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Scientific Foundations of the Methodology of Using Water Resources in Economic and Other Activities

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Abstract: Planet Earth, orbiting the Sun after Mercury and Venus at a distance of 149.6 million km from the star, the primary source of Energy, is a giant vessel of water, within which every living organism of the flora and fauna also constitute vessels of water, determining the combination of the world and life on Earth. Under the influence of economic and other activities, the total volume of water on planet Earth does not change, but its qualitative composition does. Based on the unity of the actions of Nature and the economic and other activities connected to the use of water resources, the quantitative and qualitative indicators of which are formed within the spatial limits of river basin geosystems, the scientific foundations of the energy-entropy methodology for using water resources in economic and other activities are considered using the examples of the Kuban, Terek and Lower Don rivers. Problem statement. In economic activities connected to the use of water resources, the conceptual model is the natural-technical systems (NTS) of "Natural Environment-Object of Activity-Population" ("N.E.-O.A.-P."), in which "N.E.", "O.A." and residents "P." are in interconnection, interaction, relationship (IIR) in the zones of influence of "O.A.". The theoretical and methodological basis of such systems are the fundamental concepts of matter, energy, entropy, and time. The difference between "useful" exchange of energy and "dissipative" energy determines the fundamental concept of entropy, introduced by Clausius in 1854. The problem of entropy in the use of water resources is poorly studied.

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1 INTRODUCTION

The methodology (from “method” and “logy”) of using water resources in practically all branches of economic and other activities sets conditions for the study of the processes of formation within the spatial limits of river basin geosystems, the structural organization of methods, constructive technologies, and means of activity. Methodology, as a scientific understanding of the processes of formation of water resources within the spatial limits of river basin geosystems and their intra-basin or inter-basin regulation for the purposes of practical use in various technological processes, sets conditions for the creation of natural-technical systems of the «N.E.-O.A.-P.» NTS, which include a natural component ("N.E.") in the form of the natural environment of the river basin geosystem, where quantitative and qualitative indicators of water resources are formed under the influence of continuous flows of Energy coming from the primary source of Energy on Earth, the Sun (99.98%) (Bondarenko, Volosukhin, Ylyasov, Semyonova, Shtavdaker, 2021); a technogenic component ("O.A.") in the form of an "Object of Activity", which includes a system of various types of hydraulic structures (SHS), providing regulation of water flow, select estimates of water flow rates of the object (river, reservoir), and transportation to water users and water consumers, the social component "Population" ("P.") living in the zones of “O.A." influence on the catchment area (Khetsuriani, Khetsuriani, Bondarenko, Ilyasov, Semenova, 2020; Ged,1990).

2 MATERIALS AND METHODS

There are many forms of motion and interaction of matter, therefore Energy, as a generalized measure of the motion of matter and Entropy, as a measure of the dispersion of Energy, are properties of matter and cannot be identified with it or separated from it. Based on this, the doctrine of Energy and Entropy is developing in the most important area of economic and other activities in the use of water resources.

In the general body of scientific knowledge, the methodology of water resources use has two bases as its source. Firstly, scientific knowledge comprehends increasingly complex objects of activity in the natural environment in various climate conditions, which leads to an increase in the level of cognitive activity. Secondly, the complex studies of river basin geosystems that are being conducted form the necessary standard form of results of systemic complex environmental monitoring (SCEM) (Budyko, Drozdov, 1950).

In the global system of "Nature-Society-Man", the 4 most important problems of our time have formed in a cause-and-effect relationship: Energy, Water, Food, Ecology, where water resources are second place in terms of importance, and require fundamentally new methodological approaches taking into account their limitations in the limited conditions of the current types of economic and other activities. In the example of river basins of the geosystems of the Southern Federal District, North Caucasian Federal District, the Kuban, Terek, Lower Don rivers as elements of the Earth's biosphere, in which about 50 thousand km^3 are formed annually, the limited nature of water resources is determined by global hydrological processes in conjunction with basins at higher hierarchical levels of the composition of the Earth's biosphere, the volume of which is 10^{10} km^3 (Odum, 1987; Bondarenko, 2010).

