CURRENT STATE OF DEVELOPMENT IN THE FIELD OF ECONOMIC AND MATHEMATICAL MODELING OF THERMAL POWER

Urgency of the research. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

Target setting. Creating application of economic and mathematical tools for decision support in the process of modernization and renewal of generating capacity of thermal generation, construction of replacement facilities using modern technologies to achieve European standards for emissions of pollutants and the use of other fuels, renovation of trunk and distribution heat networks allow perform analysis of alternative management actions and will boost the development of energy-efficient, technically reliable and safe operation of heating systems of society with minimal economic burden on end-users and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies.


Uninvestigated parts of general matters defining. However, until now no one has proposed to apply the models and methods of the theory of planning and network management, as well as still have not developed a science-based system of economic and mathematical models of decision support with respect to the modernization of communal heat power.

The research objective. The main objective of this work is to systematize and review of scientific works of foreign and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies.

To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

Target setting. Creating application of economic and mathematical tools for decision support in the process of modernization and renewal of generating capacity of thermal generation, construction of replacement facilities using modern technologies to achieve European standards for emissions of pollutants and the use of other fuels, renovation of trunk and distribution heat networks allow perform analysis of alternative management actions and will boost the development of energy-efficient, technically reliable and safe operation of heating systems of society with minimal economic burden on end-users and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

Target setting. Creating application of economic and mathematical tools for decision support in the process of modernization and renewal of generating capacity of thermal generation, construction of replacement facilities using modern technologies to achieve European standards for emissions of pollutants and the use of other fuels, renovation of trunk and distribution heat networks allow perform analysis of alternative management actions and will boost the development of energy-efficient, technically reliable and safe operation of heating systems of society with minimal economic burden on end-users and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

The research objective. The main objective of this work is to systematize and review of scientific works of foreign and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

The research objective. The main objective of this work is to systematize and review of scientific works of foreign and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

The research objective. The main objective of this work is to systematize and review of scientific works of foreign and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

The research objective. The main objective of this work is to systematize and review of scientific works of foreign and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.

The research objective. The main objective of this work is to systematize and review of scientific works of foreign and domestic scientists, containing analogues and prototypes, which are the basis for further improvement of the concept of rational functioning of the market of energy materials and products based on the creation of a complex of economic and mathematical models of resource management and costs in generating and heat supply companies may decrease if the state budget the difference in tariffs for communal heat-generating and heat supply companies. To overcome the image of one of the most energy-intensive countries in Europe, to reduce gas consumption in Ukraine, the need for compensation from the state budget the difference in tariffs for communal heat-generating and heat supply companies may decrease if the cost of services, to take into account and eliminate heat loss. The priority of the Government of Ukraine has been the introduction of new mechanisms to promote energy efficiency on the consumer side (in particular, the payment of the loan, which the inhabitants of the house take for its thermo-or to go to alternative heating, etc.), while according to experts 80% of heat loss it occurs in areas generating and transporting. Tasks relating to the modernization and reorientation of the country's heating systems in order to reduce consumption of natural gas are those that actually increase national, primarily the energy security of Ukraine and are highly relevant and important state.
the process of modernization of communal heat energy in Ukraine.

The statement of basic materials. The paper systemati-
cally analyses and scientific works of foreign and domestic
scientists, containing analogues and prototypes, serve as the
basis for further improvement of the functioning of the concept
of sustainable market for energy materials and products
based on the creation of a complex of economic-mathematical
models of management of resources and costs in the process
of modernization municipal power system in Ukraine. It is
proved that the idea of adapting the methods of graph theory,
as well as deterministic and probabilistic network models tak-
ing into account the time, cost and resources for planning and
management practice, modernization, reconstruction and
replacement of process equipment heating stations and ther-
mal networks enterprises of power in Ukraine, characterized
by scientific novelty and is a tool for decisions heat gener-
at ing and heat supply companies, investment companies, the
legislative bodies regarding the technically reliable and safe
functioning of the energy supply company systems.

Conclusions. The use of modern information technology
and network of economic and mathematical models and
methods to simultaneously consider all the economic and
physical conditions and to determine the best option in the
process of modernization of communal thermal power will
become one of the components forming a system of support
for the introduction of new management systems to the inno-
vative development of the energy sector of Ukraine, will pro-
vide decision-making in favour of the power supply systems,
which are the most beneficial to the safety position, the relia-
bility (continuity), the quality of energy supply and the provi-
sion of affordable and attractive for the environmental conse-
quences of energy services.

Keywords: heating; energy efficiency; economic and
mathematical modeling; methods and models of project man-
agement; network planning and management.

