OPTIMIZATION OF ENERGY MANAGEMENT THROUGH THE MODERNIZATION OF DISTRICT HEATING SYSTEM (DHS) CHISINAU: CHALLENGES AND SOLUTIONS

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DOI: https://doi.org/10.36004/nier.cecg.III.2024.18.08

Abstract. *The need to modernize the DHS Chisinau and the optimization of its energy management is very actual for ensuring living conditions in accordance with the demands of modern society. The improvement and modernization of the DHS structure represents the basis for obtaining thermal comfort of the residences in the Chisinau municipality. The development of DHS in Chișinău since the 1950s has had the function of providing its citizens with long-term energy insurance and security. Initially the distribution system of DHS was equipped with 22 pumping stations, whose initial functionality was compliant with the provision of quality services for the supply of thermal energy to consumers and ensured the efficiency and reliability of the operation of the main thermal networks. The pumping stations play a significant role both on the delivery and suction side of the thermal agent. As a result of recent technological improvements, the number of these stations has been gradually reduced to 18. The Republic of Moldova, in particular the city of Chisinau, based on the perspective of continuous industrial development, in most cases faces important tasks in the field of efficiency of natural resources utilization, production, transportation, and distribution of energy and its use in all forms. Energetics management, as a science, in the given context, occupies an important place relying on methods of organizing production, transportation, and efficient use of energy. This article purpose is to explore the specific challenges faced in the modernization of the city's DHS and present potential solutions aimed at improving energy efficiency and sustainability.*

Key words*: energy management, optimization, improvement, modernization, production efficiency.*
JEL: *M00, M10, M20*
UDC: *338.45:621.31(478-25)*

Introduction. The Republic of Moldova, in particular the city of Chisinau, based on the perspective of continuous industrial development, in most cases faces important tasks in the field of efficiency of natural resources, production, transportation and distribution of energy and its use in all forms. Energetics, as a science, in the given context, occupies an important place relying on methods of energy production, transportation, the result being and efficient utilization of energy, [3].

In the city of Chisinau the energy sector has an ongoing issue of national interest, which emphasizes on high efficiency cogeneration energy production. This approach implies a much more efficient use of available resources. In this context, a key objective is to research and optimize the operation of the Western CT of SACET Chisinau through retrofitting. The process of retrofitting will involve the integration of cogeneration plants adapted to the quality and quantity requirements of local thermal energy consumption. In this way, the aim is to identify the most efficient technical and economical solutions that will meet the energy requirements of the entire community of the city. Chisinau.

The centralised District Heating System (hereafter DHS) is an integrated set of technologies, functionally unitary, which includes a wide range of constructions, equipment, installations and specific facilities, as well as measuring instruments, all intended for producing thermal energy, transporting, distributing and supplying it to consumers [1]. This system aims to achieve high efficiency performance and compliance with high quality standards.

Results and discussions. The DHS is one of the main pillars of an urban infrastructure. An DHS can integrate different thermal energy sources, such as Combined Heat and Power (CHP) plants, District Heating Power Plants (DHPP), renewable energy plants and other modern technologies, operating in a common network, starting with the production, distribution and final supply of thermal energy to a wide range of uses, such as citizens' homes, office buildings, public institutions, etc., with a high level of stability and reliability [8].

The components are structured as follows:

- Sources of heating energy generation - thermal and/or district heating power plants;
- The primary heating distribution system;
- Central heat points placed at district level or individual heating points placed at building level;
- Thermal networks for the distribution of hot water and hot water for heating;
- Heat metering system at building level;
- Internal network for the supply of hot water and heat in buildings;
- Automation and control equipment and systems.
- The operation of DHS as a public heating service is regulated by the authorities in order to guarantee the following aspects [7]:
- Continuity and high quality of the services provided;
- Affordable prices for consumers;
- Securing the necessary long-term resources for the public service;
- Reliability in the operation of the public heat supply service;
- Transparency regarding heating costs and tariffs.

The objectives of the central heating system operator in the provision of services are

- Optimal use of energy resources;

- Contributing to the sustainable development of the administrative-territorial entities;
- Reducing the negative impact on the environment;
- Promoting efficient cogeneration and the use of new and renewable energy sources;
- Ensuring transparency of heating tariffs and prices.