Modern methodological approaches to the use of water resources in theoretical and practical terms, as shown by the results of many years of research, are associated with new technical solutions, tactical and strategic thinking. In the formation of scientific thought in the methodology of using water resources, the important system concepts are those that reflect the essential properties, connections and interactions of components with the elements included in them in their contradiction and development as part of the existing or created NTS "N.E.-O.A.-P.” A concept is a thought or a system of thoughts in the methodology in question that acquires real thought development, which is practically the basis of the methodology of using water resources. It should be noted that all types of natural water forms in the Earth's biosphere are interconnected by the processes of the global hydrological cycle in a volume of 577 km^3, which consumes about 3600 TW of solar energy (Vernadsky, 1988; Denisov, Zimenko, Kohanov, 2014).

Based on the results of the SCEM of the existing NTS "N.E.-O.A.-P.” (Denisov, Zimenko, Kohanov, 2014) on the river basin geosystems of the Kuban, Terek and Lower Don rivers, the development of the methodology for the use of water resources, as established, is based on a systems approach, where "The whole determines the nature of the parts, and the parts cannot be cognized when considered outside the whole and are in constant interconnection, interaction and relationship." By nature, IIR between the components and the elements included in them in the composition of the existing NTS "N.E.-O.A.-P.” within the spatial limits of river basin geosystems are

open to the higher basin geosystems, in which the input and output of flows of matter, energy and information (MEI) constantly occurs. (Fig. 1, 2, 3, 4) (Denisov, Zimenko, Kohanov, 2014).

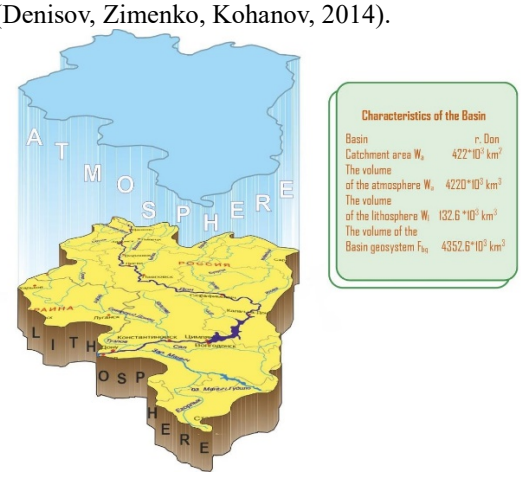

Figure 1: Basin geosystem of the Don River.

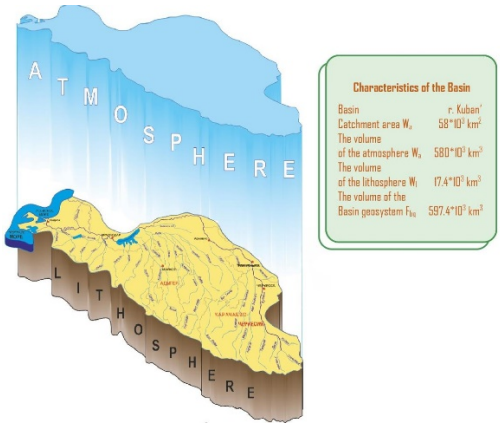

Figure 2: Kuban basin geosystems.

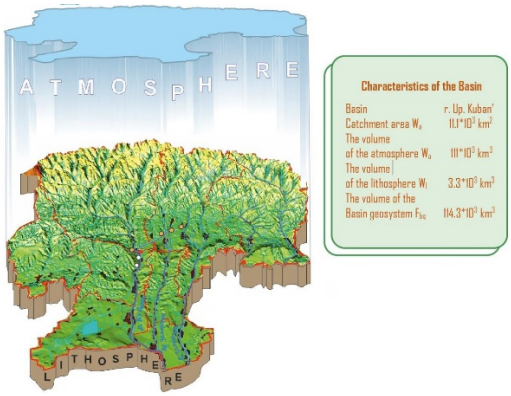

Figure 3: Upper Kuban basin geosystem.

