

V.I. Deshko, D.S. Karpenko*National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine***ANALYSIS OF CONDITIONS FOR THE CREATION OF THE LOCAL THERMAL ENERGY MARKET IN UKRAINE**

In this paper the preconditions for the creation of a market for thermal energy in Ukraine are considered. The urgency of the use of renewable energy sources in the thermal energy market is considered. The disadvantages of functioning of the existing sphere of heat supply are described. The features of heat supply systems in Ukrainian cities are described. The features of thermal energy as a commodity are determined. The main subjects of relations in the field of heat supply are determined. The basic forms of competition in the thermal energy market are determined. Classification of heat supply systems depending on the level of localization in accordance with the current legislation. The basic structural schemes of relations between the subjects of the market depending on the level of localization of the system of heat supply are determined. The features of interaction of thermal energy market participants within the system of heat supply, depending on its type, are described. Presented models of a single buyer, direct provision of services with their own networks and direct provision of transit services through the networks of a third party are possible for use in the thermal energy market. The priority model for the creation of the thermal energy market is analyzed and determined. The basic problems of the technical, economic and legal nature of the heat supply sector that are to be resolved for the effective implementation of the thermal energy market in Ukraine are identified. Extended definition of "thermalenergy market" is given.

Keywords: *thermal energy market, heat supply systems, district heating, market model*

Introduction

The organization of the thermal energy market within the state is an integral part of the functioning of the state economy in the energy sector. Unfortunately, at present stage of the development of Ukraine's energy sector there are many technical, economic and legal issues that need to be addressed to build an effective model of the thermal energy market. At the same time, it is necessary to consider the questions of constructing models of the heat energy market taking into account such features of our state as: significant territories, heterogeneity of the climate, technical state of heat supply networks, general economic and social situation, etc.

At the moment, fluctuations in prices on world markets for fossil fuels have led to the rapid development of technologies in the renewable energy sector (RES). The diversity of these technologies every year shows the rapid growth of the level of competitiveness in the field of energy in the general sense. For example, in the states of Europe, taking into account the tough environmental policy, the direction of RES has been rapidly developing. In this regard, the question arises of the effective use of surplus resources, which are formed as a result of natural processes or the work of enterprises of various spheres of the state's economy. Among the priority directions of utilization of surplus local resources, the tool of the thermal energy market (TEM) can be distinguished. The

transformation of local resources into heat energy is a technologically simple process, while the final price of products can be much lower than traditional heat energy production methods. Consequently, the creation of competitive conditions in the area of heat supply can lead to an increase in the quality of heat energy as a commodity for the consumer, reduction of tariffs for heat energy, and increase of the level of reliability of heat supply. Moreover, due to the effective use of local resources, the creation of the TEM can partly lead to Ukraine's energy independence.

A prerequisite for studying the issue of creating TEM is the ineffectiveness of the existing heat supply system at all its stages of operation from the production of thermal energy to its use by consumers. The sphere of energy, from an economic point of view, has the type of a natural monopoly, that is, such a model of functioning of the system should lead to maximum economic welfare within this system. But, based on current realities, it should be noted that the theoretical calculations, which indicate the effectiveness of the monopoly in this sector of the economy, do not coincide with the practical results of such enterprises. The absence of a motivating factor in the functioning of such a model results from a lack of competition, therefore, the level of performance of such a system can be estimated in advance as low. The system can not work without a person's participation, therefore it should be understood that the problem of lack of a motivational factor is primarily social. The

monopolization of energy sector in Ukraine leads to inefficient use of resources at the stage of heat energy production, and as a result, to the overestimated tariffs for this type of products both for domestic consumers and for industrial-budget enterprises.

In the absence of the market, the motivational factor, which is a prerequisite for technological progress, reduction of the cost price of products, and implementation of measures for energy efficiency is excluded.

