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Socio-economic assessment of the use of nature-like nanotechnologies for the reengineering of the technosphere

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ABSTRACT: Introduction. Recently, the term “nature-like technologies” has appeared in the everyday life of scientists and politicians, which quite deservedly include the so-called alternative energy sources (sun, wind, heat). At the same time, despite the fact that installations using these sources are “seasonal” and low concentrated, their use is rapidly and haphazardly developing, and many economists and politicians mistakenly consider them as basics, misleading business. Based on the analysis of the epistemology of the origin of the term “nature-like technologies”, this article shows the groundlessness, and even the harm of the rapid and unsystematic use of wind turbines. Evidence is given of the inconsistency of the “myths” that Nature cannot cope with the compensation of the economic activity of mankind, therefore, according to Academician Sergeyev S.M., President of the Russian Academy of Sciences, “reengineering of the technosphere” is required. At the same time, modern economic science is far from taking into account in his models of the assimilation potentials of the biosphere of regions and the functions of entropy production in them, preferring to model various “cycles and modes”, as well as calculate different “coefficients” in order to predict “crises and equilibria”, without taking into account the interaction nature and society. In this connection, a scientific and technical task about determining the “place of reengineering of the technosphere” in the structure of the life support systems of society, and, consequently, to evaluate its effectiveness. **Methods, models and tools.** To solve the tasks set, it is proposed to use the “retro-forecast method” of socio-economic losses from the introduction of “natural nanotechnologies”, using as “tools” the method of “spatio-temporal analysis”, model of the Leontief-Ford and adaptive taxation systems of “harm production”, the use of which in solving the problems of fire and environmental safety in the “technospheres of the regions” of the South of Russia (in road transport infrastructures, in cities and towns, in buildings and structures), proved their adequacy to the processes under study and usefulness. **Results and discussion.** The results of modeling the costs of efficiency of “reengineering of the technosphere” in Russia, in particular individual residential buildings, and a retro-forecast of changes in socio-economic and environmental losses during the autonomy of their resource supply (electricity, water and heat) are presented. It is shown that the production of domestic innovations in this area (“Shukhov’s” wind turbines, atmospheric water condensation devices and electric heating) will allow stopping the “total gasification” of rural settlements, as well as more economically than abroad, to implement decentralized supply of resources in Russia more than 10 million individual houses and about 40 million country houses, thus determining the “true place of alternative energy” in the structure of the Russian systems of electricity, gas, water and heat supply. **Conclusion.** The proposed approach allows us to determine the place of the so-called renewable energy in the structure of resource supply systems for cities and rural settlements. At the same time, it is possible that the emergence of more productive design solutions of the proposed innovations in the field of wind energy and solar panels will expand the “autonomization” to low-rise and multi-apartment buildings in regional centers and workers’ settlements, instead of a major restoration of centralized engineering systems with boiler houses and mini- CHP.

KEY WORDS: nanotechnology of autonomy, engineering systems of buildings, fire-energy harm, reliability, quality, safety.

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INTRODUCTION

Oddly enough, the term “nature-like technologies” appeared officially not in the publications of the scientific community, but in the Speech of the President of

Russia at the plenary session of the 70th session of the UN General Assembly on September 28, 2015 [1].

It should be noted that domestic publications in this area have periodically appeared over the past 15 years [2–9], but only in 2016, the president of the National

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Research Center “Kurchatov Institute”, Corresponding Member RAS M.V. Kovalchuk “deciphered” and suggested that the scientific community use the following terms [10]:

“nature-like technologies” – to refer to fundamentally new methods and means of generating and consuming energy on the model of wildlife,

“nature-like technosphere” – to describe its new look, which consists in the restoration of a natural self-consistent resource turnover, which should be created by convergent nano-, bio-, information, cognitive and socio-humanitarian technologies (NBICS technologies)”,

after which the concept of “nature-like technologies” appeared in the Decree of the President of the Russian Federation [11].

However, the academic community for a long time “did not accept” these new terms [12], continuing to criticize Kovalchuk M.V. for simplifying these concepts [13–16]. And the President of the Russian Academy of Sciences Academician Sergeev S.M. speech in September 2018 in Sochi at the Global Forum of Converging and Nature-Like Technologies, has stated: *“Nature-like technologies are not a new trend, and we even know from the last century that this direction has taken various names (bionics, biogenetics, and so on). I would use the term “reengineering of nature” ... Nature-like technologies are the kind of reengineering that should be proud of.* [17].

From time to time myths are born about future environmental catastrophes associated with the loss of the ozone layer, climate warming due to ever-increasing greenhouse gas emissions and the coming “global flood”. There are various hypotheses about the future shortage of water, energy and mineral resources, food due to the loss of part of the land resources, etc. But **the most harmful thing is that the opinion is being asserted about the degradation of the biosphere as a structure, with the simultaneous loss of its function of supporting life on Earth** [15, 16].

Assessments of the state of the assimilation potential of the biosphere allow us to conclude that, to put it mildly, the possibilities of human economic activity to have a significant impact on its structure and function are exaggerated. The assimilation potential of the biosphere still performs its functions to ensure the balance of the circulation of matter and energy. **The energy contribution of human economic activity remains insignificant in relation to the energy potential of the biosphere**, which has accumulated it over billions of years of evolution. The inertia of the biosphere, as **the ability to resist disturbances from human economic activity in terms of mass and energy, the time of its formation and development, exceeds them millions of times** [16,18].

The natural resource potential of the biosphere remains high not only in terms of energy reserves of hydrocarbons, various metals, but also in terms of reserves of renewable sources – solar, wind, water, geothermal energy

of the Earth, etc., the relative share of which is increasing in the overall energy balance of developed countries. However, **despite the significant economic costs and low efficiency, as well as the fact that many of them are unstable, low concentration and periodic sources, many experts and politicians mistakenly consider them as basic**, including from the point of view of conservation quality of the natural environment [16, 19].

The relationship of man with nature is determined by the pressure of human economic activity on nature (by withdrawing resources, producing waste, etc.). Nature responds to this to man by changing its quality strictly according to the principle of action and reaction, thus stimulating man to find solutions that will not violate the natural processes of reproduction of the quality of the environment due to the circulation of inanimate and living matter. Nature in its development does not make any choices at all, it changes according to its own laws of self-organization, according to the laws of self-preservation and random events [16,18].

You cannot tie nature to society, incl. to unnatural technologies, and talk about socio-natural development. They have different laws: nature has only natural ones, while humans have both natural, social, and technical ones.

Man and society have the goal of unlimited development and unlimited existence in time, but nature has no goal. The homeostasis of nature is in its conservation laws. Thus, **in combining the concepts of nature and society**, in particular, in nature-like technologies and in the nature-like technosphere, **there is an insoluble internal contradiction** [16, 18].

The fact is, and this is the main thing, that emissions from economic activity (heat, moisture, gases, soot, etc.) into the atmosphere and biosphere, a person carries out with different intensity and locally, on a relatively small part of the Earth’s surface. It is **local thermal and material emissions** containing “unnatural” amounts of toxic gases, **moisture and dust that lead to perceptible disturbances in the atmosphere**. Climatic anomalous flows arise, introducing an imbalance in its secular variations, which will necessarily be smoothed out in time due to the inertia of the biosphere as a whole. However, local balancing can occur either slowly and imperceptibly, or transiently. And in the latter case, the return of the system to the initial state of the climate in a particular space (region) can be tougher (catastrophic) than the exit from the previously balanced state. **Everything depends on the mechanism of combinations of random fluctuations, which can create resonant climatic effects leading to unexpected consequences** [16].

For example, an increase in the incidence of tornadoes and hurricanes in the Gulf of Mexico and in other parts of the United States, as well as in Western Europe, is possibly associated not only with emissions, but also with the construction of high-rise buildings and structures,

as well as wind power plants (WPP) that take away the kinetic energy of the wind. In the first case, the secular directions of seasonal winds can be changed due to the appearance of surface barriers in the path of air flows, which will certainly lead to transient fluctuations in the atmosphere and cause local eddies (turbulence) in the atmosphere. In the second case, the removal of the kinetic energy of wind turbines will also lead to a change in the secular circulations in the region and will lead to unpredictable local disturbances in the atmosphere. Thus, any human intervention in the natural course of events in the Earth's atmosphere will inevitably cause consequences that may be more noticeable locally than globally. Therefore, **the pursuit of non-traditional energy sources does not solve the problem of preserving the quality of the natural environment**, due to the operation of the principles of self-organization and the laws of conservation, action and reaction [18, 19].