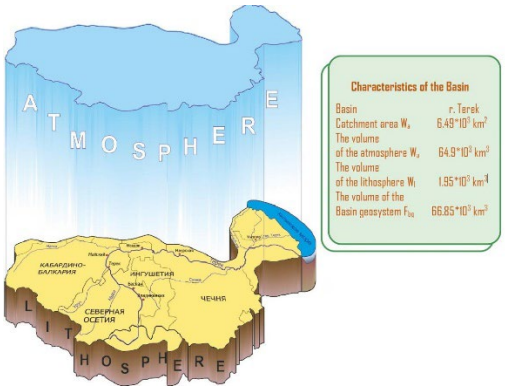

Figure 4: Basin geosystem of the Terek River.

In scientific terms, the use of water resources sets conditions for a dialogue with the natural environment, but what makes this dialogue possible?

In an objective consideration of the spatial limits of both the river basin geosystem and the basin geosystems at higher hierarchical levels, recognizing that the processes of interaction between natural elements in the "N.E." that occur in them are reversible in time would be unidentifiable, since the "N.E." affects us and our measuring instruments create differences between the past and the future (Kuznetsov, Kuznetsov, Bolshakov, 2000; Moiseev, 1992).

The progress of human thought is at the root of the problem: the denial of what is commonly called the Arrow of Time. As such, at the level of engineering sciences, hydraulics, hydrotechnics, ecology, etc. the past and the future play different roles. In economic activities using water resources, irreversibility leads to many new phenomena in the "N.E." elements within the river hydrographic network of the basin geosystem, where quantitative and qualitative indicators of water resources, altered channel processes, vital activity of ichthyofauna and flora are formed, each of which illustrates the constructive role of the Arrow of Time (Moiseev, 1992). Irreversibility in the observed phenomena of the river basin geosystem in the use of water resources in the river basins of the Kuban, Terek, and Don rivers, as established by long-term observations, leads to coherence, to new phenomena and effects covering almost the entire hydrographic river network in basin geosystems, which introduces the phenomenon of "irreversibility" into the symmetrical in time local part of the Earth's biosphere (Nikolis, Prigozhin, 1990; Nikolis, Prigozhin, 1979).

In nature, there are both reversible and irreversible processes in time (Nikolis, Prigozhin, 1979; Prigozhin, Stengers, 1986), but it should be noted that

irreversible processes are the rule, and reversible ones are the exception [m]. The distinction between reversible and irreversible processes entered natural science through the concept of Entropy connected with the second law of thermodynamics. The concept of Entropy was introduced by Rudolf Julius Clausius in 1865. According to the second law of thermodynamics, irreversible processes produce Entropy, but reversible processes do not decrease it. According to Clausius's formulation: "The energy of the world is constant, and the Entropy of the world increases."

3 RESULTS AND DISCUSSION

Irreversible processes associated with the Arrow of Time play an important fundamental constructive role in the use of water resources within the basin or inter-basin regulation of water flow within river basin geosystems, affecting significant spatial limits of the "N.E." (Fig. 1-4). Violation of natural symmetry within the spatial limits of a river basin geosystem results from the static and geometric view of space, according to which the properties of the space in question are determined by events, such as regulation or redistribution of water flow within the river hydrographic network. This kind of transition of the natural regime of the river hydrographic network leads to complex management of water flow, which provides order to a certain extent. A typical example can be the management of the passage of flood discharges in the calculated sections of the riverbed (Prigozhin, Stengers, 1986).

The concepts of complexity, coherence and order are fundamental in the current «N.E.-O.A.-P.» NTS Time coherence in the «N.E.-O.A.-P.» NTS is a constant relationship in time in the IIR processes between the components and the elements included in them when using water resources.

Since the 1960s, observations have led to the conclusion that the climate on Earth can exhibit internal variability, and human economic activity has an integral impact on the functioning of the global climate system, in which river basin geosystems are integral functional elements of “N.E.” (Nikolis, Prigozhin, 1979; Rumyantsev, Kromer, 2003).

