

POSSIBLE PROSPECTS FOR HEAT SUPPLY OF MULTI-APARTMENT BUILDINGS IN ARMENIA



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Abstract: The research was carried out for the selection of optimal options for the heat supply of multi-apartment buildings, taking as an example several new buildings in Yerevan. The purpose of the study is to confirm the choice of the best method of providing heat in apartment complexes. It was used to calculate and analyze the energy-economic and operational-technical indicators of individual heating boilers, small centralized systems, and hybrid systems to solve this problem. The calculations considered both natural gas tariffs and fluctuations in the value of the Armenian dram against the US dollar. The value of 1 kWh of thermal energy or specific heat capacity has been determined as an important criterion for choosing the most efficient method of heat supply, considering the careful analysis of almost all variable factors.

Keywords: multi-apartment, individual or centralized heat supply, specific heat capacity.

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Introduction

The best solutions for heat supply have been the subject of numerous studies in the past, but the relevance of this research has increased due to contemporary social and political circumstances [1,2].

Since the RA and many other nations import fuel, their economies strongly depend on the stability of its price and supply, making efficient methods for heating apartment complexes a crucial concern.

Central boiler houses and thermal power plants (TPPs), were the primary source of heat for the cities of the former Soviet Union and many other Eastern European nations [3]. The heat was transferred through heating networks. After the energy crisis of the early 1990s, when gas supplies to the country fully ceased, Armenia's district heating systems essentially stopped functioning. New issues with the heating of residential areas emerged once the gas supply was resumed in the early 2000s [4].

Using cutting-edge cogeneration technology at the time, some regions of the RA made an effort to rehabilitate central heating systems [5,6]. Due to the outdoor heating network's prolonged idleness, it deteriorated, and the heating systems of apartment buildings were either fully or partially disassembled. Since the beginning of the certificate of property rights to real estate, it has been technically impossible to restore the unified heat supply system for buildings because it would require large investments. It became common to install individual gas boilers to heat each apartment in multi-unit residential buildings as well as individual homes [7].

It is necessary to compare and assess the viability of individual and centralized heat supply options in apartment buildings that are currently under construction, taking into account the proportion of thermal energy consumed by residential buildings in the Republic of Armenia's overall energy balance as well as a noticeable increase in newly built residential buildings. The probability of gas equipment mishaps and water leaks in the heating systems is extremely high, despite the fact that individual heating systems are not supervised by the building operator. Due to the fact that the heating boiler, heating appliances, as well as the acquisition, installation, and ongoing maintenance of the system, are typically handled in this situation, the majority of developers continue to prefer the individual-apartment version of building heating and hot water supply [6].

The theoretical value of the generated thermal energy should be utilized as the main criterion for orientation, however, considering the regulatory framework of the republic and the socioeconomic position of the population [8,9].

Based on the peculiarities of settlement development, individual gas boilers with a capacity of 24-32 kW are now used in the Republic of Armenia to heat apartments. The typical heat load of apartments or small private homes under "Yerevan parameters" throughout the heating season calculation period is 4–12 kW.

According to our past research:

- 8–12 kW in January,
- 6–8 kW in December,
- 8–12 kW in February,
- 4-6 kW around in November and March.

So, an apartment or private home's gas boiler, therefore, runs at 35 to 55 percent load [5]. The "Yerevan parameters" do not only apply to the city of Yerevan, it should be mentioned, based on the Republic of Armenia's territory's climate zoning, which takes into account climate, degree-days, the length of the heating season, and a seasonal benchmark for energy production¹ (Fig.1). The trends found by the study can be applied to other communities in the third zone, which composes around 20% of the republic's land area and is also the most densely populated in Armenia (56 percent of the total population) [9].

The choice of heat source is not necessarily ideal in a traditional district heating system with huge district heating boilers or TPPs because of the network's high heat loss, particularly in the case of TPPs.

Since investments for medium and small businesses are mainly made through banks, attracting private capital is counterproductive. As a result, local residents are often forced to use individual heating systems for their homes.

The main focus is on the use of individual heating and hot water systems, with the expanded use of renewable energy sources, in accordance with the regulation on heat supply of the program ensuring the growth of the energy sector of the RA until 2040^{2,3}.

Materials and Methods

Various new building projects were surveyed in Yerevan's administrative districts of Shengavit, Kanaker-Zeytun, Malatia-Sebastia, Ajapnyak, and Kentron. They were contrasted in terms of how they delivered heat. To compare the economic viability of two systems, centralized and individual heat supply, it is crucial to calculate the precise values of thermal energy generated. In this study, the boiler rooms designed for multi-apartment buildings' own needs are considered central heating systems.



Fig. 1. RA Climatic Zones
1 - Cold Dry, 2 - Temperate, 3 - Hot dry, 4 - Cold humid,
5 - Average cold, 6 - Hot medium humid

¹ RACN II-7.01-2011, Construction Norms, Construction climatology, Yerevan, 2013.

² Energy Law of the Republic of Armenia, March 7, 2001.