The biosphere still remains a balanced system, despite the ever-increasing pressure on its structure and function from the side of man. And this means that the metabolic processes in the biosphere should increase their speed in proportion to the emerging loads based on the law of action and reaction, on the basis of the principles of synergy. Climate change on Earth is a response of the structure and function of the biosphere to disturbances caused by human economic activity, since the atmosphere is more sensitive to energy disturbances than the hydrosphere, and the latter is more sensitive than the metabolic processes occurring in the geosphere. At the same time, global changes are not so important (they are more difficult to notice and isolate), but regional or even local fluctuations, which can lead to a spontaneous change in the direction and intensity of metabolic processes in biogeocenoses – the elementary components of the biosphere. And human economic activity should not be considered outside the structure and function of the biosphere and presented as an external disturbing factor. It is internal, belonging to the biosphere itself, since a person cannot single out his activity from it and is not only its subsystem, but also an evolutionary factor that provokes a change in the environment. Within the framework of the theory of evolution, a change in the environment leads to a change in the structure of ecosystems and living organisms, adapting to new conditions, compete for survival in the human ecological niche. Therefore, **a person's awareness of his place in nature imposes on him the obligation not only to follow the laws of nature, but also to make a conscious choice in the pace of his development, conforming them to the rate of reproduction of natural resources and the quality of the natural environment** within the assimilation potential of the biosphere in the global plan and the assimilation potential of the environment – in the local plan. Therefore, **in the future**, using the achievements of science and technology, **mankind will be able** to use the

energy potential of the biosphere and **switch to a model of adaptive nature management within the co-evolution of the technosphere with the biosphere**, which will require of entropy approach to determine the optimal thermodynamic parameters of such adaptation, and “reengineering of the technosphere”, in particular [2, 7, 18].

It is quite obvious that **modern economic science** is far from taking into account in its models the assimilation potentials of the biosphere of regions and the functions of entropy production in them, preferring to model various “cycles and modes”, as well as calculate different “coefficients” in order to predict “crises and equilibria”, without taking into account the interaction of nature and society, **operating only on investments and created benefits** (public, collective and private), **probably because they do not understand their dialectical unity with his opposite – by harm** (public, collective and private), i.e. **the impossibility of creating benefits without the simultaneous production of harm** [2, 15].

The only acceptable way to solve such problems is, in our opinion, the method of retro-prognosis of safe life activity [20, 21], with the following “tools”:

- the Leontief-Ford model, adapted to determine the costs by suppression road, transport, energy and environmental harm in the region, and, consequently, predicting the safety of road, transport, and energy infrastructures when introducing innovations in them [22];
- the method of “spatio-temporal analysis” of socio-economic losses from fires in the regions, to determine the reduction of damage by the suppression of fire-energy harm in their technosphere and biosphere, and also of retro-forecast of fire safety of life activity when introducing of innovations in them [23];
- models of the system of adaptive taxation of “production of harm” in the region, instead of various “insurance systems”, for the targeted spending of funds on innovations, which are designed to improve the safety of the population in the regions to the level of 0.999999 required by the standard [24, 25].

METHODS, MODELS AND TOOLS

If the Leontief-Ford model is quite well known in world economic science and it remains only to “include” in it the parameters of the assimilation potentials of the biosphere of regions and the functions of entropy production in them, then the retroprediction method [20, 21] and the model of adaptive taxation systems for the technosphere [24], according to the authors, are little known, although they were published, and the system of adaptive road-transport-environmental taxation (SARTET) was proposed by Rostov scientists instead of “auto citizenship” at hearings in the Federation Council on June 7, 2004, but did not receive support [20, 26].

The fundamental difference between the retro-forecast method and all other forecasting methods is that the forecast vector rushes from the “current” to the “past”, and its phase space is not built on “imaginary data”, the variance of which is large and is difficult to correctly determine, but on “historical”, i.e. on statistically reliable events in the past (fires, traffic accidents, deaths, injuries, material damage, destroyed objects and areas, etc.), incl. about the causes of fires and accidents, as well as the parameters for the performance of operational and tactical tasks by the “emergency services” (exit radius, times of detection, arrival, localization, etc.), which are established by experts and documented, i.e. on data with near-zero variance.

Initially, the retroprediction method was tested on arrays of an automated system processing data about fires (ASPD “FIRES”), which was developed at the All-Russian Research Institute of Fire Defense in the 80s of the last century [27] and “it was put into service” by the Ministry of Internal Affairs of the Russian Federation since 1995, and then finalized at the Ministry of Emergency Situations of Russia and introduced by us into the educational process of training fire safety specialists at the Rostov State Civil Engineering University [28].

A set of programs developed at the university made it possible to carry out a correlated data sampling, realizing a “spatio-temporal analysis” of the activities of any fire garrison in Russia (Fig. 1) using Erlang distributions

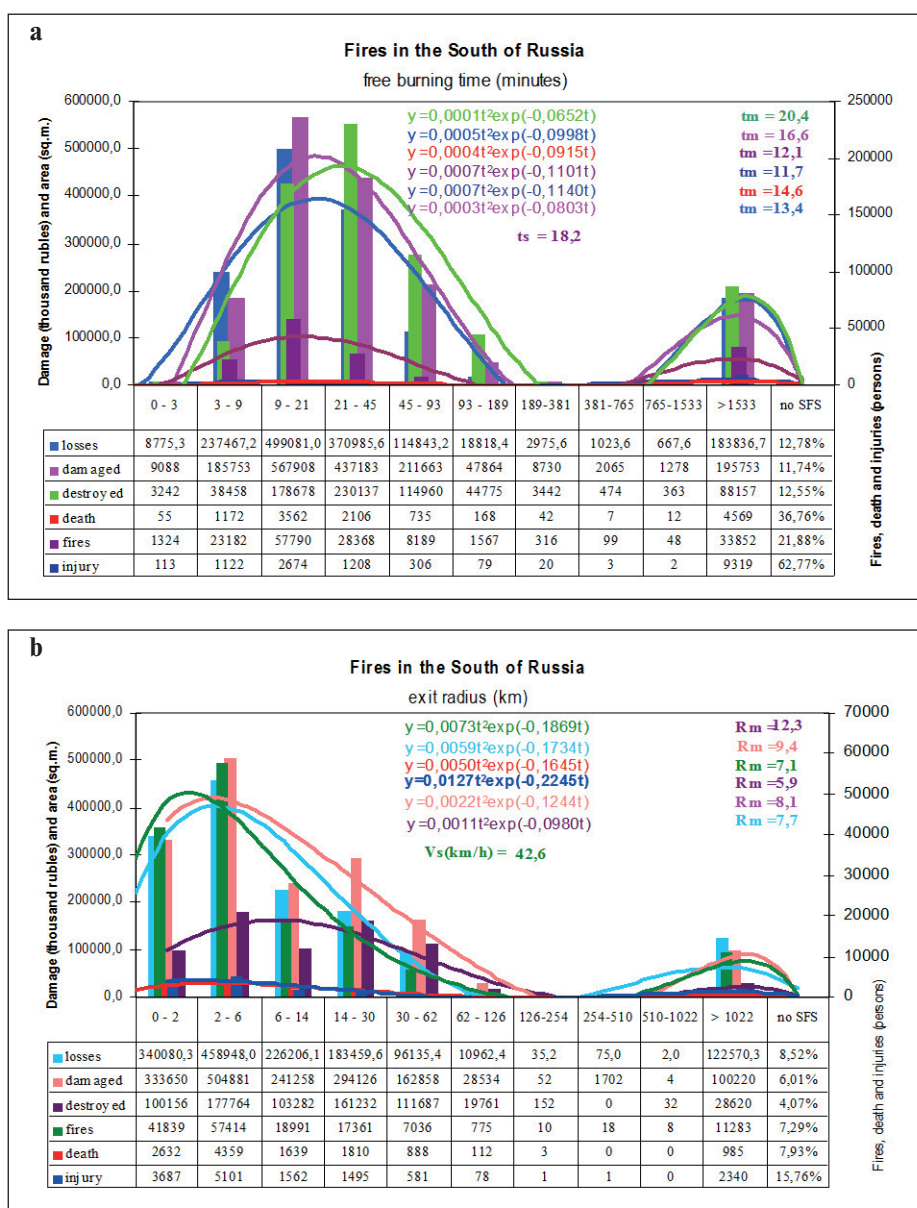


Fig. 1. Probability density functions: a – free burning times (min.); b – exit radius (km)