The necessity to create a thermal energy market can be justified by three unresolved problems:

1. In Ukraine, there are surplus resources that have potential energy in one form or another arising from the production process of any production or agricultural activity, but which are not utilized. This problem has a direct impact on the ecological and economic indicators of enterprises separately, and in Ukraine as a whole.

2. Lack of full use of the territorial potential of Ukraine for the production of thermal and electric energy from renewable energy sources.

3. Lack of civilized and competitive relations in the heat supply sector of Ukraine, which leads to high tariffs for heat energy for consumers.

When reforming the heat supply system in Ukraine with a view to creating a thermal energy market, it is important to determine the market model on the basis of which its functioning will take place. The most significant contribution to the reform of the heat supply model is the arrival of private energy companies in the sphere of generation of thermal energy. The main mission of the creation of the thermal energy market is the creation of adequate tariffs for heat energy, namely for heating and hot water supply, which can lead to an increase in the level of efficiency of energy consumption and an increase in the state of well-being of the population in the state.

Purpose and objectives

The purpose of this article is a general overview of the situation in the area of heat supply in Ukraine in terms of the implementation and functioning of the thermal energy market.

To achieve this goal it is necessary to solve the following tasks:

- definition of the term "thermal energy market" from the legal and technical point of view;
- description of the list of forms of competition in the thermal energy market;
- classification of heat supply systems in Ukraine and definition of market models suitable for use in creating a local thermal energy market.
- identification of the main problems when creating the market of thermal energy.

Analysis of literary data

The Law of Ukraine "On Heat Supply" provides for the possibility of creating and functioning of the heat energy market [1]. However, the general definition of the concept of the market of thermal energy and the absence of any mechanisms for its functioning do not allow to consider the market of thermal energy in Ukraine as a systemic phenomenon. An assessment of the possibility of introducing competition in heat supply systems in terms of all components from equipment and fuel to the final product in the form of thermal energy is analyzed in [2]. Organizational structures of the relationship between the entities of the thermal energy market in Ukraine and other countries of the world are analyzed in works [3, 4]. Considering the conditions of operation of heat supply systems in different countries of the world, one can notice that there is no complete unambiguousness in the strategy of development of this sphere. Each of the states is guided by its rules in the field of heat supply, based on the technical and legal conditions that exist at the moment. The paper [5] analyzes the state of the development of the district heating system in Ukraine in terms of the potential of alternative energy sources and their use in creating a competitive heat energy market. A large variety of energy sources leads Ukraine to their effective use, so the analysis of the amount of resources is an important characteristic when planning energy development of the country. An analysis of heat energy market models in different countries of the European Union is presented in [6]. The "single buyer" model in the first stage is the easiest to implement for countries that have a monopoly position in the field of heat and power. The structural distribution of energy sources used for thermal energy production in the states of the European Union is analyzed. Principles of pricing and setting tariffs for heat energy, as well as legal aspects of the operation of thermal energy markets in the European Union states are analyzed in [7]. The main specific features of the thermal energy market, in contrast to other markets, and thermal energy as a commodity are determined [8]. The paper [9] presents the experience of Poland in terms of the implementation and operation of the heat energy market. The main problems and conditions of the functioning of the heat energy market are presented in [10]. The technical aspects that need to be provided at the stages of production, transportation and supply of thermal energy are given. The peculiarities of the work of the most common model of the thermal energy market of the "single buyer" are given. This model is the easiest in terms of implementation and operation, but there are problems that are related to the "length of money" [11]. The methods of calculating the effective radius of heat supply for thermal networks of centralized systems are presented [12, 13]. On the basis of this work it becomes possible to determine the level of

localization of the heat energy market. In the works [14, 15, 16] the modern technical state and prospects of the reformation of the heat supply systems in Ukraine are analyzed.

Statement of the main material

Description of the term "thermal energy market"

The term "heat energy" in accordance with the Law of Ukraine "About heat supply" is defined as the goods produced on the objects of the heat supply sector for heating, hot water, other economic and technological needs of consumers, intended for sale [1].