In the modern climate system of the Earth, as it has been established, water resources, which occupy about 70% of the Earth’s surface, play an important role (land occupies 30%). In the global moisture cycle, 458 million km^3 of water evaporates from the World Ocean, and 149 million km^3 evaporates from continental land. Land rivers carry water runoff of about 45.8 thousand km^3, and 44.7 thousand km^3 is discharged into the World Ocean. 1.1 thousand km^3 is lost during transportation (Kuznetsov, Kuznetsov, Bolshakov, 2000). In methodological terms, it is important to note that all the Water in the Solar System originates from a giant primordial cloud consisting of gas and dust that abruptly contracted more than 4 billion years ago, forming the Sun and the planets of the Solar System ("In the World of Science" Magazine, No. 6, p. 46-47, 2015).

In the methodology of cognition of the targeted use of water resources as a special type among multifaceted types of economic and other activities, and in scientific and practical terms, the important system concepts are those that reflect the essential properties in the processes of IIR between components and the elements included in them as part of the current «N.E.-O.A.-P.» NTS, providing intra-basin or inter-basin regulation of water flow (surface or underground), and selection of estimated expenditure (Q m^3/s) of water for the purposes of consumption and use. Thus, the concept of Thought (or system of thoughts), generalizing and highlighting the elements essential to the system components: "N.E.", "O.A.", "P." The concept acquires its real thought form in development as part of the methodology considered. One of the features of the formation of scientific thought in the methodology considered are the basic concepts as a universal measure of forms of movement and interaction of matter: Energy and its integral Entropy, Time, Arrow of Time, system, systemic approach, integrity, development, and a number of other important concepts: reversibility, complexity, structure, self-organization, environmental acceptability, environmental safety, the “dominant role of the whole", natural and man-made components (Moiseev, 1992; Tyurina, Basilaia, 2014).

In the methodology of water resources use, an important systemic principle associated with structure, hierarchy, and plurality is the "dominant role of the whole", which makes it possible to manage processes between the natural "N.E.", technogenic "O.A.", and social "P." components with the elements included in them, respectively: soil cover with underlying rocks, upper layers of the lithosphere, surface layers of the atmosphere, flora and fauna within the hydrographic river network; a system of hydraulic structures (SHS), associated knowledge, service roads, etc.; the population living in the "O.A." influence zones. " In methodological terms, the systemic principle of "integrity” refers to the irreducibility of the properties of the whole in the form of the system considered to the sum of

properties of the constituent elements in the components of the system. Important concepts relate to the regulation of water runoff within the catchment area of the river basin geosystem, where a system of hydraulic structures in the form of "O.A." with its constituent elements and the social component "P." in the form of the population living in the zones of "O.A." influence are located. As such, the concept of "complexity" in the methodology of water resources use to a significant extent, as evidenced by the results of the SCEM of the Upper Kuban river basin, affects the evolutionary processes of the formation of the hydrographic network, river ichthyofauna, exogenous processes, etc. to a certain extent.

It has been established that in the cognition of complex ideas when using water resources, unstable processes can be observed in the movement of MEI flows in the life activity of biota, the usage of "O.A." during periods of flood discharges, etc. It is worth noting that the concepts of complexity, order, and coherence in the methodology of using water resources are fundamental. The coherence of the «N.E.-O.A.-P.» NTS is characterized by a constant in time relationship between the elements in the composition of the natural "N.E.", technogenic "O.A." and social "P." components in the processes of water use and consumption of water resources. The violation of natural symmetry within the spatial limits of a river basin geosystem leads from a static and geometric concept of space to Aristotelian views, according to which the properties of the space in question are determined by events. For example, the regulation of water flow within the catchment area of a river hydrographic network, which leads to complex management of water flow, which to a certain extent conditions order (Nikolis, Prigozhin, 1979; Tyurina, Basilaia, 2014).

In the use of water resources, irreversible processes play a fundamental constructive role in the natural component of the “N.E.” river basin geosystem.