³ Government of RA. Resolution No. 48-L. To adopt the Republic of Armenia's strategic plan for the development of the energy sector (until 2040), the plan-time-table assuring the implementation of the strategic plan for the development of the energy sector (until 2040), and a number of government decisions on repeal; 14.01.2021.

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Table 1 presents the geometric and thermal characteristics of apartment buildings designed for several districts of Yerevan, RA in 2020-2022. The Table shows the number of stories of buildings, the number of apartments, the estimated number of residents, the heated volume, the calculated heating and ventilation load, and the specific heat and power characteristics of heating and ventilation [1]. Calculations were carried out for the difference in air temperatures in the room and outside ($\Delta T = 39K$). The thermal protection characteristics of building envelopes designed after 2016 practically do not differ from each other and comply with the requirements of RASN 24-01-2016. When calculating the thermal and ventilation loads of buildings, the materials of the external structures of buildings and their design features were considered⁴.

Table 1. Geometric and thermal characteristics of apartment buildings designed for several districts of Yerevan, RA in 2020-2022

N	District	Number of floors	Living area (m^2)	Heated volume (m^3)	Number of apartments	Number of inhabitants	Heating and ventilation loads (kW)	Hot waterheat load (kW)	Specific thermal energy characteristics ($W / (m^3 K)$)
1.	Shengavit	10	5300	15900	110	330	259.2	627	0.418
2.	Kanaker-Zeytun	14	6048	18144	84	252	358.2	377.0	0.506
3.	Malatia-Sebastia	18	8586	25758	72	216	447.2	471.0	0.445
4.	Achapnyak	17	6562	19686	102	306	447.7	667.1	0.583
5.	Kentron	16	11376	34128	128	384	513.4	729.6	0.386

Let's assume that the lower combustion heat of natural gas imported to Armenia has an average value of 8000–8200 kcal/m³. Assuming that natural gas's average lower combustion heat is 8000 kcal/m³, it turns out that burning 1 m³ of gas results in the production of 9.3 kWh of heat.

The studies were conducted between May 2021 and June 2022. The calculations were made taking into account the natural gas tariffs that were valid until 04/01/2022⁵, and set after 01/04/2022⁶. In the first case, with the consumption of up to 10.000 m³ of natural gas, the monthly tariff for 1.000 m³ of natural gas was 139.000 drams including value added tax, in the second case – 143.

700 drams including value added tax. For consumers with a monthly consumption of 10.000 m³ or more, the price of each 1.000 m³ of natural gas sold is \$255.91 and \$265.81, respectively, including value-added tax. The tariff has increased by 3-4 percent.

During this time, the cost of natural gas sold to consumers has fluctuated significantly, as has the exchange rate of the US dollar against the Armenian dram (the US currency has depreciated by more than 27 percent, see Fig. 2, line 1). Since RA is a fuel-importing country, changes in the exchange rate have a large impact on the economy, especially in the gas and heat supply sectors. Taking into account exceptional fluctuations in the exchange rate of the US dollar (USD) against the Armenian dram (AMD) (see Fig. 2, line 2). The average exchange rate index for the period from May 2021 to June 2022^{7,8} was also determined [10].

⁴ RACN 24-01-2016, Construction Norms, Thermal Protection of Buildings, Yerevan, 2016.

⁵ Tigran Gnuni. 2018. Energy Balance of the Republic of Armenia. Development of Armenia's Fourth National Communication and Second Biennial Update Report to the UNFCCC.

⁶ RACN II-7.02-1995, Construction Norms, Building Thermophysics of Fencing constructions, Yerevan, 1995.

⁷ Central Bank of the Republic of Armenia, <https://www.cba.am/am/SitePages/ExchangeArchive.aspx-URL> 26.05.2022

⁸ RA Public Services Regulatory Commission. Decision No. 83-N.