Thermal energy, as a commodity, has a certain number of essential features that are prerequisites for the operation of the heat energy market itself:

1. Thermal energy is limited in the distance of transport with centralized heat supply, as well as the use of decentralized heat supply plants - small CHP plants and boiler houses, as there are processes of irreversibility (the second law of thermodynamics). This means that it is economically inexpedient to accumulate thermal energy during a considerable time interval under the existing conditions in Ukraine, and consequently, the level of production and consumption, in general, should be equal to each other at any given time.

2. Thermal energy is a heterogeneous commodity, since it can be consumed in different aggregate states of the coolant with different heat engineering parameters. The use of heat energy should be subject to both quantitative and qualitative assessment, depending on the type of heat load (process steam, heating, ventilation, hot water), for example, by analyzing exergy indicators.

3. Thermal energy supplied to a common system with several suppliers may be defined as the product of a particular supplier only on source leads [2].

4. The level of thermal energy consumption has a pronounced seasonal character. This is mainly due to the uneven schedule of heating loads.

The existing structure of the subjects of relations in the field of heat supply in general terms is determined by:

- 1. Suppliers of fuel and energy resources;

- 2. Equipment suppliers and energy service organizations;
- 3. Heat generating or heat supplying organizations;
- 4. Organization of the heating network;
- 5. Consumers of thermal energy;
- 6. Governmental regulation and control in the field of heat supply.

Consequently, the term "thermal energy market", in the simplest sense, can be defined as a set of economic relations between suppliers of fuel and energy resources, suppliers of equipment and energy service organizations, heat generating organizations, heat supply network organizations, public regulators and regulators in the field of heat supply, and consumers thermal energy [6].

According to the current legislation, the term "thermal energy market" is defined as the sphere of heat energy turnover as a commodity for which there is demand and supply [1].

The heat supply sector has a number of peculiarities in terms of the process of production, transportation and use of heat energy. Speaking about the heat energy market, the ownership and management of trunk heating networks, distribution heat networks, central heating units and individual heat points (ITPs) should be distinguished as such activities falling within the concept of a natural monopoly [17]. This type of activity should be strictly controlled by the state bodies of management and control in the field of heat supply, with the provision of a certain level of profitability of these organizations.

In turn, competitive activities in the field of heat supply should include:

- design, construction and operation of heat energy sources;
- supply and use of fuel and energy resources;
- production and supply of equipment and energy service activities;
- energy sales and marketing activities.

There are quite a variety of forms of competition in the heat supply sector. Characteristics of forms of competition in the thermal energy market are given in Table. 1

Table 1

Forms of competition in the thermal energy market

Competition of suppliers of fuel and energy resources (FER)	In the production of thermal energy, in almost all cases, the main cost item is the price of FERs that take part in the conversion process to the final product (thermal energy). The cheapest kind of fuel or energy (UAH / Gcal) will be in high demand among heat generating organizations.
Competition of projects	This is the most advanced type of competition in the heat energy market at the moment. First of all, it is about competition of projects of new heat sources, intended to cover growing loads in separate regions, replacement of more cost sources with less cost, projects to increase the reliability of heat supply, as well as projects to increase energy efficiency for different groups of consumers. The criterion for choosing another project could be whether the amount of

