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# TECHNICAL AND ECONOMIC COMPARISON OF GAS-SUPPLY SYSTEMS IN RESIDENTIAL AREAS

Gas distribution systems in settlements are quite complex engineering structures, composed of pipelines with various pressures and applications, gas-control units and gas-fired plants, protection against galvanic corrosion, control valves, control and measuring equipment, etc.

Design and construction of gas-supply systems in residential areas in general as well as in the individual objects in particular are carried out in accordance with the requirements of Regulations and current Legislation of Ukraine on these issues [1, 2]. They are generally based on recommendations of well-known gas experts, such as D.B. Bayasanov, Ye.I. Berhman, O.I. Hordyuhin, O.O. Ionin, V.O. Smirnov, Ya.M. Torchynskyi, etc. [3-6]. They solved the problems related to:

1) selection of the optimal number of gas-supply sources: gas distribution stations (GDS), gas-control units (GCU) and gas-fired plants (GFP);
2) selection of optimal schemes of connecting centered consumers to gas networks with different pressures;
3) optimal allocation of the estimated pressure difference and transitory gas losses in gas pipelines.

However, one can argue that these recommendations are primarily related to gas distribution systems in residential areas. They had been developed in the 60s through 70s of the former century, having a number of assumptions. For example, while determining the optimal number of network GCU - the sources of low-pressure gas-supply systems - a residential area with the following features was selected as a computational model:

1) architectural and planning solutions provide a symmetrical construction of area of gas distribution circled network to form square-shaped circles;
2) GFP shall be placed in chess order in the centers of their areas;
3) the parts of networks, equidistant from GCU, shall have the same bandwidth;
4) length of all calculated sections of the network shall be even.

In addition, the gas distribution networks of residential areas (RA GDN) were designed for the shortage of natural gas and, therefore, one of the goals was to create an optimal flux.

In rural areas the number of network gas control units is determined primarily by the type of the building (usually it is one-store, i.e. minor gas flow at a relatively large and irregularly built-up area). Therefore, they are placed in the center of the densest housing centers for the supply of certain streets, farms, etc. In this case, the load on GCU is equal to the maximum gas consumption by small consumers (people, pets, decentralized heating, small communal facilities), located in these areas. Thus, according to O.O. Ionin [5], technical and economic analysis of optimal number of GCU, designed for city areas, is not necessary for rural areas.

Given that the RA GDNs are rather material-consuming, and therefore expensive, decrease of their cost and metal consumption, especially under market economy conditions, is becoming ever more important at the state level.

Today in Ukraine there are different materials and equipment, such as plastic pipes and fittings, combined gas pressure regulators for houses, etc. for gas-supply systems produced by domestic as well as by well-known foreign manufacturers.

In order to identify economically viable option for rural areas gasification, analytical studies of possible schemes of gas distribution networks for a particular residential area in Cherkasy Oblast have been performed.

In the village there are all categories of natural gas consumers. Gas flow calculations have been made in accordance with the Law DBN V.2.5-20-2001 [1]. The total maximum one-hour flow is 4276 $m^3$ per hour, and the cost ratio for evenly located and densely centered consumers is about as 40:60%.

The source of natural gas is the main gas control unit (MGCU) which is connected to inter-village pipeline with pressure $P \leq 1.2$ MPa. The width of the streets in the village is sufficient for installing pipelines with high pressure ($P \leq 0.6$ MPa).

In the analysis different RA GCNs have been considered: single- (medium pressure gas) and two-stage (high and low pressure gas) using steel and poly-ethylene pipes with different pressure differences.

Hydraulic calculations for pipelines were performed on a PC using the application package “Hidra”. When considering the two-stage networks, at first, street networks with low pressure gas were calculated, which resulted in refined network load GDU. Location GDU was considered on the basis of residential planning decisions: gas control units were located either at the center of building, or provided certain streets with natural gas. In order to improve the reliability of gas supply, the pipelines with both low and medium pressures were made circular. Length of areas under calculation did not exceed 200 m.

