APPLICATION OF THE METHODS OF GREEN LOGISTICS AND SUSTAINABLE DEVELOPMENT FOR THE SYNTHESIS OF HIGHLY EFFICIENT SYSTEMS OF ENERGY SUPPLY WITH HEAT PUMPS

Olga Ostapenko
Candidate of Engineering Sciences, Ph. D, Associate Professor,
Associate Professor of the Department of Heat Power Engineering,
Vinnytsia National Technical University,
Vinnytsia, Ukraine

ЗАСТОСУВАННЯ МЕТОДІВ ЗЕЛЕНОЇ ЛОГІСТИКИ ТА СТАЛОГО РОЗВИТКУ ДЛЯ СИНТЕЗУ ВИСОКОЕФЕКТИВНИХ СИСТЕМ ЕНЕРГОЗАБЕЗПЕЧЕННЯ З ТЕПЛОВИМИ НАСОСАМИ

Ольга Остапенко
к. т. н., доцент,
доцент кафедри теплоенергетики,
Вінницький національний технічний університет,
м. Вінниця, Україна

Introduction. Green logistics is a new scientific field, which provides for the use of advanced logistics technologies and modern equipment in order to minimize pollution and increase the efficiency of the use of logistics resources. The concept of sustainable development, according to [1], aims to maintain economic advancement and progress while protecting the long-term value of the environment. The concept of sustainable development implies the optimal use of limited resources and the use of environmentally friendly nature-, energy- and material-saving technologies at all stages of the life cycle with the production of environmentally acceptable products. The problems of energy efficiency increase of energy generation were studied in numerous studies, published during last years in branch editions [2 – 5] in the world and in Ukraine. The article [2] presents the theoretical approaches to increasing the energy efficiency of municipal heat power engineering with taking into account the concept of sustainable development. As it is noted in [2], three aspects of sustainable development should be considered: economic, environmental and social aspects. Therefore, in order to increase the efficiency of heat power engineering, it is necessary to identify and implement a number of measures. They should ensure the needs of services and goods at the lowest economic and social costs for the required energy and protection of the natural environment in harmony with sustainable development at all levels of the state, as it is noted in [2].

Aim of the research is the justification of the application of the methods of green logistics and sustainable development for the synthesis of highly efficient systems of energy supply with heat pumps.

Presentation of the material. Nowadays it is very important for Ukraine to take into consideration main challenges, concerning the development of fuel and energy complex: critical state of energy resources base, outdated equipment and technologies of organic fuel mining, processing and burning, low level of energy efficiency and ecological safety of energy production, shortage of domestic fuel and energy resources, high cost of imported energy resources, grows of ecological requirements. Realizing of objective character of these challenges, a number of urgent measures, realization of which enables to solve the problem of provision of high level of energy efficiency and ecological safety of energy production and energy usage are to be developed. Further considerable increase of natural gas price in Ukraine and growth of tariffs for heat energy stipulate the search of new highly efficient sources of heat supply. Usage of cogeneration heat pump installations (CHPI) in the energy supply systems (ESS) will provide the economy of fuel and protection of the environment as a result of reduction thermal pollution and amount of harmful emissions of combustion products, according to [3 – 5].

In our studies [3 – 4] it is suggested to perform the comprehensive assessment of energy-ecological-economic efficiency of ESS on the base of CHPI and peak sources of heat (PSH) according to complex generalized dimensionless criterion of energy-ecological-economic efficiency of ESS with CHPI and PSH:

$$К_{ESS}^{compl.} = К_{ESS} + \Delta E_i^{ESS} + \Delta EC_i^{ESS} = (1-\beta)\cdot К_{PSH} + \beta \cdot К_{CHPI} + \Delta E_i^{ESS} + \Delta EC_i^{ESS}, \quad (1)$$

where $К_{ESS}$ – complex dimensionless criterion of energy efficiency of ESS with CHPI and PSH, which used for the determination of highly efficient operation modes of the ESS on condition that $К_{ESS} > 1$; ΔE_i^{ESS} – is relative economic efficiency for ESS with CHPI and PSH for *i*-th operation mode of ESS, which used for the determination of economically valid operation modes of the ESS with CHPI and PSH on condition that $\Delta E_i^{ESS} > 0$; ΔEC_i^{ESS} – is relative ecologic efficiency for ESS with CHPI and PSH for *i*-th operation mode of ESS, that enables to determine ecologically safe operation modes of the ESS with CHPI and PSH on condition that $\Delta EC_i^{ESS} > 0$; β – share of CHPI loading within the frame of ESS; $К_{PSH}$ – dimensionless criterion of energy efficiency of PSH within ESS (hot-water fuel-fired boiler, electric boiler, solar collectors, etc.); $К_{CHPI}$ – dimensionless criterion of CHPI within ESS energy efficiency. The relative economic efficiency (in shares) ΔE_i^{ESS} for ESS with CHPI and PSH for *i*-th operation mode of ESS is determined in the following manner:

$$\Delta E_i^{ESS} = \frac{(E_{SH})_i - (E_{ESS})_i}{(E_{SH})_i}, \quad (2)$$

where $(E_{SH})_i$ – are operation costs for *i*-th operation mode of the substituted source of heat (SH), $(E_{ESS})_i$ – are operation costs for *i*-th operation mode of ESS. The relative ecologic

efficiency (in shares) ΔEC_i^{ESS} for ESS with CHPI and PSH for *i*-th operation modes of ESS is determined in the following manner:

$$\Delta EC_i^{ESS} = \frac{(EC_{SH})_i - (EC_{ESS})_i}{(EC_{SH})_i}, \quad (3)$$

where $(EC_{SH})_i$ – is the amount of harmful emission in the atmosphere for *i*-th operation mode of the substituted source of heat, $(EC_{ESS})_i$ – is the amount of harmful emission in the atmosphere for *i*-th operation mode of ESS with CHPI and PSH.

Conclusions. The justification of the application of the methods of green logistics and sustainable development for the synthesis of highly efficient systems of energy supply with heat pumps is presented in the given research. According to such approach, it is determined that: ecologically safe, energy efficient and economically substantiated operation modes of ESS with combined CHPI and PSH will be provided on conditions of: $K_{ESS}^{compl.} > 1$ and $K_{ESS} > 1$ and $\Delta E_i^{ESS} > 0$ and $\Delta EC_i^{ESS} > 0$. The greater is the value of $K_{ESS}^{compl.}$ index, the more energy efficient, ecologically safe, economically efficient and competitive ESS with CHPI and PSH will be.

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