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PROGRESS IN NON-TRADITIONAL POWER ENGINEERING

Dmitry Strebkov, Academician of Russian Academy of Sciences
Federal State Budgetary Scientific Institution "All-Russian Scientific Research Institute for Electrification of Agriculture", Moskow
e-mail: nauka-ds@mail.ru)

Annotation. The twentieth century was the last age of cheap energy. The era of cheap energy is over, and we need new energy technologies in order to ensure the sustainable future development. The review aims to find economic, reliable, renewable and non-polluting energy sources for future power engineering. Advanced tendencies in future power engineering are presented. The forecast for development of electric and power engineering in 21 century is discussed.

Key words: Fuel-free energy, renewable energy, global solar power system, energy extraction from organic waste, future lighting system, resonant electric power system, solar education.

1. Introduction

Almost all of the energy produced by generating all kinds of sources, brought to consumers by transmission and distribution systems (DSS), where a substantial part of it is lost for technical and commercial reasons. In addition, customers received energy is used in many cases, ineffective due to the technological imperfections of energy consuming equipment and the lack of appropriate management strategies for energy management.

Because of these reasons, technical, organizational and commercial nature in many countries up to 40-50 % of the energy produced is not used and lost. For example, in Russia currently unused technical potential for energy savings of up to 420 mln. Tce. t, or 45 % of the total energy consumption in 2015.

In addition, the transmission of electrical power is accompanied by significant losses amounting to the world average of 8.8% of its produced volume. Total losses in the transmission of electricity in the world today exceeds the volume of production in a country like China (3433.4 Tw·h) [1, 2].

Mankind is looking for the answers to global issues [3]:

- What should be done about climate change and global warming?
- Where energy resources, which are distributed very unevenly and are being depleted, can be found?
- How can stability in the world be maintained and sustainable development be assured with the presence of risks associated with climate change and deficiency in energy resources?

• How can energy security of each country be ensured and global security as well?

Answers to these global questions can be reached by implementing a new energy strategy to be based on the following elements of future energy development:

Transition from energy based on fossil fuels to fuel-free energy with the use of renewable energy sources.

Transition to distributed energy production combined with local energy consumers.

Creation of a global solar energy system.

Replacement of oil products and natural gas by liquid and gaseous biofuels, and solid fossil fuels by energy from biomass.

Replacement of automobiles' internal combustion engines by non-contact, high frequency resonant electric transportation.

6. Substitution of overhead power transmission lines by underground and underwater cable lines.

At VIESH, studies have been conducted on all of these topics. We have developed technologies and prototypes protected by Russian patents. In order to compete with fuel energy, solar energy needs to reach the following criteria:

- The efficiency factor of solar power stations (SPS) must be at least 25%.
- The service life of a solar power station should be 50 years.
- Cost per kilowatt of installed peak capacity at SPS should not exceed US $ 1,000.
- The volume of SPSs production should be at least 150 GW per year.
- Manufacturing of semiconductor material for SPS should exceed 1 million tons per year at a price of no more than US $ 25 per kg.
- SPS should be able to produce electric energy the clock round.
- Materials and production technologies of the solar cells and modules must be environmentally compatible and safe.

2. Perspectives of using fuel-free energy technologies

Currently, fuel energy meets 87,1 % of the world's energy needs. Our assessments as well as evaluations of foreign experts show that by the end of this century, more than 80 % of global energy consumption will assured by fuel-free energy technologies: hydropower, bio-energy, solar energy, wind and geothermal energy, as well as by hydrogen energy. With regard to the efficiency factor increase of photovoltaic modules, I would like to say that there has been considerable progress in this area, both in Russia and abroad. This is happening on several fronts, especially in finding ways to make more efficient use of silicon, the most readily available semiconductor material, whose possibilities have not yet been exhausted. For example, new Russian solar energy technologies include chlorine-free solar silicon production technologies, technologies of producing silicon modules with an efficiency factor of 25 % under a 60-fold concentration of solar radiation. Other technologies relate to assembling solar modules with a lifespan of 40–50 years, as well as to producing high-voltage solar modules with a voltage of 1000 V [3]. It also seems that, in order to introduce new solar energy