	annual reduction in the cost of producing heat energy, or the payback period of the project relative to the existing costs.
Competition of equipment suppliers	There are a large number of manufacturers and suppliers of equipment that is used directly in the technological processes of the heat energy sector. The competitiveness of this equipment is manifested in its level of energy and ecological efficiency, the level of technological perfection, the number of functions, the resource of work and the price of it.
Competition of energy service companies	This type of competition takes place directly during the operation of equipment, and provides for competition among organizations that are able to solve the problems of reducing the cost of production of thermal energy, increasing the energy efficiency of the generation, transportation and consumption of heat energy, and the introduction of advanced technologies.
Competition of heat-generating (heat supply) organizations	Implementation of this form of direct competition requires the solution of a significant number of technical, organizational and legal issues. The solution to these issues involves the organization of a particular model of the thermal energy market. Thus, competition of heat sources is possible in principle only in large looped junctions and centralized heat supply systems. Since the organization of the thermal network is a natural monopoly, it is necessary that the process of production and transportation be divided into two independent organizations, in addition, the organization of the heat network should provide work in the system without discrimination and be subject to the state regulation and control authority in the field of heat supply, and not have their own large heat sources. The free access of producers to the unified heating system should be legislated. Then, in the presence of excess heat generating capacity, the market operator (the organization of the heat network) can perform economically appropriate switching of loads, for example, according to the criterion of the minimum cost of generation (selling price) during this period. Actually, this kind of competition is the result of competition of projects, as there always are processes of fluctuations in prices for energy resources and technology.

All considered types of competition in the market of thermal energy are integral parts of it. The emphasis on thermal energy as a commodity needs to be shifted, since the above forms of competition determine the entire list of goods and services in the market, without which the functioning of this market is impossible. Taken together, all these form and determine the level of competitiveness of a different entity.

The sphere of heat supply in Ukraine

In Ukraine, the level of localization of the heat supply system is determined as follows:

- autonomous heat supply system (power of heat sources up to 1 Gcal / h);
- decentralized heat supply system (from 1 to 3 Gcal / year);

- a system of moderately centralized heat supply (from 3 to 20 Gcal / h);
- district heating system (from 20 Gcal / h) [1].

Depending on the localization of the heat supply system, one or another structure of interconnections between the entities prevails.

In the autonomous system of heat supply, the scheme of relations has a fairly simple view, where the consumer of heat energy himself serves as a heat supply and organization of the heating network. At the same time, the processes of construction and operation of equipment are almost, or not at all, controlled by the state. At this level, competition arises between suppliers of fuel and energy resources, suppliers of equipment and energy service organizations. The block diagram is shown in Fig. 1.

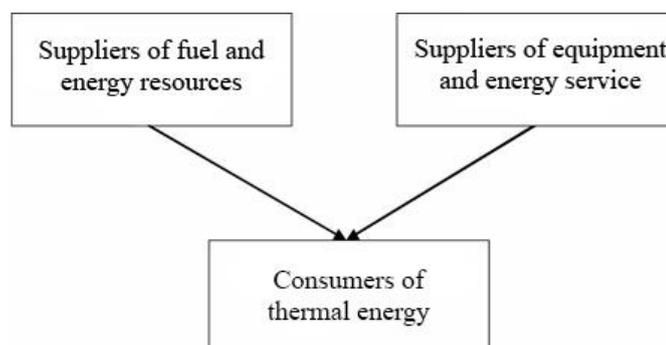


Fig. 1. Structural scheme of subjects of relations in autonomous systems of heat supply

The decentralized heat supply system implies the presence of not very large thermal networks, but in the majority of cases, the activity of thermal network companies is excluded because the heat network is usually owned either by the consumer of thermal energy

or by the heat supply organization. Compared to autonomous heat supply systems, decentralized is subject to state control and supervision. The structural scheme of the relationship in a decentralized heating system is shown in Fig. 2.