Irreversibility processes in the formation of water flow (surface or underground) within the spatial limits of the river basin geosystem is conditioned by the use of part of the water resources in technological processes of water consumers (water supply, irrigation, etc.) and water users (hydroelectric power plants, pumped storage power plants, thermal power plants, nuclear power plants) by creating a system of hydraulic structures (SHS) in the form of "O.A." for regulating water flow. The constructive role of irreversibility is determined by the coherence in the processes of IIR between the components and the elements within them in the composition of the «N.E.-O.A.-P.» NTS.

The distinction between reversible and irreversible processes came through the concept of Entropy, related to the second law of thermodynamics, which was defined by Clausius in 1865. Irreversible processes produce Entropy, while reversible processes leave Entropy constant (Tyurina, Basilaia, 2014).

It is worth noting that the first attempts to scientifically define the concepts of Energy and Entropy were undertaken about 120 years ago. The concepts of "Energy", "Entropy" and the related concepts of "force", "work of force", "impulse of force" (quality of movement) are inseparably interconnected with economic and other activities related to the use of water resources (Rumyantsev, Kromer, 2003; Tyurina, Basilaia, 2014).

Results. **Energy** and Entropy are words of Greek origin. "En" means "in" or "content", "erg" is the root of the word "work", and "trope" is "transformation". Therefore, it can be said that the change in Entropy characterizes the amount of "dispersion" of Energy in the processes of mutual transformation of its types. There are two ways of transferring Energy: doing work and heat exchange. The change in Energy in the system considered is determined only by the difference in its values in the initial and final states of the transition. Of all known properties of bodies, Entropy is the only physical quantity that unambiguously changes over time from the past to the future. In economic activity, air and water resources are of great importance within the spatial limits of river basin geosystems, where negentropy is produced in the form of food and raw materials (Semenova, Bondarenko, Khetsuriani, Shtavdaker, 2020).

In the development of the methodology for the use of water resources by creating the class of «N.E.-O.A.-P.» NTS, an important concept is their integrity, which determines the "dominant role of the whole" over the parts over the natural "N.E.", man-made "O.A." and social "P." components with the elements included in them.

The methodology of water resources use is based on general scientific and technical concepts. Thus, the concept of "System" is a composition of components, "N.E.", "O.A.", and "P.", with the elements included in them in the IIR processes ensure the use of water resources, which defines the class of «N.E.-O.A.-P.» NTS In a generalized sense, «N.E.-O.A.-P.» NTS is an intra-system regulated set of elements in interconnection within the components of the system. At the operating «N.E.-O.A.-P.» NTS during the

transition from the state to the flood patterns under the influence of solar energy flows that form an increase in water flow (Q m^3/s) in the channels of the river hydrographic network, flood water flow regulation occurs through the operating system of hydraulic structures as part of the technogenic component "O.A." In the methodology of water resources use in systemic consideration, integrity is an important concept.

The systemic principle of “integrity” in methodological terms refers to the irreducibility of the properties of a whole in the form of the system considered to the sum of properties that make up the elements within the components of the system.

A number of systemic functional indicators, as established by research on the river basin geosystems of the Kuban, Terek and Lower Don rivers, determines the systemic integrity of the operating «N.E.-O.A.-P.» NTS:

- demand for the use of water resources in economic and other sectors of activity;

-openness to the surrounding external environment within the considered river basin geosystem;

- processes of self-organization;

-reflection of objective reality during the components’ functioning in the «N.E.-O.A.-P.» NTS;

- ecological acceptability "O.A." as part of the current «N.E.-O.A.-P.» NTS.

The reflection of objective reality when functioning as part of the natural “N.E.” and social “P.” components is manifested in the processes of the IIR as part of the «N.E.-O.A.-P.» NTS

The demand for “O.A.” as part of the «N.E.-O.A.-P.» NTS, for instance, of the Upper Kuban river basin geosystem is determined, on the one hand, by the environmental acceptability for “N.E.” in its zones of influence, and on the other hand, by the needs of the social component for electricity and water supply in populated areas of the zone of “O.A.” influence (Rumyantsev, Kromer, 2003).

The ecological acceptability of the "O.A." depends on the perfection of the structural elements in the man-made component, particularly at water intake structures, and the dominance of natural transformation processes in the natural component of the "N.E." and, consequentially, a decrease in the growth rate of the Entropy level in space and time of the zones of "O.A." influence.