technologies, it is necessary to create a favourable social and economic climate in our contemporary society. Therefore, we have proposed, as it was done to restrict and subsequently block the use of inefficient electric filament lamps, to prohibit budget procurements of solar modules with an efficiency factor below 10%. We are also proposing that the design, construction, and usage of low-rise buildings, schools, hotels, and resort and recreational facilities take place only under the conditions of availability of cogeneration systems based on solar energy installations. The International Energy Agency (IEA) has published the technology roadmap called "Solar Photovoltaics, ed. 2014". According to this document, the worldwide-established capacity of photovoltaic power plants will reach 400-500 GW by the year 2020, and 4,600 GW by 2050, with solar electricity production increasing to 6,300 TW·h. Solar photovoltaic plants will provide 16 % and solar thermal power plants 10% of the global electricity production, or 40,000 TW·h, by the year 2050. By then, solar energy will generate 10,300 TW·h, or more than 50 % of the present world electricity production based on 2015 levels (20,000 TW·h) (see www.iea.org, Road maps section).

Our vision for overall global renewable energy development, the basis of which, in our opinion, should be solar energy includes the following technologies. In 2003, Russian scientists proposed and patented an energy model for the Earth's future, which was based on the creation of a global solar energy system. Its essence is installing solar power stations on the three points of the globe every 120 degrees of longitude in the latitudes with maximum seasonally uniform solar radiation. Just three in the whole world! Installing such stations would require land plots of 200 km by 200 km in the hot desert regions of Africa, Australia, and Latin America.

Computer modelling based on solar radiation data has showed that this proposal would fully meet global electricity demands of both people and industries (20,000 TW·h per year). It would eliminate the main Achilles' heel of solar energy, dependence on day-night changes, seasons, and climate unpredictability. Energy would be generated the clock round, without interruption, and transmitted to national energy systems through the waveguide resonant lines of power transmission based on the technologies of N. Tesla [3, 4].

In the next 30-40 years, the movement to fuel-free energy will be inevitable, not just because of the depletion of raw materials, but due to cost reductions of alternative energy sources and the acuteness of environmental problems. Thermonuclear reaction and other technologies that further heat the Earth's crust will unlikely become the primary alternative. The additional +2 °C would lead to terrible disasters. Therefore, the future belongs to "clean", fuel-free energy, which includes solar, wind, geothermal, hydro, and bio-mass energy. According to generally accepted forecasts, by the year 2050, such energy will cover 50 % of mankind's needs, and by the end of the century, more than 80%. The system described above, developed by VIESH, could be adopted as the foundation for this energy. It requires broad international cooperation and could be fully implemented only after many decades. But this would solve the problem of energy supplies on a global scale without pollution and climate change.

3. Advanced tendencies in development of electric power transmission system

Today's systems of electric energy transmission use two- and three-wire lines, wherein electricity is transferred from generator to receiver through traveling current waves of current, voltage, and electromagnetic fields. The major losses are due to Joule losses on the resistance of wires from the flow of current around a closed path from generator to receiver and vice versa. The major energy companies around the world are investing huge funds and scientific resources in creating high-temperature superconductivity technology intended to reduce Joule losses in the line.

Another, perhaps more effective way, to reduce losses, at least in the main interconnection lines, is to develop adjustable resonant waveguide systems for electrical energy transfer under a high frequency range of 1-100 kHz. This does not use watt conduction current around a closed path. The waveguide single-conductor line features neither closed paths nor traveling waves of current and voltage, but instead has standing (stationary) waves of a reactive capacitive current and voltage with a phase shift by 90°. By adjusting the resonant modes, selecting the frequency of the current depends on the line length and can be generated in antinode voltage and the current node can be generated in the line (for example, for a half-wave line). At the same time, due to the absence of a active current, the phase shift 90° between standing waves of reactive current and voltage, and the availability of a current node in the line, there is no longer a necessity for the high-temperature superconductivity mode. Thus, Joule losses become negligible due to the absence of closed conduction currents in the line and minor values of the unclosed capacitive current near the nodes of stationary current waves in the line.

The electric power transmission mechanism must also be changed. The new physics of electrical processes associated with the use of reactive currents will solve three major problems related to the present electric power industry:

- Establishing long-distance transmission lines with low losses without superconductivity technology.
- Increasing the transmission line capacity.
- Replacing overhead lines with single-conductor cable waveguide lines and reducing the current-carrying section of the cable core by 20-50 times.