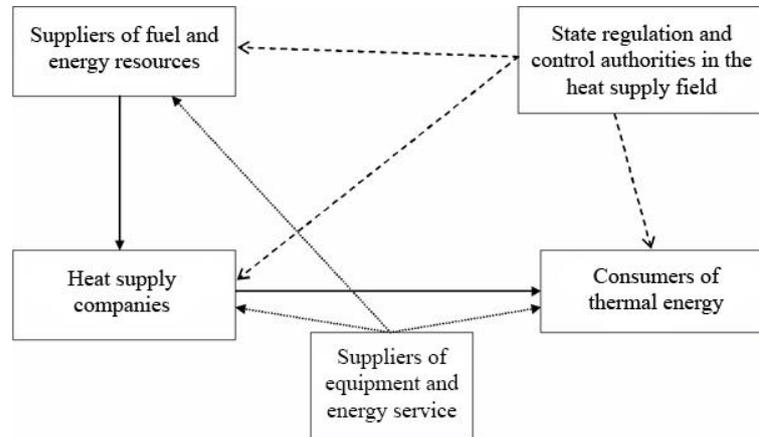


Fig. 2. Structural scheme of subjects of relations in decentralized systems of heat supply

The system of moderately centralized heat supply is a transition from decentralized to centralized and includes the features of both systems. As the subject of the system appears the organization of the heating network, but in some cases, interconnections between heat supplying organizations and consumers of heat energy can be traced directly without the participation of the heat network organizations. Structural schemes of relationships between subjects of moderately centralized and centralized heat supply systems are presented in fig. 3.

- heat energy sales model through a single wholesale reseller or sole purchaser. This model involves obtaining rights to the grid or heat supply companies to purchase heat energy at free market prices in any heat generating organization connected to this heating network and sell it to a customer connected to the heating network at prices that are formed on the basis of competitive bidding from the side of the heat generating organizations, and the norms of profit of the organizations of the thermal network regulated by the state authorities in the field of heat supply [16]. This model is the most promising in terms of the creation of the thermal energy market, because it provides free conditions for entry into the market and participation in the process of its functioning.

There are several basic models of the thermal energy market, which in one form or another already operate in developed countries of the world, and therefore one of these models can be imposed on the above differentiation of heat supply systems in Ukraine:

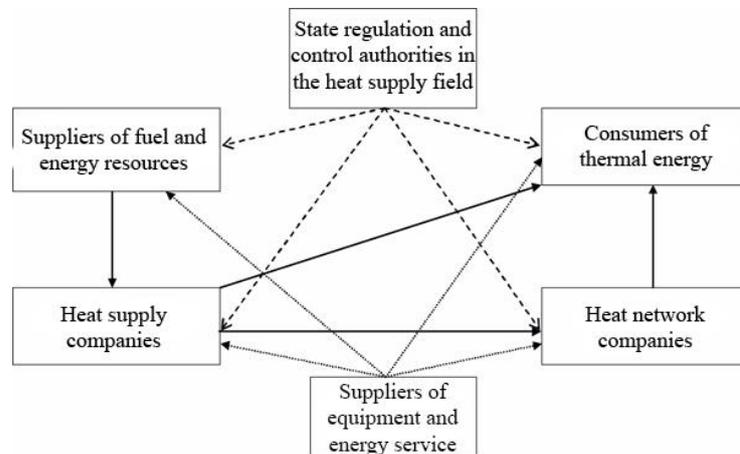


Fig. 3. Structural scheme of subjects of relations in moderately centralized (centralized) heat supply systems

- model of direct provision of heat supply services using own / leased networks. This model involves direct interaction between the heat-generating organization and the consumer on the basis of direct heat supply contracts. Unfortunately, this model, as such, does not anticipate competition, is a prerequisite for the creation of monopolies, and can not be considered effective.

- the model of direct provision of heat and hot water supply services to consumers with transit through networks of a third party organization. This model is somewhat similar to a single buyer model, where the owner of this heat network acts as a buyer. This model in the realities of Ukraine may be a transition to a single buyer model.

The listed models of the heat energy market can be based on the systems of heat supply according to their differentiation by the level of localization, in addition to the autonomous system of heat supply, since it does not provide for the possibility of functioning of the market as such.