(1,2), after which the synthesis of “new distributions into the past” was carried out, taking into account the implemented innovations [28, 29]. At the same time, the reduction of socio-economic losses from fires when introducing innovations that eliminate certain causes and sources of fires, as well as their distribution, was determined by calculating the differences between “current and new distributions in the past” (dead’s, injuries, losses, damaged and destroyed areas, etc.) [30].

$$y = \frac{\left(\frac{t}{c}\right)^{b-1} \cdot \exp\left(-\frac{t}{c}\right)}{c \cdot [(b-1)!]} \text{ and}$$

$$y = \frac{\left(\frac{R}{c}\right)^{b-1} \cdot \exp\left(-\frac{R}{c}\right)}{c \cdot [(b-1)!]} \quad (1)$$

$$P = 1 - \exp\left(-\frac{t}{c}\right) \cdot \left[\sum_{i=0}^{b-1} \frac{(t/c)^i}{i!}\right] \text{ and}$$

$$P = 1 - \exp\left(-\frac{R}{c}\right) \cdot \left[\sum_{i=0}^{b-1} \frac{(R/c)^i}{i!}\right], \quad (2)$$

where b/c is the maximum of the function, $(b+\sqrt{b})/c$ is the “right” inflection point, $(b-\sqrt{b})/c$ is the “left” inflection point.

A systematic analysis of the functioning of the residential sector of the technosphere (using the engineering systems of multi-apartment buildings and individual residential buildings as an example) made it possible to discover the processes of “turning consumed collective and private goods” (electricity, gas, heat, etc.) “into collective and private harm” with the help of electrical, gas and plumbing appliances (hereinafter household appliances). After that, a method was developed for measuring fire-electrical damage [31] and an electric meter-detector that turns off (in case of a fire-threatening consumption mode) the power supply of an apartment / individual residential building, with early detection of fire hazards and a “cellular alert” of the fire department [32], which were protected by patents of the Russian Federation.

This made it possible to substantiate and create a model of the system of adaptive taxation of fire-electrical harm [24], instead of “economic-legal impasse” – of insurance of civil liability of individuals and legal entities from fires (“firecitizenly”), which, as was proved by the example of civil liability insurance owners of vehicles (“autocitizenly”) does not affect road traffic safety and ecology in any way [33, 34].

Further research made it possible to supplement the above method with a gas meter and derive a unified formula for determining fire-energy harm (3) and a local adaptive fire-energy tax (AFET) for consumers (4) of energy resources (electricity, gas, coal, diesel fuel, etc.) [24, 35, 36]:

$$FEH = k_j \cdot (P_{aq} \cdot W_{aq} + P_{uq} \cdot W_{uq}) + q_g P_g \cdot W_g, \quad (3)$$

where FEH is the fire-energy harm over time t , MJ; P_{aq} – the probability of fire from electrical appliances with an acceptable quality of electricity; W_{aq} – the amount of electricity consumed with acceptable quality, kW/h; P_{uq} – the probability of a fire from electrical appliances with an unacceptable quality of electricity; W_{uq} – the amount of electricity consumed with unacceptable quality, kW/h; k_j – coefficient of conversion of kilowatt / hour to Joules (3.6 MJ), P_g – probability of fire from gas appliances; q_g is the calorific value of the gas (35 MJ/m³); W_g is the volume of consumed gas, m³.

$$AFET = \frac{\sum_{i=1}^n T_i \cdot V_i \cdot P_i}{K_p}, \quad (4)$$

where AFET – adaptive fire-energy tax, rub; T_i – the corresponding tariff rates in the region for “n” energy resources, rub; V_i – actually consumed volume of energy resources for the period of taxation, kW/h, ton, cubic meter, etc.; P_i – current statistical probabilities of fires in the region from household appliances, K_p – “adaptation coefficient”, which at the beginning of the introduction of AFET is equal to 1, and then increases, reducing the tax, synchronously with the increase in fire safety of the population in the region to 0.999999 according to GOST 12.1. 004.

Modeling the costs of introducing top-priority innovations (electric gas meters, detectors, self-rescuers, etc.) and a retrospective fire safety forecast for the residential sector in the South of Russia (Rostov Region, Krasnodar and Stavropol Territories) showed that due to AFET and reducing losses from prevented and detected in the early stages of fires, it is possible to achieve the required level of safe life of the population in the residential sector, where, on average, 70% of fires occur [21].

The final results of “simulation into the past” are interesting [20, 37, 38]:

“If in 1995 in the South of Russia work had begun on the introduction of a “starting” structure, or, as is customary in the ASM, the 1st stage of the macro fire safety management system (MFS MS), which intensifies preventive activities, then by 1998 it was possible to prevent 23,620 fires, than to save the lives of 2,528 and the health of 2,771 residents of the South of Russia, to reduce direct and indirect losses from fires by a total of 32.1 billion rubles, save from destruction 93,163 sq.m. and from damage 140733 sq.m. residential and

industrial areas, to have provide current costs for the operation of the MFS MS, in the amount of 5.9 billion rubles. per year due to the reduction of annual losses from fires and due to AFET in the amount of 18.828 billion rubles. (6276.0 billion rubles per year), having paid back 25.4 billion rubles in three years. one-time costs. However, the probability of death and injury, having decreased by 2.5 times, would be $7.62 \cdot 10^{-5}$, which is 76 times higher than the permissible level of safety of the population in case of fire (0.999999). Therefore, in the next 2nd stage of the MFS MS, it is necessary to supplement the 1st stage with models that increase the safety of people in fires”;

“If in 1999 in the South of Russia the work on the introduction of the 2nd stage of the MFS MS, which intensifies operational and tactical activities, had continued, then by 2001 it would have been possible to prevent 33869 fires, which would save the life of 2865 and the health of 3664 residents of the South of Russia, reduce direct and indirect losses from fires by a total of 33.1 billion rubles, save from destruction 132,083 sq. m. and from damage 250553 sq. m. of residential and industrial areas, o have provide current costs for the operation of MFS MS in the amount of 13.82 billion rubles. per year, due to the reduction of annual losses from fires, and due to AFET in the amount of 18.828 billion rubles. (6276.0 billion rubles per year), recouping over the same three years all one-time costs, and the “saved” 15.9 billion rubles. direct to the introduction of self-organization models, tk. the probability of death and injury after the implementation of the 2nd stage will be $1.2 \cdot 10^{-5}$, which is 12 times higher than the permissible level of public safety”;

“If in 2002 in the South of Russia the work on the introduction of the 3rd stage of the MFS MS with the re-equipment of the fire department (voluntary and professional) with the equipment of “atmospheric nitrogen fire extinguishing” were continued, then within 6 years, i.e. by 2008, 64,676 fires and their spread could have been prevented, thereby saving the lives of 6,544 and the health of 6,533 residents of the South of Russia, reducing direct and indirect losses from fires by a total of 841.359 billion rubles, and save from destruction 235,236 sq.m. and from damage 733745 sq. m. of residential and industrial areas, o have provide current costs for the operation of the MFS MS, in the amount of 17.9 billion rubles. per year by reducing annual losses from fires, and at the expense of AFET in the amount of 37.656 billion rubles. (6276.0 billion rubles per year), recouping all one-time costs over the same six years, and the “saved” 97.4 billion rubles. direct to the creation of a unified geographic information system (GIS) of the South of Russia, tk. calculations showed that the probability of death and injury, having decreased by another 9 times over 6 years, will be $1.34 \cdot 10^{-6}$, which is 1.35 times higher than the permissible level of safety of the population in case of fire (0.999999).”

In other words [20,21]: “without the introduction of other models that require GIS, and, consequently, the interaction and self-organization of all life support services and

the Administrations of the region, it is impossible to achieve the normative level of safe life of people in the region.”

Similar results were obtained on the basis of a systematic analysis of existing legal, technical, economic, organizational and social measures that determine road safety, by means of a retro-forecast already according to the adapted Leontiev-Ford model [20,22,34], with the virtual implementation of the “Communication adaptive system of control automobiles traffic” (CASCAT), the target control function in which is the function of the production of the entropy of movement in road-transport infrastructures, which determines the probability of road-transport-environmental of harm, and when the minimum of which is reached, its maximum suppression occurs, which ensures the required level of public safety - 0.999999 [39].