It is now known about the fundamentally new Russian technology to create a global power network with single-wire or wireless power reactive current based on the ideas and experiences of a brilliant scientist Nikola Tesla. These technologies allow not only to solve the problems mentioned above, but also to create highly reliable global electric power system. VIESH scientists received more than 50 patents of the Russian Federation in the field of resonance method of transmission and application of electrical energy [5].

In the experimental resonant single-conductor electrical energy transmission system installed in the laboratories of VIESH, we transmitted electrical power of 20 kW at a voltage of 6.8 kV over a distance of 6 m through a copper conductor with a diameter of 80 microns at room temperature. The effective current density in the

conductor was 600 A/mm^2, and the effective power density was 4 MW/mm^2. Among other types of resonant energy applications based on the unclosed currents, we must note a wireless office, contactless high-frequency electric transport, creation of local energy systems using RES, connection of offshore wind power plants with onshore substations, electricity supply for consumers in islands, and fireproof single-conductor systems for street and building lighting [6].

For those who doubt the existence of unclosed electric currents, we present the statements of the two most eminent scientists in the field of electrical engineering and electric energy: "The exceptional difficulty of harmonizing laws of electromagnetism with the existence of unclosed electric currents is one reason among many others why we should accept the existence of currents generated by a shift change." (D. Maxwell).

"In 1893, I proved that there was no need to use two conductors for electric power transmission... Energy transfer through a single conductor without return was practically justified." (N. Tesla, 1927).

"Transmission efficiency can be at 96 or 97 per cent, and there are practically no losses... When there is no receiver, there is no energy consumption at any other place." (N. Tesla, 1917).

"My experiments showed that the maintenance of electrical oscillations across the planet requires a little horsepower." (N. Tesla, 1905).

N. Tesla also responded to the question that we are often asked: why did the electric power industry not accept his ideas? "My project is constrained by the laws of nature. The world was not ready for it. It was too ahead of its time. But the same laws will prevail in the end and implement it with great triumph" (N. Tesla, 1919). The resonant electric power industry needs state support for the implementation of pilot and demonstration projects and is waiting for a new Morgan, the banker that 100 years ago financed the works of N. Tesla.

4. Future lighting systems

There is currently a glut of LED lighting fixtures. According to forecasts, by the year 2020, the LED lighting market in Russia will grow to $3,6 billion. LED lighting fixtures will occupy 75 % of the Russian market. The main drawback of LED lamps is their high cost – US $ 10 per unit, due to the use of expensive semiconductors. In the future, LEDs will be replaced by cheap fluorescent lamps with cold cathode field emission. This is an effective and inexpensive alternative. The innovative lamps use a completely different principle of operation and other components, but their basic performance characteristics are the same: 50,000-70,000 hours of durability, reliability, and very high efficiency. In contrast to LEDs, these new lamps do not require expensive semiconductors, and the cost of cold cathode tubes with field emission is 3-5 times lower. In 2013, VIESH together with the Vacuum Electronics Department of the Moscow University of Physics and Technology (known also as MFTI) patented this technology and proposed to

introduce a new lighting system with the use of these lamps and the resonant power supply based on the ideas of N . Tesla [3, 6].

Fluorescent lamps with a cold cathode field emission have the following advantages:

- high luminous efficiency and brightness.
- human-friendly radiation spectrum.
- Environmental cleanliness, without any hazardous or noxious substances.
- Immediate readiness for operation.
- Wide range of operating temperatures, from -196 to +150 °C.
- Large area of light-emitting surface.
- Lifetime of more than 70,000 hours.

Production of these lamps draws on simple technologies and widely available and inexpensive materials. The new lamps will replace LED fixtures in many fields of application, and their market share could reach 50 %.