The model of sales of heat energy through a single wholesale reseller most effectively fits into the framework of the relationship of subjects of the centralized system of heat supply. In turn, the model of direct provision of heat services to consumers with transit through the networks of a third-party organization can be the basis of the systems of moderately centralized heat supply and act as a transitional model for the organization of the market based on a centralized heat supply system. The direct heat supply model with the use of own or leased networks can function within the limits of decentralized heat supply.

Problems of the heat supply sector in Ukraine

There are a number of problems and peculiarities that are taking place in the present day with the work of various types of heat supply systems in Ukraine and which are a barrier to creating an effective market system:

1. The heat supply system, as an energy sector, is a socially responsible process, in particular, for objects of the social sphere and the population. Therefore, an important indicator for heat supply systems is the level of reliability of such systems. In the absence of the market of thermal energy as such, the level of responsibility of monopoly structures may not provide an adequate level of reliability of heat supply systems.

2. Thermal networks have significant physical deterioration, which leads to significant losses of heat energy in the process of transportation (sometimes more than 30%). Since the amount of heat energy losses is one of the determining indicators of the level of efficiency of the heat supply system in terms of functioning of the market, the solution of this problem is a priority. On the example of Poland, it becomes clear the priority of

solving this problem, when in Poland in 1992, the state of the heating networks was disastrous and a decision was made to restore them. After the modernization in Warsaw, it was possible to reduce the level of heat losses of the fluid by 68%, the loss of thermal energy from 20% to 12% of the thermal load, increase the reliability of thermal supply and increase the resource of heat networks [9].

3. The low level of personnel qualification in the energy sector, which results from the monopolization of the market and the lack of motivation for the development of professional qualities of workers, causes considerable losses in the design, construction, operation and repair of equipment.

4. Absence of responsible bodies (operators) of control or dispatch control of the system of heat supply at the level of local markets of thermal energy. Any model of the energy market, where there is competition, involves the technical regulation of the system, depending on the loads that take place at the present time due to its features of thermal energy as a commodity.

5. One of the most priority issues when creating a market is the level of infrastructure development. This indicator depends directly on the density of thermal loads in the area, and the level of heat energy losses in the heating networks, which are the determining criteria for the estimation of the level of localization and loopiness of the system [15]. An analysis of the need to install new thermal networks, or the creation of the so-called "Rings" relies on technical and economic calculations, where one of the criteria should be the above-mentioned indicator. Actually, the optimization task should be defined as follows: the definition of the dependence of the scale of the local heat energy market on the density of thermal loads, while ensuring the level of regulatory losses in the heating network.

6. Lack of separation of functions of production and transportation of heat energy between different organizations [3,4]. The need to solve this problem is that activities in the process of transportation of thermal energy fall into this type of market structure as a natural monopoly, and the process of generation of thermal energy can be technically, economically and legally organized in a competitive environment.

7. Significant barriers, in terms of legislative framework, when entering the market. An important issue is to ensure the free access of investors to the construction and operation of heat generation facilities [18]. According to the current legislation on heat supply, the process of connecting to the heating networks should be unhindered, but in practice these positions are not fulfilled because of the imperfection of the mechanisms for their implementation.

8. Lack of standards for the quality of heat energy as a commodity. Ambiguity in the process of accounting for thermal energy in terms of non-compliance with

different temperature levels (as a measure of comfort level) in heating rooms with the same amounts of consumed thermal energy. Functions of observance of parameters can be assigned to power sales companies.

9. The low level of the provision of commercial accounting of heat energy by consumers makes them pay for the use of heat energy due to overestimated payment standards, which results in consumer overpayments. At the same time, in consequence, the level of disorientation in the processing of statistical data that is used to estimate macroeconomic indicators increases. The problem of availability of thermal energy counters for apartments is still not solved, and entails some difficulties in the work of energy-saving organizations with domestic consumers.

10. High level of non-payment by consumers and freezing of assets of heat-generating companies. This problem can reduce the intensity of market and technology development, while the market efficiency can not be maximized.