Relevance of the research topic. Modernization and reorientation tasks of the heat supply sys-
tems of the country for the purpose of reducing natural gas consumption are those which actually im-
prove the national, first of all, energy security of Ukraine, and are extremely urgent and of the utmost
importance to the state [1]. A key priority of the Government of Ukraine is an implementation of new
mechanisms for the stimulation of energy efficiency on the demand side (in particular, it is a compen-
sation of a credit part which the householders take for the thermal modernization or conversion to the
alternative heating, etc.) while according to the experts 80% of heat losses arise in places of its gen-
eration and transportation.

Image overcoming of one of the energy intensive countries in Europe, reducing a gas consumption
in Ukraine, need for a covering from the budget of a difference in rates for district heating companies
can be reached via reducing costs of services, accounting and control of heat losses that make possi-
ble the modernization of boiler stations and heating systems, moreover, the International Energy
Agency declares that each dollar invested in an energy efficiency will become 4 dollars of economy,
and such project will completely pay off approximately in four years [2].

Yushchenko, N. L. Current state of development in the field of economic
and mathematical modeling of thermal power
Problem statement. Creation of applied economic-mathematical tools for the decision making support in the course of modernization and renovation of the generating capacities of the thermal generation, a construction of replacement capacities with the use of modern technologies which allow to reach the European standards on pollution emissions and use of other types of fuel, renovation of the transmission and distribution heat supply networks, will allow to analyze the alternative types of management activities and promote activation of the energy efficient development, technically reliable and safe operation of the heat supply systems of society with the minimum economical impacts on final consumers.

Analysis of the last researches and publications. The researches of Y. Bakhshan, S. Motadayen Aval, F. Kamel and A. Hajhossini [3], J. Okragni, K. Mutwil and M. Ciesla [4], B. Yakovlev [5], A. Sapukhin, V. Kurochkina and S. Novikov [6], S. Orlovsky, V. Volkov and O. Timofeenko [7], V. Polovnikov and V. Khuzeev [8], V. Klimenko and Y. Orlov [9], D. Chernikov [10], A. Aleksakhin and A. Boblovsky [11], A. Buyaka [12], A. Havrys [13], K. Makhotilo [14] and other domestic and foreign scientists are dedicated to scientific, methodical and applied aspects of economic-mathematical modeling of the heat power industry development.

Open parts of a shared problem. However nobody still suggested applying models and methods for network planning and management theory, and also the scientifically-based system of the economic-mathematical models of decision making support regarding municipal power system modernization isn’t developed yet.

Problem definition. A key objective of this research is a systematization and a scientific works overview of foreign and domestic scientists containing analogs and prototypes, is a basis for further enhancement of the concept of the rational functioning the energy materials and products market on the basis for creation of a economic-mathematical model complex for resources and costs regulation in the course of municipal power system modernization in Ukraine.

Statement of the main material. Ensuring energy security and transition to energy efficient and energy saving use and consumption of energy resources with implementation of innovative technologies, infrastructure modernization of the fuel and energy complex and introduction of modern power - and ecologically effective equipment and technologies for the loss reduction of fuel energy resources are by Strategy on Sustainable Development „Ukraine – 2020“ [15] in preference manner determined as a top-priority within implementation of the power reform and the energy efficiency program according to the vector of development and programs of energy independence and preservation of the environment according to the safety vector. Thereby the task of the effective analysis methods development using modern information technologies is critical in case of decision making for the municipal power system modernization in Ukraine.

District heat supply system of the residential and public facilities in Ukraine, which generally were created during mass housing construction in the 60s - the beginning of the 80s of the past century and since then were practically not renovated, cover heat requirements of about 55% of the population. The main and auxiliary equipment of many boiler rooms was used up the allowable working period; low-efficiency and obsolete boilers, obsolete automatic equipment and burner devices operate there that causes considerable fuel consumption, unacceptably high environmental pollution and results the loss in reliability and quality of the heat supply.

Total length of heat pipes in Ukraine makes about 47 000 km in two-pipe calculation; there are 20,8 thousand km of heat distribution networks on balance of the enterprises of the municipal heat power industry. There is one of the highest in the world saturations of heat distribution networks in the cities in Ukraine. According to the different data more than 80% of the heat distribution networks are amortized, and more than 40% are worn-out in service. The specified circumstances are substantially the fact that in Ukraine the heat consumption for heating of facilities of the same area exceeds the level of WEC by 2-3 times [16].