5. Energy extraction from organic waste

The total volume of solid waste disposal in the landfills of Russian cities amounts to 95 billion tons and is annually increasing by 3,5 billion tons. The total area of landfills in the Russian Federation for the disposal of solid waste is 2,500 km^2. These landfills contain metal, stone, glass, and solid organic waste (SOW). Let us estimate that the SOW content is 75 % of the total landfill mass. Thus, 2,625 billion tons of new SOW and 2,375 billion tons of SOW from old disposal dumps could annually be used as fuel. This would completely stop formation of new landfills and eliminate old landfills at a volume of 95 billion tons over 95:2,375/0,75 = 30 years. Gas-fuelled energy units with electrical and thermal power capacity of 1 MW have been proposed to be used as cogeneration power plants (CPP). In order to produce gas fuel for CPP operations, it is recommended to use fast pyrolysis plasma technologies whose SOW processing capacity amounts to 100 tons per day and with their own consumption of 300 kWh. Thus, taking into account the energy consumption for its own needs, a CPP will generate electric power of 0,7 MW for the energy system and will process 36,000 tons of SOW per year [2].

In assessing the payback period of the energy projects under consideration, we must take into account the economic effect from the landfills' destruction, soil reclamation, and environmental improvement in urban and rural settlements. Other SOW renewables are the wastes from agriculture and forestry, and in treeless areas include energy plantations of fast-growing trees on soils not suitable for agricultural production. The major sources of environment pollution and of fuel renewables for CPP are the liquid sewage of cities and villages, liquid sewage of farms, and liquid sewage of sugar and distilling plants, etc [7].

Plasma pyrolysis technologies are unsuitable for transforming liquid organic wastes (LOW) with a water content of 80–95 % into electric power due to the large energy consumption by the LOW pre-drying process. Russian scientists have proposed new

technologies for LOW processing of supercritical water oxidation (SWOT) of organic substances in the liquids. A CPP with a 1 MW electrical capacity will require processing 150 tons of LOW per day, which is associated with a lower content of organic substances in LOW in comparison with SOW. For cities, this means a reduction in the area used for sewage treatment facilities, termination of sewage discharged into the sea, as is the case of Sochi and Gelendzhik (RF), as well as Malaga, Barcelona (Spain), and the coastal cities of Australia and other countries as well.

Large farms that now contain several treatment ponds for manure discharge will be able to provide electricity and heat not only for their own needs, but also for surrounding villages and rural areas. We propose to develop a program of solid and liquid organic waste recycling for cities and agricultural enterprises (landfills, liquid sewage effluents, and farms) into electrical energy and heat by implementing high-tech, innovative Russian technologies.

6. The Role of Education in the sustainable energy development

Current trends in global development have dictated new imperatives for education, especially agricultural education. On the one hand, there is a need for a high level of industrialization of agricultural production to meet the growing food demand. On the other hand, we are confronted with the limited resources of the planet's agro-biological potential. It is no secret that the reckless exploitation of resources will lead to an irreversible depletion of agricultural, biological, and energy resources over the course of just a few generations. In accordance with the position of the UNESCO Chair of Renewable Energy and Electrification of Agriculture at VIESH, solutions to these problems can be found with the help of modern technologies and, consequently, modern education. The objectives of our Chair include the promotion and implementation of an integrated system of research and education in the field of renewable energy sources as well as innovative energy saving and energy-efficient solutions in the field of energy transfer, especially in rural areas, including the training and retraining of personnel in these fields. One of our most recent projects, which we are particularly proud of, was implemented to mark the celebration of the anniversary of the launch of Sputnik. Moscow's Department of Education and the Department of Science and Industrial Policy financed the project, "Space Technologies, Ecology, and Safe Energy in the Schools of the Future," which introduced pupils to modern informatics and new energy technologies. We helped several Moscow schools to install portable ground-based units that enabled the real-time receiving and processing of satellite images of the Earth. We provided scientific and methodical supervision for the development of programs and working materials for lessons of relevant disciplines. In addition, experimental educational solar energy modules were installed. We developed and incorporated laboratory experiments with solar panels for the reception of satellite signals into the natural sciences programs at the schools-participants in our project. School teachers demonstrated great enthusiasm for this project. Conferences summarizing the results of this project and disseminating new teaching methods were held in Moscow. The most noteworthy