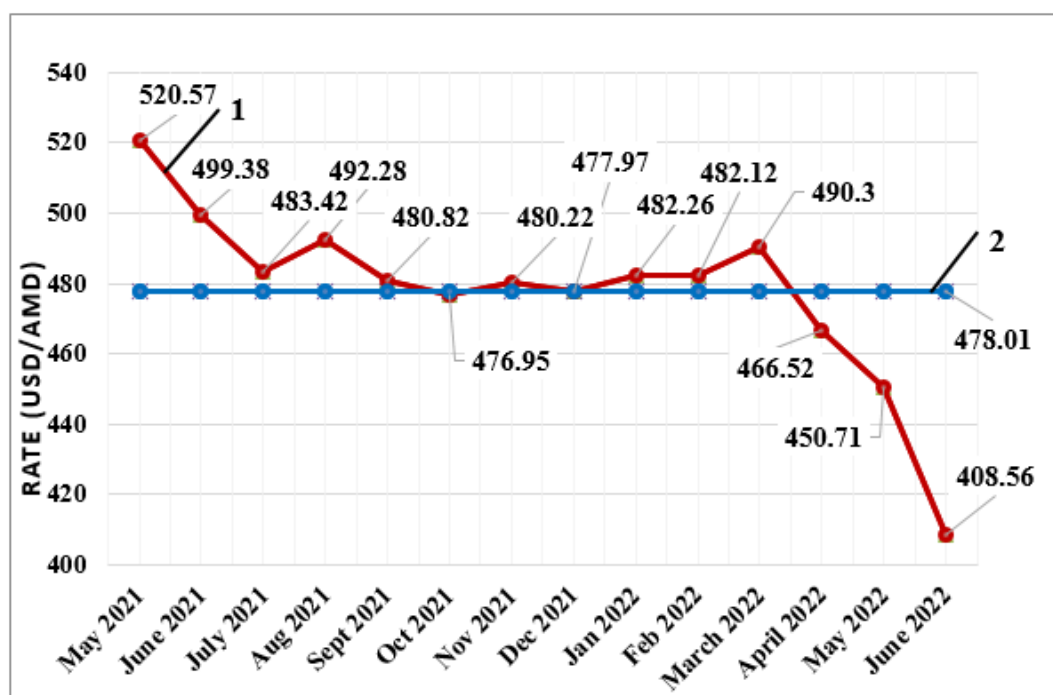


Fig. 2. May 2021 to June 2022 fluctuations in the USD/AMD exchange rate

Natural gas usage for residential needs (heating, domestic hot water, cooking) is limited to 10.000 m³, while power plants, production facilities, boiler houses, and other facilities all use 10.000 m³ or more.

To ensure that the calculations were practical, they were also performed using the following formula for determining the unit cost of the product, which is currently widely used [8,9]:

$$C_i = \frac{K_i + E_i + M_i + H_i}{Q_i},$$

K_i is the annual component of capital investments (AMD/USD),

E_i is the system operation annual cost (AMD/USD),

M_i are mandatory costs regardless of production processes (such as salaries and benefits), (AMD/USD),

H_i are taxes and fees (AMD / USD),

Q_i is the annual amount of heat received (kWh/year).

For clients with a monthly usage of up to 10.000 m³ of natural gas, the price per 1000 m³ was 255.91 USD in 2021 and 265.85 USD in 2022⁹. Production facilities, massive boilers, thermal power plants, etc. use more than 10.000 m³ ¹⁰.

For the observed apartment buildings, the specific value of thermal energy was calculated in 2 variants: in one case with a centralized heating system, in the other case with individual boilers. Table 2 shows the calculation results. According to studies, a medium-capacity boiler's average seasonal efficiency is about 0.85. The specific average cost of heat energy with centralized heat supply was around 0.042 USD/kWh (before 01/04/2022) and around 0.044 USD/kWh (after 01/04/2022), while with decentralized heat supply, the average value was around 0.113 USD/kWh (until 04/01/2022) and 0.126 USD/kWh (after 04/01/2022).

⁹ RA Public Services Regulatory Commission. Decision N95 and, Natural Gas Supply and Use Rules, 08.07.2005.

¹⁰ RA Public Services Regulatory Commission. Decision № 221-N. - On repealing the decision 333 of November 25, 2016 of the Public Services Regulatory Commission of the Republic of Armenia to set the tariffs for natural gas sold to consumers by "Gazprom Armenia" Closed Joint-Stock Company. 19.06.2020.

Table 2. Value of the product or specific heat capacity (SHC), (*USD/kWh*)

Value	Centralized heating					Individual heating
	№ 1	№ 2	№ 3	№ 4	№ 5	
Value of the product (SHC), (<i>USD/kWh</i>)	Up to 01.04.2022					
	0.046	0.037	0.04	0.043	0.042	0.1
	After 01.04.2022					
	0.048	0.039	0.042	0.046	0.045	0.13

The estimates take inflation into account in addition to variations in the dram's value relative to the US dollar and natural gas tariffs. In particular, the 12-month average inflation rate in Armenia (June 2022 compared to June 2021) was 10.3 percent based on data released by the RA Statistical Committee. According to a thorough review of all indications, the cost of 1 *kWh* of thermal energy increased by approximately 5% with centralized heat supply and by approximately 12% with individual heat supply¹¹.

Result and Discussion

Based on the study, an attempt was made to justify the choice of an effective method of heat supply. In this paper, the authors did not consider all aspects of energy saving in buildings, which will help reduce the energy consumption of buildings and dependence on imported fuel and energy resources. However, having assessed the danger of the method of providing heat supply by individual boilers, which is widely used in multi-apartment buildings being designed and newly built today, attention was also paid to the energy-economic side of this important issue. The study carried out in the article can serve as a basis for further correction of the vision of heat supply in the Republic of Armenia, quickly overcoming the problems associated with the import of fuel resources, in particular natural gas, to create prerequisites for effective and sustainable harmonious development.

Conclusion

Thus, along with the growth of modern construction in the Republic of Armenia, important issues that contribute to increasing the energy independence of the country and protecting the environment are ignored. In the Republic of Armenia, the regulatory and technical base of approaches to the design of apartment buildings is far behind the requirements of the time. Not only normative documents on heat supply of multi-apartment buildings and new residential areas are subject to revision, but also the attitude of residents to receive more affordable and safe heat supply.

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¹¹ Statistical Committee of the Republic of Armenia. <https://www.armstat.am/> - URL - 07.07.2022.

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