Some parts of the pipeline at the entry compressor stations, which worked at lower pressure for decades, turned into exit stations, where pressure was significantly higher. In case there were any defects in pipelines that were not detected during a long-term work at a lower pressure it could cause a serious breakdown. As there were no failures at that period we can assume that Ukraine's gas transmission system is in a good technical condition.

## 5 CONCLUSIONS

To meet the requirements of the market, further development of UGS in Ukraine presupposes the increase in working volume and highest possible productivity, reliable national gas supply and gas transportation to the neighbouring countries.

Implementation of these measures will provide an additional reduction of total time of gas withdrawal (to 20%) of the underground gas storage facilities without increasing energy expenditures and more efficient and optimal management of underground storage facilities in the gas transmission system of Ukraine.

Large working volume of UGS in Western Ukraine, its wide range of possibilities for taking natural gas ensure great manoeuvrability of gas flows, optimisation of operating particular UGSF, creation of necessary operational and strategic gas reserves that is very important in market economy.

For a reliable supply of natural gas to domestic consumers up to 15 billion cubic meters of working gas from the underground gas storage facilities are used, confirming the existence of significant reserves of active power storages in the volume of about 15 billion cubic meters for potential European consumers.

A distinct feature of the underground gas storage facilities network development in future is the availability of sufficient volume of underground gas reservoirs (gas-condensate), as well as depleted oil fields with favourable conditions for underground gas storage.



Experience of the maximal use of UGSF resources and GTS operation in the reversible mode in emergency situation witnessed high manoeuvrability and reliability of the gas transmission system of Ukraine. Although such situations happen extremely rarely, this experience can be useful to other countries, which do not have the proper diversification of gas supply sources and for diverse reasons can face a similar situation.

It is necessary to create a long-term reserve in underground gas storage facilities on the basis of increasing UGSF network productivity for country's economic safety. It is essential to use free space at mutually beneficial basis both for seasonal and long-term gas storage for other countries.