11. Cross-subsidization policy. The process of compensating by the state the difference in tariffs for the population in relation to tariffs for budgetary institutions and industry entails distortions in economic relations between organizations, and as a consequence of a decrease in the level of well-being of the heat energy market, which is the main indicator of the level of efficiency of the market itself.

12. Lack of marketing activity in the field of heat supply. The lack of awareness of domestic consumers about the possibilities to improve the process of using heat energy through energy efficiency measures.

Creation of the heat energy market in Ukraine involves solving the above-mentioned problems at a high level of quality, with the increased attention given to the issue of the theoretical determination of the level of localization of the thermal energy market, depending on the density of thermal loads within the specified territories. Actually, when creating the market of thermal energy, the scale of the heat supply system should be maximal, ensuring normative losses of thermal energy. Then there will be more market entry opportunities where the level of competition will be significant, which is likely to result in low tariffs for services such as heating and hot water supply in this region.

Conclusions

Consequently, the thermal energy market is a set of economic relations between market participants that may or may not be present, depending on the level of localization of the district heating system, where the heat energy and related products are in the form of goods (for which there is demand and supply) and services without which the functioning of the market is impossible.

In this paper the main structural schemes of relations between the entities of the thermal energy

market were defined and appropriate models of the thermal energy market were proposed, depending on the level of localization of the heat supply system.

The further direction of work is to determine and maximize the scale of the thermal energy market, depending on the density of thermal loads within defined territories, providing regulatory losses of heat energy in the heat networks.

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АНАЛІЗ УМОВ СТВОРЕННЯ ЛОКАЛЬНОГО РИНКУ ТЕПЛОВОЇ ЕНЕРГІЇ В УКРАЇНІ

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У роботі розглядаються передумови створення ринку теплової енергії в Україні.

Розглянуто актуальність використання відновлюваних джерел енергії в рамках ринку теплової енергії. Описано недоліки функціонування існуючої сфери тепlopостачання. Описані особливості систем тепlopостачання в містах України. Визначені особливості теплової енергії як товару.

Визначені основні суб'єкти відносин у галузі тепlopостачання, такі як:

- *постачальники паливно-енергетичних ресурсів,*
- *постачальники обладнання та енергосервісні організації,*
- *теплогенеруючі організації,*
- *організації теплової мережі,*
- *споживачі теплової енергії,*
- *органи державного регулювання та контролю.*

Визначено основні форми конкуренції на ринку теплової енергії:

- *конкуренція проектів,*
- *конкуренція постачальників обладнання,*
- *конкуренція енергосервісних компаній,*
- *конкуренція теплогенеруючих компаній.*

Класифіковані системи тепlopостачання в залежності від рівня локалізації відповідно до чинного законодавства, та визначені основні структурні схеми відносин між суб'єктами ринку відповідно до рівня локалізації системи тепlopостачання. Описано особливості взаємодії учасників ринку теплової енергії в межах системи тепlopостачання, в залежності від її типу.

Представлені моделі «єдиного покупця», прямого надання послуг з власними мережами та прямого надання послуг з транзитом через мережі сторонньої організації можливі для використання на ринку теплової енергії. Проаналізовано та визначено, як пріоритетну, модель «єдиного покупця» при створенні ринку теплової енергії.

Визначено основні проблеми технічного, економічного та юридичного характеру в сфері тепlopостачання, які необхідно вирішити для ефективного впровадження ринку теплової енергії в Україні. Надано розширене визначення "ринку теплової енергії", як сукупність економічних відносин між суб'єктами ринку, які можуть бути, у певних межах, присутні або відсутні, в залежності від рівня локалізації системи тепlopостачання, де в якості товару, на який є попит та пропозиція, виступає тепла енергія та супутні товари та послуги, без яких функціонування ринку неможливе.

Ключові слова: *ринок теплової енергії, системи тепlopостачання, централізоване тепlopостачання, ринкові моделі.*