Over many years the housing and communal services enterprises and first of all heating supply enterprises performed and still perform a function of „the social buffer“. In the last 15-20 years almost all internal technical reserves of systems and the equipment were used, they are technically obsolete. Investments in a modernization of the existing heat supply systems make only a part from the neces-
sary and are insufficient not only for energy efficient modernization, but even for the maintenance of systems in good repair [1].

The use of economic-mathematical models and methods is rational in the performance of tasks of the resources sharing and using necessary for the modernization, reconstruction and replacements of the equipment of heat points and heat distribution networks of the enterprises of heat power industry of Ukraine, the reduction of time for the performance of work items for reduction of a general duration of the project and determination of admissible delays for further coordination of the project execution.

The most complete and significant researches of network planning and management models by means of which it is possible to determine duration of works, intensity of the resource consumption, rationally and in a balanced way to allocate labor, material and financial resources by each type of the interconnected works which performance requires the compliance with a specific technological sequence, belong to the American scientists, to D. Phillips and A. Garcia-Diaz [17].


The Polish scientists J. Okrajni, K. Mutwil and M. Ciesiła developed models for the description and calculations of strength and durability of steam pipes under the conditions of mechanical and thermal influence [4].

Scientific activities of the Belarusian researcher Yakovlev B. V. are connected with creation of the new theoretical and practical approaches and bases promoting increase in functioning of district heating and heat supply systems [5]. Methods and models generalization of the graph theory as the bases of network planning and management is performed by Sakovych V. A. [18].

Based on mathematical models the Russian researchers Sapukhin A. A., Kurochkin V. A., Novikov S.O. analyze the efficiency of polyethylene and steel pipes use from the point of view of economic and other components [6], Averyanova O. V. studies thermodynamic processes and interrelation regularities [19], Akhmedov A. M. investigates the condition and quality of capital repairs of main pipelines [20], Orlovsky S. Y., Volkov V. N., Tyymofeyenko A. P. calculate in terms of quantity the pipeline corrosion control methods of heat networks and various increases of pipe wall thicknesses [7], Kochemskova L. G., Kocheva M. A. - sufficiency of the pipeline cathode protection [21]. Skapynets A. Y., Pota-pov O. D., Lavrusevych A. O. developed the mathematical model of the hazard evaluation of pipeline erosion [22], Polovnykuv V. Y. carried out the mathematical modeling of the heat transfer in a trenchless pipe laying zone in case of earth freezing and the analysis of heat losses in similar conditions [8]. Klymenko V. A. and Orlov Y. N. constructed an optimization mathematical model allowing to analyze the market of heat and quality of services provided to consumers [9]. Chernikov D. M. developed an information technology for the support of planning processes and carrying out repair of heating mains which component was a synthesized simulation model for the factor evaluation, which is essential in reaching the decision about modernization and reconstruction of the existing sites of heat networks for the increase in their operational reliability [10].

The Energy strategy will be in effect till 2030 in Ukraine [23], regional and town programs of designing, construction and reconstruction in the sphere of heat supply taking into account implementation of energy-saving technologies and the principle of an optimal combination of the centralized, moderate and centralized, decentralized and autonomous systems of heat supply were approved. The body of scientists headed by Havrys O. M. of the National Technical University «Kharkiv Polytechnic Institute» improved an economic-mathematical model for stabilization of the existing rates for heat energy on the basis of optimization of the fuel resources use, developed an economic-mathematical model of a cost optimization for the service provision in the centralized hot water supply for the big city [13]. A complex of economic-mathematical models for the power development of the region of Buyak A. E. [12], a mathematical model and corresponding technique for evaluation of damages of heat pipelines of Lobko O. N. [24], an analysis model of the relationship of heat losses values by pipelines of the microdistrict heat network from a method of their laying, heat insulation parameters, a length and an arrangement of weatherproof houses relative to the central heat supply station of the residential district of Aleksakhin A. A. [11], a neuro-fuzzy model of the return temperature of the combined heat and
power station of Makhotylo K. V. [14], and other developments are of current interest. Due to the declaration of 2012 by the United Nations General Assembly as the International year of the sustainable energy for all, Bondar O. V. offered the overview of scientific publications, professional literature, the legislation concerning power and energy saving [25].