A clear picture of the interconnection and functioning of all system components is provided by the schematic diagram of the structure of an DHS (Figure 1.).

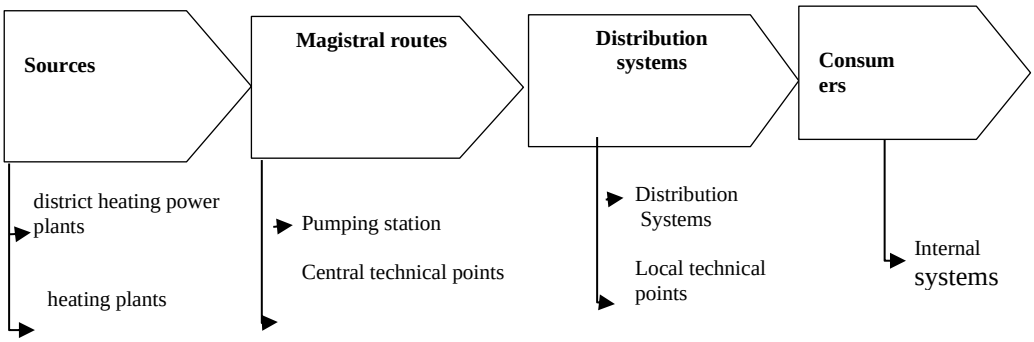

Figure 1. **The infrastructure of a centralized DHS [6]**

The system operator, as well as the Energy Regulatory Agencies and the relevant ministry, have a significant role in optimizing the management of the public service for the supply of heating energy, with multiple and diversified responsibilities. These include:

- Creating and approving specific programs for the thermal energy sector, reflecting local needs and particularities;
- Determining the tariffs for heating energy distributed to consumers, based on recommendations made by the service operator;
- Ensuring uninterrupted supply of thermal energy to consumers, thus ensuring the continuity of this essential service;
- Facilitating studies and analyses to assess the local potential of renewable energy resources and to develop feasibility projects to capitalize on this potential;
- Delimiting unit heating zones based on feasibility studies addressing regional development and specific community needs;
- Overseeing the establishment by the operator of protection and safety zones for DHS, thus ensuring the safety and efficiency of the system.

The system operator is also responsible for monitoring and maintaining the DHS infrastructure in optimal working order. Implementing annual maintenance and repair programs, as well as taking appropriate measures to prevent and manage possible emergencies or failures in the system, [1].

In addition to those listed above, of major importance is the promotion of heating energy innovations and solutions, thus contributing to increasing energy

efficiency and reducing environmental impacts. This includes exploring and integrating new technologies and energy efficiency practices in order to optimize the services offered and to meet the increasingly varied demands of consumers.In modern society, most people spend more than two thirds of their lives indoors. This creates significant challenges in terms of ensuring a comfortable indoor climate, especially in terms of temperature regulation. To address these challenges, heating systems play an important role in the implementation of innovative and efficient solutions. These systems are designed to:

- Equalizing room temperature, keeping it as constant as possible;
- Adapting the internal temperature according to specific requirements, considering thermal inertia;
- Preventing cold radiation and water vapor condensation on building surfaces;
- Warming spaces without polluting indoor air or the environment;
- Eliminating disturbing draughts inside rooms;
- Providing efficient and economical solutions, both in terms of installation and operation.

To optimize the energy management of a heating installation, a set of criteria of varying degrees of importance is established. The first priority is thermal comfort, assessed by indoor air temperature, followed by the stability and uniformity of this temperature and vertical temperature differences. The overall thermal comfort index, air flow velocity and relative humidity are also key factors in optimizing energy performance. Safety in operation, fire prevention, stability, airtightness, health and environmental protection, acoustic comfort, together with economic efficiency, are crucial criteria for ensuring optimal and sustainable energy management [4].

The choice of the optimal heat supply method should take into account relevant criteria such as energy efficiency and sustainability. Consumers have various options available to them, including:

- Individual heating systems in apartments or houses using fossil fuels;
- Direct electric or heat pump heating systems;
- Collective heating systems for block stairwells with fossil fuel boilers;
- Centralized systems (DHS) at district, town or city level.

Consumers connected to the DHS who wish to disconnect can switch to these solutions, but the alternatives may be limited in some cases, such as in buildings without access to natural gas networks. In such situations, district heating may remain the most viable option [4].