The analysis of existing road-transport infrastructures made it possible to synthesize new principles of their formation, “tracking” and minimizing the entropy of movement in them through the function of the total “entropy production” ($\Delta S = \sum \partial_i S / \partial Y_j \cdot dY_j / dt$), which are associated with the probability of occurrence fluctuations according to Prigogine, i.e. “with road-transport-environmental harm”, by Einstein’s formula [20,39]:

$$P = B \exp(\Delta S/k), \quad (5)$$

where k is the Boltzmann constant.

It turned out that the road structure, including the quality of road surfaces, is not the main one – in the causes and consequences of road traffic losses ($S \rightarrow \min$, $\Delta S \rightarrow 0$, $P \rightarrow B$). And this meant that in the absence of transport, roads are practically safe, and road-transport-environmental harm (RTEH) depends [6,9,39]:

- on the number ($\partial_1 S / \partial N_j \cdot dN_j / dt$), speed ($\partial_2 S / \partial V_j \cdot dV_j / dt$), weight ($\partial_3 S / \partial P_j \cdot dP_j / dt$) and wheel arrangement of vehicles ($\partial_4 S / \partial J_j \cdot dJ_j / dt$),
- on the type and amount of fuel consumed by them ($\partial_5 S / \partial M_j \cdot dM_j / dt$ – through a conventional ton of fuel),
- on the number ($\partial_6 S / \partial n_j \cdot dn_j / dt$) and speed of movement of pedestrians ($\partial_7 S / \partial v_j \cdot dv_j / dt$).

The economic subsystem in the macrosystem “CASCAT” is the System of Adaptive Road – Transport – Environmental Taxation in the region (“SARTET”), which allows you to generate funds for the creation, development and operation of such a macrosystem without external investment [26, 39].

The optimality and adaptability of the introduced adaptive road-transport-environmental tax, which should be a “local tax” (instead of all road-transport taxes, including auto insurance), consists in a clear distinction, accounting and compensation for RTH by the “taxable base”, because depends and is calculated for a specific road transport infrastructure of a district (city) according

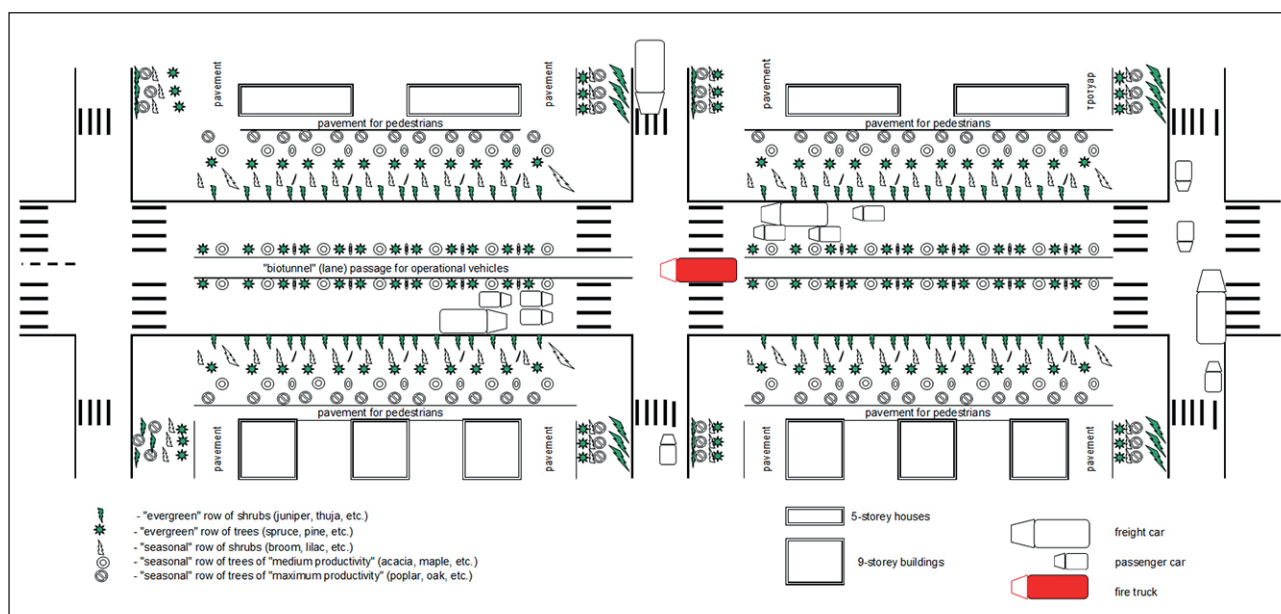


Fig. 2. Bioarchitecture of the road transport network

to the “seasonal productivity” of ecosystems, population and transport, the dynamics of their movement, including the introduction of free passenger transportation at the expense of ARTET, i.e. “turning passenger transport into a public good” [20, 33]. At the same time, the “seasonality” of ecosystem productivity is realized with the help of the bioarchitecture of the road transport network (Fig. 2), by special planting of trees and shrubs – “bio-tunnels”, which absorbs RTH and, therefore, depends on the intensity of traffic and pedestrians, including their seasonal changes [6,9].

Interesting, according to the authors, is the final result of “modeling into the past” for the city of Rostov-on-Don [20, 39]: “If in 1994 in Rostov-on-Don a state-legal experiment was started to create a “CASCAT”, then it was allowed to spend 550.0 million rubles on the development and development of the production of the necessary technical means and organizational and legal measures, and at the same time the system would pay off by reducing the direct and indirect material and moral damage caused to the population and the environment by motor vehicles. Rostov-on-Don, if its construction is carried out within 8 years and 14.5 billion rubles are spent. In other words, at the expense of the funds received by ARTET from 1994 to 2002 and the reduction of losses from RTH, it was possible to carry out “co-evolution of the technosphere and biosphere” in the road transport network of Rostov-on-Don”.

A similar “co-evolution of nature and the technosphere” was proposed for thermal and central power plants (CPP), which (Fig. 3), after motor transport, occupy “2nd place” in terms of the emission of H₂O, CO₂ and other of toxic gases and “1st place” in burns the oxygen in the atmosphere [40].



Fig. 3. External view of the city CPP

The synthesis of the “FARSEC” system (of Fire-Adaptive-Regulation and Suppression of Energy harm and Compensation for burned oxygen) was carried out (Fig. 4) based on the following innovative solutions [40, 41]:

Interesting, according to the authors, are the plans 15 years ago (of course, not implemented) to introduce the FARSEC system [40]:

“Currently, the FARSEC system is planned to be developed and implemented under the START-2006 program at one of the Rostov boiler houses, and according to preliminary calculations, it should remove the problem of environmental hazard from the CPP. Confidence in the implementation of the project is created by the participation in it of the largest domestic research and production enterprises: Geophysics-Cosmos (Moscow), Tekhnologiya (Obninsk), and successfully developing companies: LLC VM-energy (Ufa), Elegaz (Moscow) and Biotechnology (Rostov-on-Don), as well as