The changes introduced into the natural flow of MEI in space and time of the river basin geosystem condition the processes of self-organization between the components of the «N.E.-O.A.-P.» NTS

The term “self-organizing system” was introduced by the English scientist W.R. Ashby (1947).

In a general sense, self-organization of a system should be understood as a process during which the organization of a complex dynamic system is created, reproduced, or improved. Self-organization processes can only take place in systems with a high level of complexity and a large number of elements, the connections between which are not rigid, but probabilistic in nature. Self-organization processes occur due to existing and the formation of new connections between elements of the system. The distinctive feature of self-organization processes is their purposeful, but at the same time natural spontaneous nature. These processes occur during the interaction of the system with the environment.

Based on the results obtained from SCEM of the processes of functioning of technogenic components in the composition of the current «N.E.-O.A.-P.» NTS within the spatial limits of the river basin geosystems of the Kuban, Terek, and Lower Don rivers (Fig. 1-4). The changes introduced in space and time set conditions for the probabilistic nature of the formation of new, and the use of existing relationships between components with the elements included in them, conditioning a natural and purposeful process of self-organization (Rumyantsev, Kromer, 2003).

In methodological terms, three types of self-organization processes have been established:

- the spontaneous generation of an organization with the emergence of a certain hierarchical level of a set of integral objects of a certain hierarchical level, for example, the Tsimlyansk hydroelectric complex, the Don main canal, etc.;

- these are processes that ensure a certain level of organization when external and internal conditions change, functioning in the current “O.D.”;

- the third type of self-organization processes is associated with the improvement of structural elements in the composition of the "OD", for example, fish protection devices (FPD) at water intake structures.

A typical example in the Upper Kuban river basin geosystem is the KGTS for the use of water resources for the generation of electric energy, irrigation of the territories of the Stavropol Territory and water supply of cities and towns, development of land reclamation and other economic purposes.

PTS "P.S.-O.D.-N.", as a self-organizing system within the spatial limits of a river basin geosystem, in which adaptation to natural environmental conditions is achieved by changing the structure of the natural environment in the processes of VVV between biotic

and abiotic elements of the "P.S.", as well as elements of the social component "N."

The interactions between the components and the elements that comprise them in the PTS "P.S.-O.D.-N." form its spatial structure, which is determined by the nature of the location of the components within the hydrographic network of the river basin geosystem. Based on the energy-entropy approach, in the study of the PTS "P.S.-O.D.-N." the process of self-organization, as established, contributes to the ordering and complication of the current interactions between the components and the elements that comprise them, which contributes to a decrease in the rate of growth of Entropy and an increase in the efficiency in the use of the free part of Energy (Esvb). Along with the processes of ordering and complication of the current processes of interactions between the components of the PTS "P.S.-O.D.-N." important aspects are the ongoing transformations in "P.S." (in the surface layers of the atmosphere above reservoirs and open sections of water-carrying main channels, in the hydrosphere of the river hydrographic network, in the upper layers of the lithosphere under the influence of filtration processes from reservoirs, pressure front structures, water-carrying channels, irrigated lands, soil cover with underlying rocks, etc.) in active and low-active zones of influence of "O.D." within the river basin geosystem. The ongoing transformations in "P.S." are associated with the influx from the external environment in relation to the spatial limits of the river basin geosystem of matter flows in the form of atmospheric precipitation and energy coming from the primary source in the form of solar radiation.

For the considered river basin geosystems, as elementary parts of the Earth's biosphere, the concept of Energy, as a generalized measure of matter movement in the form of moisture circulation in the plant and animal world in natural and man-made technological processes under the influence of continuous flows of solar Energy and its integral figurative shadow - Entropy, as a measure of Energy dispersion, is a property of matter. In the energy-entropy approach at the existing PTS "P.S.-O.D.-N." an important conclusion is that the quantitative measure of low-quality Energy in the form of the bound part of Energy (Esvz), which is formed in the process of converting the total energy (Epol) at the input to the system into various forms (mechanical, chemical, thermal, etc.) of Energy, of which only the free part of high-quality Energy (Esvb) is capable of performing certain types of work. Natural environment of the "P.S." as part of the current PTS "P.S.-O.D.-N." is an important thermodynamic characteristic that creates and maintains internal order with a natural level of Entropy.