conference was held at Moscow School No. 444 with Moscow government's representatives. Pupils demonstrated how to independently receive and process satellite images, transcode and interpret them, prepare a weather forecast, and also make environmental impact statements. These scenes resembled the chorus of the famous Soviet song: "Let us give our children the globe." By expanding this project on a global scale, we can establish an effective mechanism for helping to solve global problems by allowing our children to observe what adults are doing and providing them with the opportunity to personally participate in real environmental monitoring. The work of the children in this regard was sometimes more effective than that of the regulatory authorities and allowed them to participate in "adult" political debates and concrete actions. During physics lessons held within the framework of this project, pupils studied the characteristics of solar modules and of other renewable energy sources. This project can truly be declared a success. It showed that pupils and teachers have a strong interest in new technologies. This means that there is a real hope that the next generation of scientists and engineers will develop new technologies, especially in the field of renewable energy, space industry, and geo-informational systems. The main result of this project was demonstrating its potential and proving the necessity of multiplying its effects by introducing it in all schools of our country as well and abroad, especially in developing countries. Our Chair would be glad to cooperate with educational institutions, of course, and primarily but not exclusively with other UNESCO Chairs and all colleagues who are interested in introducing our developments and teaching methods into the educational process. The results of their introduction into schools were analysed and published in many scientific papers, including the collective monograph "Space Educational Technologies: Investments in the Future", written by an enormous team of teachers, scientists, engineers, and managers under the leadership of the UNESCO Chair.

The European Network on Education and Training in the Field of Renewable Energy Sources, known as EURONETRES, was created under the leadership of the UNESCO Regional Bureau for Science and Culture in Venice (ROSTE). Its purpose is to increase the potential for cooperation between universities and other educational and academic institutions in European countries interested in these activities at the national and regional levels, and, in particular, in the sphere of education and training in RES with the purpose of expanding the use of RES in Europe as well as in other regions of the world. EURONETRES is an integral part of the global Renewable Energy Education and Training Programme (GREET), whose development is a priority for UNESCO in the field of Engineering Sciences and was approved at the 32nd session of the UNESCO General Conference, held September-October 2003 in Paris. UNESCO organized the network through ROSTE at the initial stage of its activity. I was appointed a chairperson of the EURONETRES European Working group on Solar Energy Education.

Within this network our UNESCO Chair has published a number of books based on some recent studies, including: "Fundamentals of Photovoltaics", "Fundamentals of Wind Energy", "Solar Concentrators", "Matrix Solar Cells" in 3

volumes, " Biofuel from Algae ", "Development of Solar Energy in Turkmenistan", "Solar Photovoltaic Water Lifters", "Photovoltaic Solar Energy Conversion", and "Fundamentals of Electrical Safety".

The results achieved by our Chair in Moscow schools and within EURONETRES under the auspices of ROSTE were appreciated by the meeting of the Working group on Solar Energy as well as by the educational community. They inspired us to create a network of UNESCO Chairs to be focused on consolidating new technologies, educational reforms, and traditional values of civilizations. Here we speak about new energy sources and the prospects of the noospheric development of the mankind. We invite our colleagues to cooperate with us on this idea! We want our achievements to be utilized worldwide.

7. The Road Map for Power Engineering

Our forecast for the development of power and electrical engineering in the next 100 years is as follows:

- Electric machines, robots with active working bodies will operate on agricultural plantations - 2040. [7].
- New energy technologies will create robotic systems for growing food in the Arctic and areas unsuitable for agricultural production. In metropolitan areas multistorey biotech robotized factory for the production of environmentally friendly products will be constructed - 2030 [7, 8].
- Overhead transmission lines will be replaced by underground waveguide single-conductor cable, the line - 2040 [5].
- Electrolysis technology to produce hydrogen with energy consumption of less than 3.5 kWh / m^3 -2020 [5].
- Liquid and solid organic wasts are used as fuel for the production of methane and electricity - in 2030 [3, 7].
- LED lights are replaced by energy-efficient fluorescent lamps with cold cathodes, and field emission - 2030 [3].
- Creation of a unified energy system Moscow-Beijing, New Delhi and Moscow-Vladivostok-Lisbon - 2060 [5].
- A global solar resonance power system with non-stop production of electricity, hydrogen fuel and heat for every person on Earth - in 2080 [4, 5].
- Fuel-free energy will provide 80-90 % of the world's energy needs. Power supply of aircraft in space and the transmission of electrical energy to mobile objects in the world are provided by resonant wireless method - in 2050 [5].
- Heat engines for vehicles will be replaced by 2-10 tns electric propulsion with thrust vector control - 2050 [9].
- Designed ekzaflopnye computer technology with a capacity of 1 ekzaflops = 1018 operations per second to control energy flows in power - in 2060 [10].
- According to assessment of Nobel laureates Feynman and John. Wheeler, in a vacuum, concluded in the amount of incandescent bulbs it is, enough energy to boil

all the oceans on Earth. The methods of producing energy from the environment - 2075 [11].