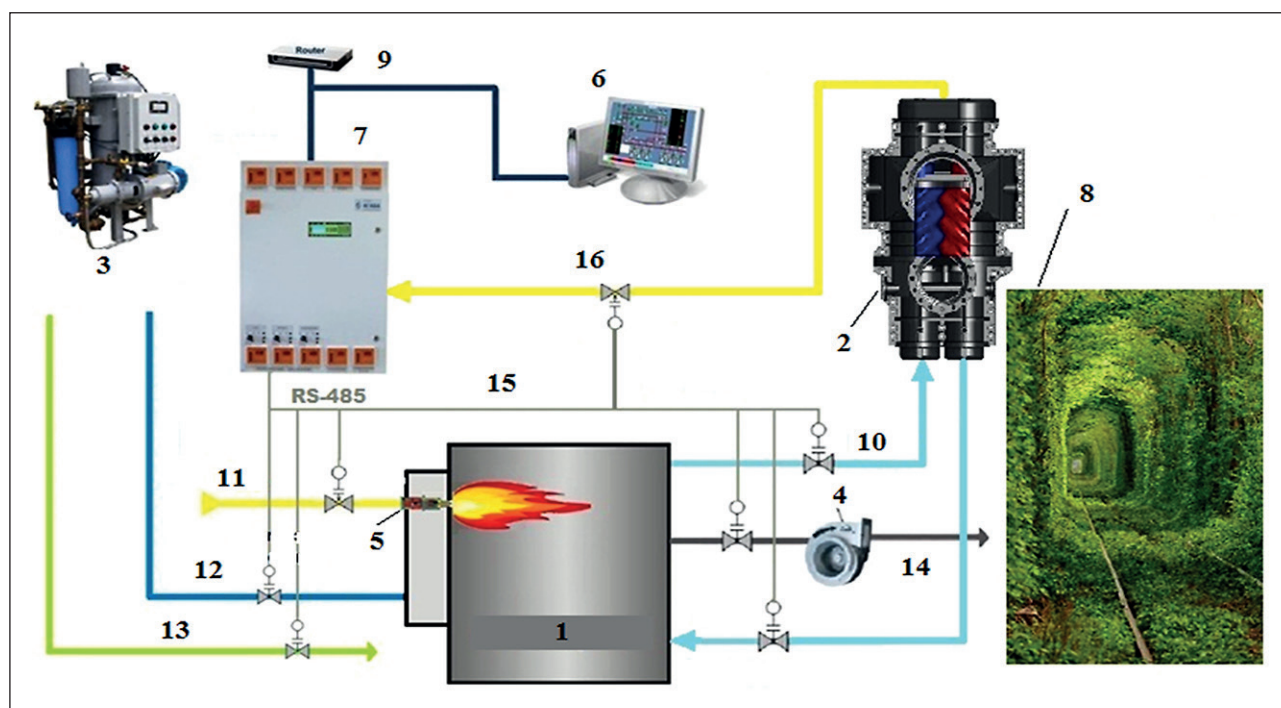


Fig. 4. Block diagram of the “FARSEC” system:

1 – SF6 boiler (R-510); 2 – Steam-screw machine (SSM); 3 – Membrane air separator; 4 – Smoke exhauster; 5 – Ultrasonic nozzle (for fuel oil); 6 – Dispatcher workstation; 7 – Multifunctional controller (MFC) with input-output modules of the process control system; 8 – Biotunnel (instead of a chimney); 9 – Router; 10 – Vapor-gas phase R-510; 11– Hydrocarbon fuel (gas, fuel oil, etc.); 12 – Air enriched with oxygen, after nitrogen separation; 13 – Nitrogen, separated from the air, for the system of suppression of fire and energy harm and hazardous factors of fire and explosion; 14 – Emissions from fuel combustion in the biotunnel; 15 – Network of remote “smart” MFC modules; 16 – Electricity for own needs from the SSM

leading domestic universities and research institutes in this field: Rostov State University (Rostov-on-Don), Academy of the State Fire Service of EMERCOM of the Russian Federation (Moscow), RSSU (Rostov-on-Don) and the Krasnodar Research Institute. P.P. Lukyanenko “.

RESULTS AND DISCUSSION

Localization and suppression of fire-energy harm in individual residential buildings, of which there are about 10 million in Russia (plus about 40 million garden and country houses), as shown by our studies, is possible due to the autonomy of electricity, water and of heat supply from alternative sources. (wind, sun, atmosphere) with the help of “nature-like nanotechnologies” [19].

Taking into account the above volume of individual residential buildings in Russia, as well as differences in structure, productivity (Fig. 5) and cost (Table 1) of component equipment (by an order of magnitude or more), the following scientific and technical problems:

firstly, it is necessary to estimate the costs of such a “reengineering of the technosphere” in Russia, with imported and domestic equipment,

secondly, to carry out a retro-forecast of the effectiveness of such reengineering of the technosphere in Russia, thirdly, to conduct a comparative analysis of the effectiveness of imported and domestic equipment, fourthly, to simulate the conditions for the implementation of the optimal variant in Russia.

Costs for imported and domestic configurations. As follows from the comparative data of wind turbines (Table 1), the cost of a Chinese wind generator with a capacity of 1.0 kW is 100.0 thousand rubles, the cost of the AQUAMATIK drinking water apparatus is 80.0 thousand rubles. [42], a set of hydraulic panels (Fig. 6) with a capacity of 10 liters. per day “ZERMAS” costs 380.0 thousand rubles. [43], and one Chinese solar battery of 300 W SRP 320 costs 18.5 thousand rubles [44,45].

Thus, the cost of one individual residential house in an imported configuration of duplicated system will amount to 634.0 thousand rubles.

As follows from the comparative data of wind turbines (Table 1), the cost of the “Shukhov wind generator” with a capacity of 1.0 kW is 1.9 thousand rubles, the cost of a domestic atmospheric water generator T-88 “Soyuz” (Fig. 7) with a capacity of 30 l. per day – 115.0 thou-

Table 1

Comparative characteristics of wind turbines

Parameter	Wind generator vane type	Wind generator with vertical axis	Wind generator «Shukhov»
Power, kWt	1.0	1.0	1.0
Dimensions, mm	Diameter-2800, (circumference described by blades)	Diameter-454, Blade height-4000	Diameter-520, Height-850
Weight, kg (wind turbine + generator)	70	98	43
Wind force during breakaway, m/s	2.0	3.0	1.0
Rotation Speed rpm	300...400	180...300	600...900
Specification	wind turbine, Generator, Battery, inverter, cable assembly, Guyed mast	wind rotor, Generator, Rectifier, Controller, cable assembly, Guyed mast	wind turbine, Generator, Transformer
Cost, euro	1300 (China)	3350 (Ukraine)	250 (Russia)

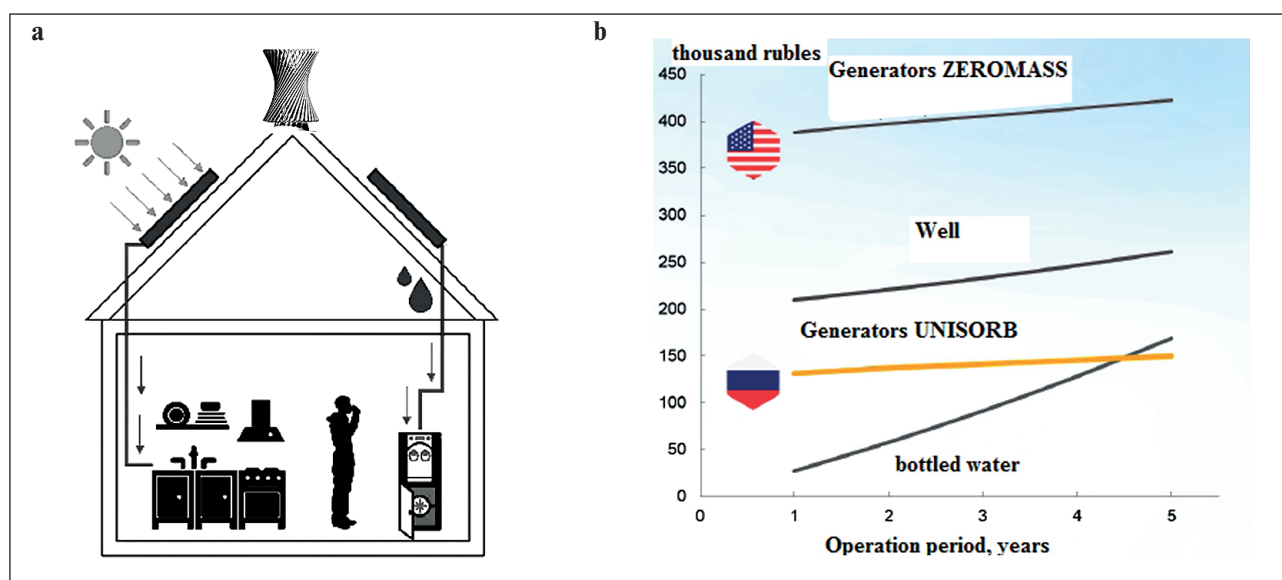


Fig. 5. Scheme of the autonomization option (a) and graphs of costs for water sources (b)

sand rubles. [46], a set of domestic hydraulic panels “UNISORB” (Fig. 5) with a capacity of 10 liters. per day – 120.0 thousand rubles. [43], one domestic solar battery of 290 W HEVEL – 23.7 thousand rubles. [44, 45].

Consequently, the cost of one individual residential building in the domestic configuration for a duplicated system will amount to 331.7 thousand rubles, i.e. almost two times less. And it remains to assess the amount of funding for the proposed autonomization and its contribution to the existing generation and delivery of electricity, water and heat to the population of Russia.