Individualized heating solutions, such as apartment central heating systems, have become increasingly popular, especially in low population density areas, offering better control over energy consumption and superior thermal comfort. In Chisinau municipality, many consumers have chosen to switch from DHS to individual systems due to the poor quality of centralized services, not necessarily for cost reasons, but to achieve a higher level of comfort.

Thus, individual and communal systems can be efficient solutions for areas with low population density, helping to optimize energy management through

increased control over the resources used and reduced dependence on centralized suppliers. The main advantages of the individualized solution include:

- Energy independence for the consumer;
- Affordability consumption;
- Personalization of comfort;
- Independence from neighbors' financial situation.

Disadvantages include:

- High initial investment;
- Dependence on a single fuel type and fuel price variations;
- Need to have or extend natural gas network;
- High local pollution and risk of explosions and poisoning in the event of individual thermal power plant failure.

DHS, compared to individual systems, has its advantages and disadvantages. Consumers connected to the DHS must accept that this centralized system has limitations in providing thermal comfort compared to individual options. DHS disconnections in the Republic of Moldova, have been influenced not only by the cost of heating [3], but also by factors such as:

- Low quality of services;
- Impossibility of local temperature regulation;
- Aggressive marketing of individual equipment suppliers and their affordability due to falling prices on the local market.

In dense urban environment, DHS represent the solution that becomes a preferable one, e.g. in city centres and high-rise neighbourhoods. If in such areas it is easy to notice the presence of residential buildings with their own heating installations, this is, for the locals, an evident sign of deficiencies in the functioning of the central heating system. A infrastructure that is well planned from the beginning, maintained and optimized, which includes advanced production, transportation and distribution technologies, followed by punctuality and competitively priced billing becomes much more attractive than individual heating systems.

Thus, the benefits of district centralized heating system are multiple:

- Promoting a healthy and unpolluted environment in inhabited areas;
- Strategic positioning of thermal power plants in suburbs and construction of tall chimneys;
- Effective dispersion of pollutants and minimization of emission sources;
- Preventing storage and handling of fuels and combustion residues in densely populated areas;
- Accessibility of high efficiency technologies, such as cogeneration, which are not feasible on an individual basis;
- Utilization of alternative fuels, such as waste and biomass, which are not viable options for individual systems in cities;
- Exploiting local renewables or waste, some of which are not efficient or individually usable;

- Limiting the use of fuels and combustion equipment by people without specific technical knowledge.

Some disadvantages of DHS can also be identified, such as:

- Producing thermal energy in one place;
- Thermal agent transportation and distribution losses;
- Extensive ageing of infrastructure and equipment;
- Lack of funds for repairs and development;
- Poor system management.

However, although central heating is generally an efficient way of heating buildings, there can be some potential disadvantages that are worth considering. For example, switching on a central heating system usually takes some time after the system has been switched off, and this means that it is necessary to wait a while for the house to warm up after the system is switched on.

DHS is usually the main object of competition between different heat producers using different resources and technologies. In this type of system, competition helps to lower the cost of thermal energy. The mismatch between the cost of natural gas for end-users and the price paid by heat producers underpins the benefits of DHS due to the impact of energy market liberalization and national policies.

The current situation of the energy production sources in the capital of the Republic of Moldova, whose operation is coming to an obvious end, being morally and physically outdated, as well as the future perspective of the modernization of these sources, becomes an increasingly relevant topic. The possibility of using cogeneration, which entails the simultaneous production of heat and electricity using the same fuel, is a promising way forward for modernizing Moldova's energy infrastructure, given the continuing increase in dependence on imported energy resources and the need to improve the efficiency of their use.

Cogeneration has its primary advantages over energy production through the direct combustion of fuels, which are reflected in the reduction of greenhouse gas emissions and the subsequent reduction in costs per unit of energy produced. Due to the recovery of waste heat generated in the electricity production process, cogeneration plants achieve higher energy efficiency compared to separate energy production in different types of plants. This is particularly important in the Republic of Moldova, as energy efficiency and energy security are a priority in conditions of import dependency.

The modernization and refurbishment of existing heating plants with the aim of transforming them into cogeneration plants is a viable solution in the field of improving Moldova's energy security [3]. This process involves not only the replacement of existing equipment, but also the implementation of new cogeneration technologies that will make the efficient use of energy resources possible.