The calculations used the minimum diameter of pipes:

1) networks with low and high pressure gas (two-stage system): Steel pipe: $d^3 \cdot S = 57 \cdot 3$, polyethylene pipes: $d^3 \cdot S = 50 \cdot 2.9$ mm;
2) the same with the average gas pressure (single-stage system), accordingly $d^3 \cdot S = 38 \cdot 3$ and $d^3 \cdot S = 40 \cdot 2.3$ mm.

As comparison criteria the construction of the capital cost of construction of gas-distributing street networks and structures on them were adopted, whereas operating costs for all options under consideration had been conditionally accepted as equal and therefore excluded from further calculations. In economic calculations the cost of construction of underground gas pipelines in dry soils with pneumatic testing were considered as well as reinforced corrosion insulation for steel pipes. The cost of network GCU of cabinet type, house regulators such as RDHS -10 and their installation were considered as of September 1, 2010. According to the research, the following conclusions can be made:

1. Economically more feasible option is a single-stage street pipeline system with medium pressure gas, and installation of house gas pressure regulators, and the use of polyethylene pipes. The increase in the estimated pressure difference in the network from 150 (Pfin. = 250 kPa) to 250 (Pfin. = 150 kPa) did not significantly affect the cost of the system (difference makes up to 0.1%). In the problem under consideration, the savings do not exceed the statistical error. These results can be explained, in our view, by the existing requirements to the minimum diameters of gas-distribution networks, and by the existing assortment of pipes used in gas-supply systems of residential areas.
2. The increase in the estimated pressure difference in the single-stage system using steel pipes from 150 to 250 kPa also did not significantly reduce the cost of the system. However, such systems are in average by 40% more expensive than the comparable using polyethylene pipes.
3. For two-level systems with the use of steel tubes as well as polyethylene, the main differences are caused by the value of pipelines installation. Changing the pressure difference in street networks with low pressure (1200 and 1500 Pa) caused a redistribution of the gas flow in the relevant system and led to changes in performance of network gas-control units (hydraulic calculations for low-pressure gas networks are always performed at first). However, the total construction cost under condition of pressure drop increase from 1200 to 1500 Pa decreased slightly: for networks with steel pipes - by 0.2%, with polyethylene pipes - at 0.76%.
4. After analyzing the value of the total cost of construction of gas distribution systems of various types for gasification of rural residential area, the economically feasible option is single-stage medium pressure system made of plastic pipes and installing house pressure regulators in each building. If you take the cost of such a system as 100%, the cost of a similar system made of steel pipes is about 136%, and two-stage systems with steel pipes - 164%, polyethylene - 125%. That is, even the two-stage system using plastic pipes is cheaper than a single-stage system with steel pipelines.
5. Great interest can be found in the specific indicators of the construction of gas distribution networks in the residential area, calculated per capita or per 1,000 $m^3$ of natural gas sold. Given these parameters, single-stage medium pressure gas system using polyethylene pipes and installing house gas pressure

regulators is the cheapest option. This makes up, respectively, about UAH 4725 and 525.

The received values of specific indicators can be used in a preliminary assessment of the construction value of various types gas distribution networks in rural residential areas.

## References

[1] DBN V.2.5-20-2001. Gas-supply / Ukraine State Constr., Ukraine State Constr., Kyiv 2001, 286 p, Valid since 01.08.2001.

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[5] Ionin A.A., Gas-supply: Training for High Schools, Stroiizdat, Moscow 1989, 440 p.

[6] Torchynskyi Ya.M., Optimization of the Designed and Exploited Gas-distribution Systems, Nedra, Leningrad 1988, 240 p.

### Abstract

The results of studies of gas-distribution systems in rural residential areas are outlined. Construction costs of street gas pipelines and gas-control units are taken as comparing criteria. The economically viable option is substantiated.

## Techniczne i ekonomiczne porównanie systemów przemysłu gazowego na obszarach mieszkalnych

### Streszczenie

W artykule przedstawiono wyniki badań systemów dystrybucji gazu w wiejskich obszarach mieszkalnych. Jako kryteria porównawcze przyjęto koszty budowy ulicznych gazociągów i bloków kontrolnych. Opcja ta jest uzasadniona z ekonomicznego punktu widzenia.