Volumes of necessary financing and generation of received resources (electricity, water and heat) during

autonomization. If we consider only capital individual residential buildings, then for the installation in them of autonomous engineering systems for supplying resources (electricity, water and heat) in an imported configuration (without installation costs), it will take 6.34 trillion. rub. In this case, we will obtain the following volumes of resources produced with the help of nanotechnologies in individual residential buildings during the year:

water supply with drinking water – 73 billion liters or 73 million cubic meters. m.;

hot water supply – 7.3 billion liters or 7.3 million cubic meters. m.;

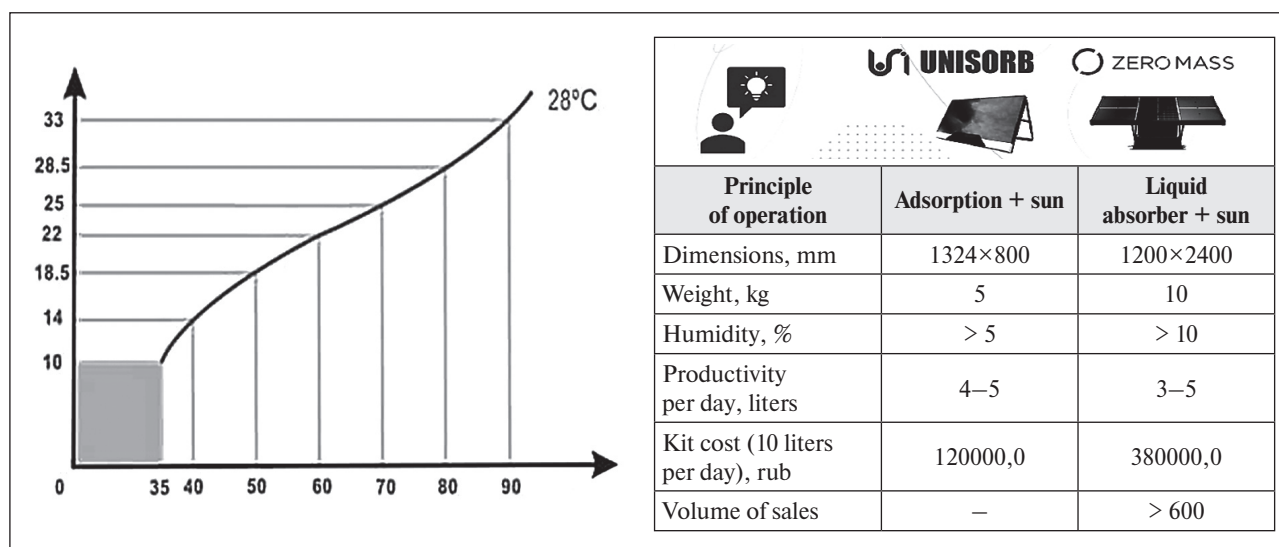


Fig. 6. Characteristics and performance chart of hydropanels

	Produced water	Drinkable, hot and cold
	Total power, W	1000–1150
	Heating power, W	500
	Cooling power, W	500
	Cold water temperature, °C	4–10
	Hot water temperature, °C	75–93
	Type of refrigerant and its quantity, g	R134–460
	Amount of water per day, liter	30
	Water tank, liters	12.5
	Hot water tank, liters	1.8
	Cold water tank, liters	2
	Medium temperature range, °C	15–40
	Humidity, %	35–95
	Noise level, dB	< 60
Device weight, kg	50	

Fig. 7. Atmospheric water generator T-88 LLC “Soyuz”

power supply – 192.72 billion kW/h;

heat supply – 102.6 million Gcal (for the heating season of 6 months – $0.0342 \cdot 6 \cdot 50 = 10.26$).

To equip the remaining 40 million summer cottages and garden houses, another 25.36 trillion rubles will be required. rub. and the total volume of produced resources per year will be:

drinking water supply – 365 billion liters or 365 million cubic meters. m;

hot water supply – 36.5 billion liters or 36.5 million cubic meters. m.;

power supply – 963.6 billion kWh;

heat supply – 513.0 million Gcal.

Under the same conditions, for the first stage (10 million houses) in the domestic configuration, 3.317 trillion rubles, and for the second stage (40 million houses) – 13.268 trillion. rub., practically with the same volume-time characteristics of the produced resources with the help of “nature-like nanotechnologies”.

To carry out a retro-forecast of the introduction of autonomous engineering systems of individual residential buildings (AES IRB), statistics of events related to the operation of the existing energy system, which was “sawed” after the collapse of the USSR, for to create the so-called “of electricity of market” into two main structures: “generating” (which includes all power plants) and “supplying” (consisting of “guaranteeing suppliers” and others, if any). At the same time, their “market interaction” consists in the fact that the “generating structure” sells electricity, for example, at “federal prices” (up to 1 ruble per 1 kWh), and the “supply structure” sells electricity at “regional prices” (from 2 to 5 rubles per 1 kWh), and even in the form of an experiment (which will not end in any way since 2013) according to “social norms” approved by regional tariff commissions. In this connection, consumers pay not only for the actual consumption of electricity, but also for losses in the electrical networks of “supplying structures” (!), Which, as our studies have shown, are “legally” allowed [19, 47, 48].

Consequently, the “economic effect” (more precisely, the annual savings of citizens in value terms) from the introduction of the “electrical part” of the AES IRB will, on average, be 3.5 times greater than the “income of the generating structure”, which will amount to 3.372 trillion rubles. rub. annually ($963.6 \text{ billion kWh} \cdot 3.5 \text{ rubles}$).

Obviously, if the population saves on electricity, then there will be those who will lose their income, and these will be power supply organizations (the guarantee-

ing supplier in the first place), because. the “generating structure” will continue to sell them electricity, which is constantly lacking for the development of Russia. However, against the general background of electricity supplies to enterprises and organizations (legal entities), no one will notice such a “loss”, and as compensation, “supplying structures” will receive a smoothing of the daily load peak, and, consequently, an increase in the quality of the supplied electricity and a reduction in losses, i.e. because usually the peak of energy production by solar panels coincides with the daily peak of consumption [44].

It remains to be determined from where, in what amount annually and over how many years 16.585 trillion should be collected. rub., for a complete set and implementation of AES IRB?

The fact is that since 2009, support for renewable energy sources has been in place in Russia – the rules are spelled out in a government-approved document. Initially, support measures were designed for the period until 2020, but they were extended until 2024. There are no state subsidies in support measures – they are aimed only at attracting private investment [49].

The retail electricity market provides for competitive selection, as a result of which the investor receives the right to build renewable energy facilities of any kind with a guaranteed return on investment. The payback period is 15 years, the rate of return is 14% per annum for objects commissioned before January 1, 2017, and 12% per annum for objects commissioned after January 1, 2017.

Since 2013, the commercial operator ATS JSC has been conducting a competitive selection of projects every year. Based on the selection results, by 2024 it is planned to invest 528.74 billion rubles in the construction of renewable energy facilities in Russia, of which 330.73 billion rubles fall to wind power plants, and 201.25 billion rubles to solar power plants. [50].

If we add to the indicated data of ATS JSC the volume of investments invested by business in the unsystematic copying of “foreign experience” from 2009 to 2013 [51], then the total amount of losses from the “dead-end development” of RES in Russia over 12 years exceeded 1.0 trillion . rub.

From the point of view of organizing the implementation of AES IRB, the experience of the Netherlands is of interest [52]. The cost of 1 kWh of using a centralized electricity supply for individuals in the Netherlands is approximately 30 euro cents, which, like ours, is 4.5 times higher than the cost of electricity produced (7 euro cents, and the rest is taxes, duties, etc.). At the same time, after coordination with local energy supply organizations, the owner installs a bidirectional electricity meter and solar panels powered by a grid inverter (an inverter operating in parallel with the grid). At night, electricity is consumed from the network, and the meter counts its amount, and in the morning the energy from solar panels through the

network inverter begins to mix into the house electrical network behind the meter, thereby reducing consumption from the network. Accordingly, the meter continues to count energy, but at a slower rate, and after the generation of electricity by solar panels reaches the level of full consumption of the house, consumption from the city network stops, the meter stops and all the needs of the house are fully provided by solar panels. With a further increase in the production of electricity by solar panels or with a decrease in consumption at home, excess electricity begins to be unloaded into the city network, while the meter begins to subtract this energy from its previous readings. By the end of the reporting period (month), three options are possible for the balance of consumed and generated energy [52]:

- energy production by solar panels for the period did not exceed the consumption of the house, in this case it is paid at the rate of 30 euro cents – the difference between consumption from the network and generation from the sun;
- energy production by solar panels for the period is equal to the consumption of the house, in this case it will not be necessary to pay for electricity at all;
- the solar panels’ energy production for the month exceeded the house’s consumption, in which case the sales company will pay for the “excess energy”, but only at a rate of 7 euro cents per kWh.