At the same time, the development of theoretical and methodical approaches to the network growth of heat and hot water supply in the process of the municipal heat power system modernization of Ukraine on the basis of creation of a economic-mathematical model complex which will become the instrument of grounds for decisions by the heat generating and heat supplying entities, investment companies, and also legislative bodies regarding technically reliable and safe functioning of supply systems of society are necessary. The economic-mathematical modeling based on the graph theory and the network analysis of the technical modernization system of heat supply facilities for the purpose of increase in energy efficiency of the energy-consuming equipment, decrease in the loss value of energy resources in supply networks, decrease in specific expenditures per unit of output (the generated energy unit) and increase in efficiency of final energy consumption positively differs from the existing in Ukraine and foreign analogs. Novelty of approach resides in adaptation of graph theory methods and the determined and probabilistic network models taking into account time, cost and resources to the practice of planning and management of modernization, reconstruction and replacement of processing equipment of heat points and heat networks of the heating enterprises in Ukraine. Such economic-mathematical models will allow to plan work on a project and to foresee the possible sources of problems and delays of its execution in time, to establish probabilistic time rates in the conditions of uncertainty; to regulate resource consumption; to plan the completion of works in the necessary terms according to the necessary sequence of task performance for the purpose of the fastest project implementation; to coordinate and control performance of works with observance of the schedule for timely project completion [26].

Conclusions. Application of the modern information technologies and network economic-mathematical models and methods allowing to consider at the same time all economic and physical conditions and to find the best option during modernization of municipal heat power industry will become one of components of support system forming of the latest management system implementation for the purpose of innovative development of the energy sector of Ukraine, will provide decision making for the benefit of power supply systems which are the most profitable from the point of view of safety, reliability (continuity), quality of energy supply and provision of energy services, which are budget-friendly and attractive on ecological consequences.

References


Yushchenko, N. L. Current state of development in the field of economic and mathematical modeling of thermal power
teplopostachannya iz vykorystannym ekonomiko-
matematyko-hnoho modeluvannya [Optimize heating sys-
tems using economic and mathematical modeling]. Kharkiv : Natsional'nyy tekhnichnyy universytet „Kharkivs'kyj
technichnij instytut” [in Ukrainian].
14. Makhtolyo, K. V. Povyshenie tochnosti modelirovani-
ia sredneshchastnovi temperature obratnogo teplonositella TETS [Increase the accuracy of modeling the return water temperature hourly thermal power generators (CHP)]. Retrieved from : http://dspace.nbuv.gov.ua/bitstream/handle/123456789/27074/16Mahotilo.PDF?sequence=1 [in Russian].
ence in the use of energy efficient technologies in the con-
19. Aver'yanova, O. V. (2009). Energosberezhnenie v teplovikh setelah za schet parametrov teplonositeli [Energy saving in heat networks at the expense of the coolant pa-
rameters]. Yznzheno-stroyetalni zhumal – Civil Engineer-
20. Akhmedov, A. M. (2013). Sovremennoe sostoyanie magistralnykh truboprovodov i tekhnologii naneseniya izo-
liatsionnykh pokrytii pri stroitelstve i kapitalnom remonte [The current state of pipelines and technologies for applying insulating coatings in construction and repair]. Internet-vestnyk VolgHASU. Seriya : Politekhnitcheskaya – Internet messen-
sermentalnye issledovaniya i opredelenie polnoty katodno-
zhachzhii teploprovodov [Experimental studies and determi-
nation of completeness of cathodic protection of heating conduits]. Modern High Technologies – Modern High Tech-
polnoty-katodnoy-zaschity-teploprovodov [in Russian].
23. Energetychna stratehia na period do 2030 roku 

Yuschenko, N. L. Current state of development in the field of economic 
and mathematical modeling of thermal power
24. Lobko, O. N. (2010). Metodyka analiza pov- 
rezhdaemosti truboprovodov [The method of analysis of 
damage to pipelines]. Kommunalnoie khoziaystvo gorodov 
nauchna-tekhnychesky sborny – Utilities cities: scientific 
and technical collection, no. 93, pp. 321-324. Retrieved from 
:http://khg.kname.edu.ua/index.- 
php/khg/article/viewFile/1284/1277. [in Russian].

suchasnomu sviti : rekomentatsiyny spysok [Power in the 
Modern World : recommendation list]. Sumy: Sums’ky 
derzhavnyy universytet. Retrieved from : 
http://library.sumdu.edu.ua [in Ukrainian].

vyznachennya rezervu chasu dlya zbalansovanoho rozpodilu 
trudovykh, material’nykh i finansovykh resursiv pry moderni-
zatsiyi komunal’noi teploenerhetyky Ukrayiny [Mathematical 
models to determine the reserve time a balanced distribution 
of manpower, material and financial resources for moderni-
zation of municipal power system of Ukraine]. Naukovyy 
16-25 [in Ukrainian].

Received for publication 15.09.2016