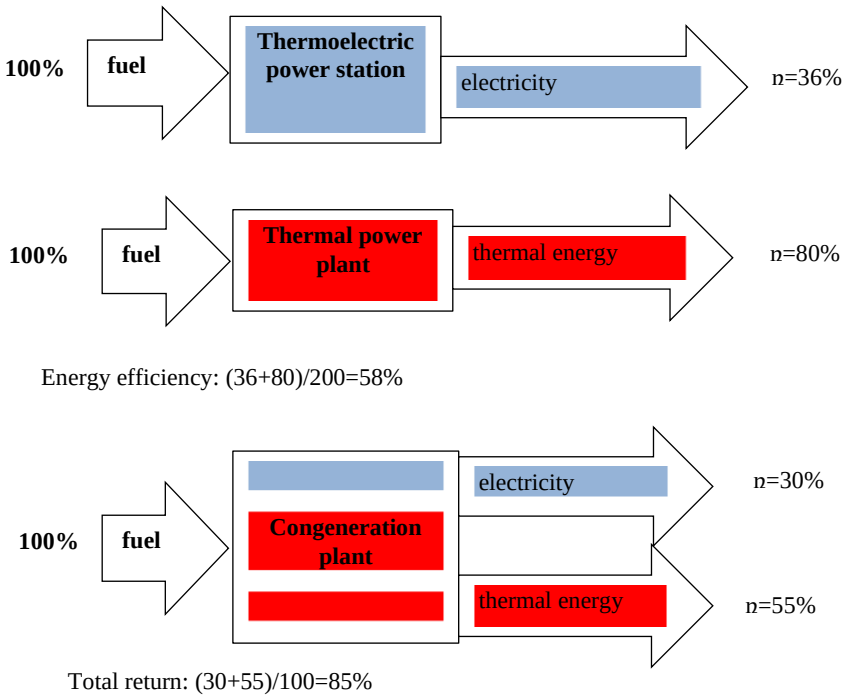

Figure 2**. Comparison of separate energy and cogeneration plants [2]**

The modernization of direct-fired heatingpower generation sources and their transformation into high-efficiency cogeneration plants is a key strategic direction for the Republic of Moldova. The analysis presented in this study can play a significant role in DHS Chisinau's development outlook and in the nation's energy transition to an energy-efficient system in line with national plans for sustainable development. Simultaneously, the Republic of Moldova may encounter various obstacles in the process of modernizing its direct heating sources and converting them into highly efficient cogeneration facilities. These issues include:

Modernization of existing plants requires substantial investments in technology and equipment, which can put pressure on the national budget and may require external financing or public-private partnerships.

1. Implementation of high-efficiency cogeneration plants requires advanced technical expertise. Moldova may face difficulties in attracting and developing qualified human resources to operate and maintain new equipment.
2. Rapid adaptation of the legislative framework and energy policies to support efficient cogeneration could be a challenge. Effective coordination between government, the energy sector and investors is needed to create a favorable environment for the development of the sector.
3. New CHP plants need to be effectively integrated into the heat and electricity distribution system. This process can be complicated by the current state of the distribution infrastructure and the need to modernize it.
4. Major technological changes require public awareness and consumer acceptance. Public reluctance may arise due to initial costs or changes in supply regimes.

5. Ensuring a stable and sustainable fuel supply for the operation of congeneration plants can be a challenge, particularly in the context of Moldova's dependence on energy imports.
6. Although cogeneration plants are more efficient, careful analysis of the environmental impacts, especially in terms of greenhouse gas emissions and use of natural resources, is needed.

Conclusions. The modernization of heating sources and their transformation into high-efficiency cogeneration plants is an essential direction for optimizing energy management and re-engineering the district heat supply system (DHS) in Chisinau. This would increase energy efficiency and reduce carbon emissions, supporting Moldova's sustainable development objectives. However, implementation involves major challenges. The need for significant investments in infrastructure and technology, the lack of local expertise in the operation of CHP plants and the need to update regulations are the major challenges that face this modernization process. Efficient integration into the energy grid and public acceptance will be critical to the success of the initiative, as will ensuring a sustainable fuel supply.

In conclusion, the modernization of the DHS and the optimization of energy management can make a significant contribution to Moldova's energy security and sustainability, if supported by clear policies and appropriate investments.

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