However, such an organization encourages the installation of panels of such power that the balance of consumed and generated power approaches zero, because it is simply unprofitable to produce more, due to the fact that a tariff of 7 cents will not allow you to recoup the funds invested in installing extra panels during their entire service life. And this method of “forced organization” in conjunction with the controlled issuance of permits implements the process of “self-organization”, since no work is required to adapt the network to receive power from the grid companies, which eliminates the problems associated with an excess of power in the sections networks between consumers and nearby transformers). This system works well and makes a tangible contribution to the overall energy balance of the Netherlands, without requiring batteries to store excess electricity [52].

In Russia, despite changes in the legislation in the field of microgeneration of electricity, due to the lack of regulatory by-laws, the existing system practically does not allow unloading of excess electricity into the network by individuals [53], therefore, to accumulate of surplus, batteries are required, which increase the cost of implementing AES IRB. However, technically, nothing prevents us from borrowing the experience of the Netherlands, because. many of the electronic meters used in Russia are initially capable of counting energy in two directions, now this function is disabled by software [52].

PROBLEMS OF USING NANOMATERIALS AND NANOTECHNOLOGY IN CONSTRUCTION

So, let’s list the advantages of such a circuit solution (Fig. 8) for the population and our state, built taking into account the processes of self-organization:

firstly, citizens receive better quality electricity without interruptions in electricity supply and save on paying for it (at least 100 rubles per month for each person living according to the “social norm”);

secondly, citizens receive better quality drinking water without interruptions in water supply and save on paying for it (at least 300 rubles per month for home ownership);

thirdly, citizens receive better quality hot water without interruption and save on paying for it (at least 300 rubles per month for home ownership);

fourthly, citizens receive comfortable living conditions without interruptions in heat supply with autonomously controlled heating, while saving payment (at least 1,000 rubles per month for home ownership during the heating season);

fifthly, citizens really participate in solving the problem of “reengineering of the technosphere” with the help of “nature-like nanotechnologies”, saving, on average,

144.0 thousand rubles. per year on payment for electricity, water and heat in an individual residential building;

sixth, the state ensures the growth of the share of alternative energy in the overall balance, stimulates the production of solar panels and hydropanels, wind turbines, drinking water generation devices and other devices included in the AES IRB, which increases the gross domestic product (GDP) and the number of jobs, improving, thus, the attitude towards power on the part of society, etc.

There are also relevant applications for small alternative energy – these are engineering systems for remote autonomous objects. What hinders the implementation of such an approach?

Firstly, the lack of a systematic approach to alternative energy, as evidenced by the above data on the erroneous vector of its development, “laid in 2009” by the Government of the Russian Federation [48].

Secondly, the lack of systematic support in the production of domestic innovations in wind energy, in the generation of drinking water, and in the production of “budget” hydropanels and solar panels.

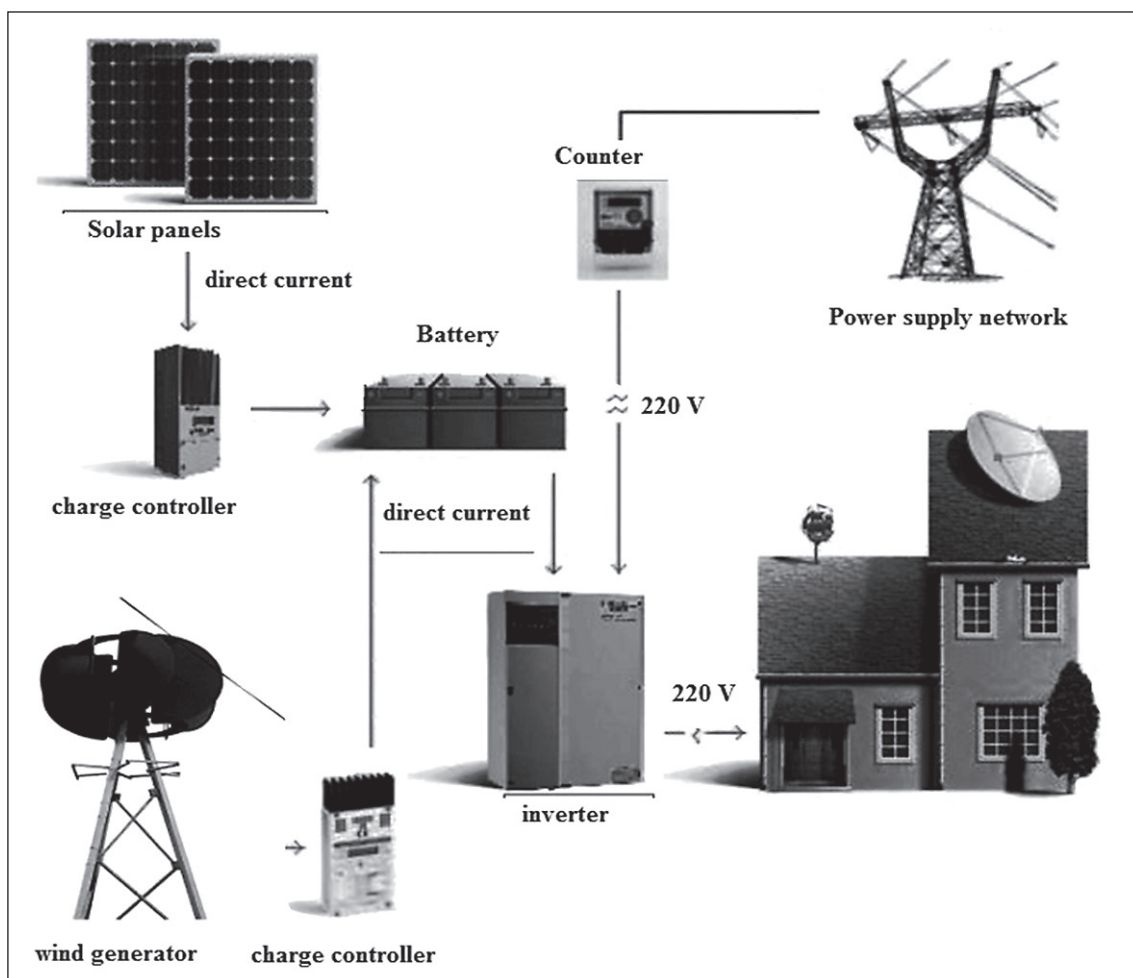


Fig. 8. The structure of the wind-solar part of the AES IRB

Thirdly, and this is the main thing – in the absence of state will and an appropriate regulatory framework, to “direct business in the right direction”, to ensure the well-being and safe life of the people, and not to increase fire-explosion hazard from “thoughtless gasification of the village” and poor quality electricity, water, heat supply of the residential sector and households, with “super profits” of resource-extracting and resource-supplying companies.

So, let’s make a retrospective forecast for the development of alternative energy in Russia from 2009 to the present, i.e. since the adoption of the erroneous decision of the Government of the Russian Federation [54].

To determine the time interval for the deployment of the proposed autonomization of individual residential buildings, it is necessary to calculate the time for the production of domestic components of the AES IRB complex and the volume of its annual production. At the same time, an obvious solution is to locate the production of complexes in each subject of the Russian Federation, by creating enterprises in the form of a public-private partnership (PPP), with branches/plots in cities and regional centers of the region for the installation and maintenance of AES IRB on the territory of the subjects. At the same time, the number of these enterprises is easily determined by the ratio of the number of individual houses to multi-apartment/high-rise buildings according to cadastral registration data in each region [55].

However, for a retro-forecast of the effectiveness of the proposed “autonomization” model at this stage, such accuracy is not required if the total number of individual residential buildings and households is known [19].