- Methods of wireless transmission of electrical energy in the ocean will be used to supply ships - 2030 [12].

Conclusions

1. The twentieth century was the last age of cheap energy. The era of cheap energy is over, and we need new energy technologies in order to ensure the sustainable future development. Advanced tendencies in future power engineering are presented.

2. Plasma technologies for solid domestic waste processing into electric energy and the technologies for liquid organic waste processing based on supercritical water oxidation of organic substances into liquids for thermal and power plants with 1 MW capacity are under development.

3. Comparison of parameters of a classical electric power supply system with an electric power supply system using single-wire wave-guide lines with high frequency, proposed by N. Tesla 100 years ago show that in such characteristics as current density and line losses, energy transmission distance, transmission capacity, the possibility of cable and wireless power transmission the Tesla electrical systems exceeds the classical energy supply systems. In future electrified mobile robots with external wireless power supply will make it possible to organize agricultural production on the principles of "Industrial Factories on Fields" with full automation of technological processes.

4. The energy model of the future world based on direct solar energy conversion and transcontinental terawatt power transmission with the use of resonant wave-guide technology, development by N. Tesla, is proposed. The advanced Russian technologies for solar energy include chlorine-free technologies for solar-grade silicon production, technologies for silicon high voltage solar modules with 20% efficiency at 60-fold concentration of solar radiation, technologies for assembling solar modules with 40-50 years' service life, and concentrator solar modules and non-carbon fuel technologies.

5. The forecast for development of electric and power engineering in 21 century is discussed. Mankind will be able to unite and concentrate their energy resources and technology to create decent living conditions for every person and the implementation of major science and technology projects on Earth and in outer space.

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ПРОГРЕС В НЕТРАДИЦІЙНІЙ ЕНЕРГЕТИЦІ

Д.С. Стребков

Анотація. XX століття було останнім періодом дешевої енергії. Ера дешевої енергії закінчилася, і нам потрібні нові енергетичні технології, щоб забезпечити майбутній сталий розвиток. Мета статті - знайти економічні і надійні, поновлювані та екологічно чисті джерела енергії для майбутнього енергетики. Представлені передові тенденції розвитку майбутньої енергетики. Обговорюється прогноз для розвитку електро- і теплоенергетики в 21 столітті.

Ключові слова: безпаливна енергетика, відновлювальна енергія, глобальна сонячна енергетична система, видобуток енергії з органічних відходів, майбутнє освітлювальної системи, резонансні електричні енергосистеми, сонячна освіта

ПРОГРЕСС В НЕТРАДИЦИОННОЙ ЭНЕРГЕТИКЕ

Д.С. Стребков

Аннотация. XX век был последним периодом дешевой энергии. Эра дешевой энергии закончилась, и нам нужны новые энергетические технологии, чтобы обеспечить будущее устойчивое развитие. Цель статьи - найти экономичные и надежные, возобновляемые и экологически чистые источники энергии для будущего энергетики. Представлены передовые тенденции развития будущей энергетики. Обсуждается прогноз для развития электро- и теплоэнергетики в 21 веке.

Ключевые слова: бестопливная энергетика, возобновляемая энергия, глобальная солнечная энергетическая система, добыча энергии из органических отходов, будущее осветительной системы, резонансные электрические энергосистемы, солнечное образование

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RENEWABLE ENERGY SOURCES AND THE PROBLEM OF ENVIRONMENTAL PROTECTION

Volodymyr Kozyrskyi, Doctor of Engineering
Liliia Martyniuk, PhD student
e-mail: slodkalily@gmail.com

Annotation. *In this paper presents research results the environmental assessment of emissions of harmful substances into the air from burning fuel for electricity production process power plants RES. It is established that during the production of renewable energy systems pollute the environment. For general environmental assessment must take into account the environmental impact of power plants with the RES on the environment at all stages in the process of their production, use and disposal.*

Key words: renewable energy sources, environment, negative impact, ecologic and economic aspects, method of exergy optimization, exergy balance

Purpose of research - assess the impact alternative energy sources on the environment by use method of exergy optimization.