Thus, in order to determine the financing of the production and installation of AES IRB in the regions, it is necessary to organize 85 PPP enterprises for the production of AES IRB components and transfer it to city and regional branches/ plots for the assembly and installation of “specified AES IRB” consisting [19, 37, 56]:

- from “Shukhov wind-electric generators”;
- from vortex wind-electric generators – sources of atmospheric water;
- from UNISORB hydropanels;
- from solar panels;
- from inverters-meters-detectors;
- from battery charge controllers-detectors;
- from devices for generating cold and hot water from air (GCHW);
- from domestic multi-split systems-detectors;

For remote autonomous objects (weather stations, forestries, mountain posts, etc.) and for export, regional enterprises can assemble AES IRB into a container and carry out installation, commissioning and periodic maintenance on their own.

Branches/sites are located in cities and district centers and work under contracts with specific customers in the region (owners of IRR), developing projects for “bind-

ing” AES IRB already specified to a specific house (SAES IRB) with the following options:

- dubbed SAES IRB (with a specific number of hydropanels and a GCHW apparatus, with a Shukhov wind-electric generator and a specific number of solar panels with an inverter-detector and a battery charge controller-detector, depending on the number of residents) and with domestic multi-split system-detector (with a specific number of indoor units: according to the number of rooms, but at least one in a room with an electric stove);
- tripled SAES IRB (with a specific number of hydropanels, with a GCHW apparatus and with a vortex wind-electric generator-source of water, with a “Shukhov” wind-electric generator and with a specific number of solar panels with an inverter-detector and charge controller-detectors battery, depending on the number of residents) and with a domestic multi-split system-detector (with a specific number of indoor units: according to the number of rooms, but at least one in a room with an electric stove).

Branches/sections of enterprises, in agreement with each customer, determine the scheme of water supply and heating of his house, purchase an induction electric boiler with “warm floors” and / or wall-mounted batteries, or infrared heaters and other electrical heating appliances [19], including the necessary domestic plumbing and drainage components (into a drain pit prepared by the customer or into the sewerage system – if any), and also carry out the installation and commissioning of the AES IRB, after which they conclude an agreement with the customer on its periodic inspection and repair (if necessary).

Let us assume that instead of the said Decree, the Decree of the Government of the Russian Federation “On the deployment of work on the production and provision of all individual residential buildings with domestic life support complexes” was issued, in which half of the costs are allocated from the budget as a source of financing, and the remaining half – by banks, by issuing owners of individual residential buildings of interest-free loans to pay for AES IRB, the repayment of which begins after their commissioning, in the amount of 1000 rubles per month (almost corresponds to savings), which allows you to repay a bank loan (equal to half the cost of AES IRB) within several years.

In this case, we get the following average production plans for each of the 85 enterprises (PPP) from 2009 to the present (12 years):

1. 9804 complexes of AES IRB per year (10.0 million IRB / (85 PPP • 12 years), which, with 247 working days a year, will amount to 39 complexes per day. Consequently, when each enterprise operates in 3 shifts, it is necessary to produce 13 complexes per shift, which is quite feasible, and in physical and value terms will be:

1.1. 9804 “Shukhov” vortex wind-electric generators – 213.2 million rubles. (9804•250•87).

1.2. 9804 vortex wind-electric generators – 357.2 million rubles. (9804•3350/8•87).

1.3. 9804 sets of 4 UNISORB hydropanels – 1176.5 million rubles. (9804•120000).

1.4. 39728 solar panels – 529.4 million rubles. (9804•4•13500).

1.5. 9804 inverter detectors – 279.4 million rubles. (9804•28500).

1.6. 19608 controller-detectors of charge battery – 268.6 million rubles. (19608•13700).

1.7. 9804 of GCHW devices – 1127.46 million rubles. (9804•115000).

1.8. 9804 of domestic multi-split systems-detectors – 882.4 million rubles. (9804•90000).

2. The total annual volume for each PPP enterprise will be 4.834 billion rubles. and the total volume of production of equipment for AES IRB for 12 years – 4.931 trillion. rub.

3. The specification, installation, adjustment and periodic inspection of 10 million houses over 12 years in 85 subjects will require 1031.3 billion rubles, and the annual volume of branches/plots of one PPP enterprise will be 1.45 billion rubles.

To organize these PPP enterprises in the constituent entities of the Russian Federation, we will use the competition under Decree of the Government of the Russian Federation No. 218 [56]. This will make it possible to receive 245 million rubles in each region within 3 years. state loans and another 245 million rubles. attract through an interest-free bank loan, which each newly created PPP enterprise will repay within a few years.

Thus, the total amount for the creation and equipping of 85 PPP enterprises in the constituent entities of the Russian Federation with the necessary technological equipment, i.e. for 85 PPP projects, will amount to 41.65 billion rubles.

Assuming that these enterprises will produce high-tech products, we calculate their number, by analogy with domestic achievements for 2020, recorded by the Decree of the Government of the Russian Federation [58], i.e. based on the volume of output of 4.8 million rubles. for one high-tech workplace, the average annual number of one PPP enterprise will be 1,007 specialists (4.834 billion rubles / 4.8 million rubles). Taking into account the 3-shift mode of operation and the minimum size of the engineering and management staff (47 employees), it is possible to organize 24 integrated teams of 40 people each (an average of 5 specialists for one of the eight types of AES IRB equipment). At the same time, the average annual number of its branches/plots, whose design and installation activities are also considered high-tech, will average 302 specialists (1.45 billion rubles/4.8 million rubles), i.e. from 5 to 10 staff posi-

tions, on average, for one branch / site in the subject of the Russian Federation.

Thus, the total number of high-tech jobs in 85 constituent entities of the Russian Federation will amount to 111,265 staff positions.

By the end of the implementation of AES IRB, the Government of the Russian Federation should prepare and submit to the State Duma of the Russian Federation a draft law “On fire and energy taxation of the residential sector”, in order to ensure the probability of life safety in the “rest of the residential sector” is not higher than 0.999999 [20, 59].

Similarly, it is possible to estimate the volumes for equipping the AES IRB of the “remaining” 40 million garden houses and households, which can be mastered faster if PPP enterprises of the constituent entities of the Russian Federation are enlarged.

Thus, putting into production domestic innovations in the field of “so-called renewable energy sources” (“Shukhov’s” wind turbines, atmospheric water generators, solar panels, hydropanels, etc.) may will stop the “total gasification” of rural settlements than “save hundreds of billions of rubles” and drastically reduce the fire and explosion hazard of the residential sector, as well as more economically than abroad, implement decentralized resource supply in Russia for more than 10 million individual houses and about 40 million country houses, thereby determining – “the true place of alternative energy” in the structure of the Russian systems of electricity, gas, water and heat supply.

CONCLUSION

An analysis of the directions and rates of development in the world, “the so-called renewable energy sources”, showed that these installations are unstable, low concentrated and periodic sources, and therefore, their unsystematic use is a serious mistake of scientists, specialists and politicians. Based on the analysis of engineering systems of multi-apartment residential buildings and individual residential buildings, as well as fire, energy and environmental damage resulting from their operation, nanotechnologies and Russian patents are proposed that implement “nature-like technologies” that allow solving the problems of autonomous electricity, water, heat supply of individual residential buildings. It is shown that the integration of “Shukhovskaya” and vortex wind turbines, domestic hydropanels and solar panels make it possible to create a replicable autonomous engineering system for individual residential buildings (AES IRB).

Due to the duplication and tripling of AES IRB can provide individual residential buildings with electricity, water and heat with quality, reliability and safety parameters that are several orders of magnitude higher than the existing centralized resource supply systems for cities

and towns, than to create fire-explosion-safe conditions for the life of the population in accordance with GOST 12.1.004.

Mass alternative energy in Russia is indeed possible and effective, but only in the residential sector, so it is advisable to continue research in the direction of “replicating AES IRB” for multi-apartment residential buildings, thereby increasing their efficiency by reducing about

70% of socio-economic losses from annual fires, as well as explosions, when using household gas.

Subject to reasonable state support, it is possible to successfully develop alternative energy in promising regions of Russia – in Siberia and the Far East, for example, as part of the “Far Eastern hectare”, as well as in the use of AES IRB for life support of remote and hard-to-reach objects.

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Belozero V.V. – general scientific guidance; analytical review of “nature-like approaches”, including the results of own research; adaptation of the retroforecast method to RES; conclusions.

Nikulin M.A. – adaptation of methods and models of “fire and energy damage” for the residential sector and patents for them to AES IRB; participation in the modeling of costs for AES IRB and in calculations using the retroforecast method.

Belozero V.V. – participation in the simulation of SAES IRB; development of the structure and design, installation and commissioning functions of the branches of PPP enterprises; participation in calculations and design of sections.

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