Entropy characterizes the magnitude of the dissipation of Energy in the process of mutual transformations of its types, in the system under consideration, for example, PTS “P.S.-O.D.-N.”, and in the structural interaction within this system it tends to reduce the growth rate, which was proven by I. Prigogine (Sedov, 1982).

Based on the thermodynamic specificity, that in any Universe with natural changes Entropy increases, and with unnatural changes in space and time of the river basin geosystem the growth of the Entropy level decreases, which reflects the second law of thermodynamics, the formulation of Claudius.

By Energy, we should understand the processes of the VVV "O.D." with "P.S." and the resident "N." in the zones of influence of "O.D." as part of the PTS "P.S.-O.D.-N." The integral relationship of the concepts of Energy and Entropy in technological processes of water resources use, as an important factor associated with the assessment of the energy state at the existing PTS "P.S.-O.D.-N." within the spatial limits of river basin geosystems, as elements in the Earth's biosphere, where water resources are formed due to solar Energy flows, are considered as small "universes". Based on the thermodynamic specifics, in any Universe, with natural changes, Entropy increases, and with unnatural changes in space and time of the river basin geosystem, the growth of the Entropy level decreases, which reflects the second law of thermodynamics in the formulations of Claudius (Rumyantsev, Kromer, 2003).

The change in the Energy of the system is determined only by the difference in its values in the initial and final states of the transition, otherwise the system would become a source of Energy "out of nothing", which contradicts the law of conservation of Energy. Entropy is a function of the state of the system, but the amount of heat $Q = \int TdS$, expressing the "loss" of Energy, depends on the nature of the process taking place, since both the amount of heat dissipated due to direct heat exchange of the system with the environment and the amount of heat released and dissipated due to transformations of Energy forms in the system depend on it. Therefore, in reality, the work obtained also depends on the nature of the process and is never equal to the maximum, that is, the change in the Energy of the system. It is less than the latter by the amount of Energy loss "through heat" due to friction and heat exchange, etc. But that part of the Energy that is spent on performing work is then dissipated in the environment due to friction and heat

exchange, further increasing its Entropy. Thus, for example, all the energy of gasoline, which is converted into heat in a car engine, and then into mechanical energy, is ultimately dissipated into the atmosphere as a result of friction of the body against the air and its wheels against the ground and road surface (Sedov, 1982).

It is common knowledge that matter exists in time and space. Time expresses the sequence of existence of objects replacing each other, which has only one dimension. Space characterizes the order of the arrangement of simultaneously coexisting objects and has three dimensions - along three coordinate axes.

The march of the queen of the world Energy and its figurative shadow – Entropy at the present stage of development of the global system "Nature-Society-Man" and, accordingly, water management science on the use of water resources is becoming more intensive and all-pervasive in the life of the population living within the river basin geosystems, where quantitative and qualitative indicators of water resources are formed, which are used in almost all sectors of economic and other activities to ensure the objective growth of energy and food resources, both at the local and regional and state levels. Of great importance, as evidenced by modern realities, are the resources of air and water? Oxygen and nitrogen are in continuous circulation. The plant and animal world provides food (energy and negentropy) and raw materials.

Entropy has the property of always changing in one direction, that is, of always being irreversible. When Claudius announced this irreversibility of Entropy, he attributed this property, which until then had been considered as inherent only in time.

The concept of Entropy plays an important role in two aspects. The first aspect concerns the connection between Entropy and what Eddington calls the "arrow of time". The second aspect determines the connections between Entropy and "becoming". Based on this concept of Entropy according to Eddington, it introduces a direction into our world in which new areas of knowledge are opened, related to the organization and emergence of the direction of the flow of time and the difference between emergence and disappearance, when it becomes possible to distinguish between the past and the future in the study of the contribution of chance to the state of the space under consideration, for example, a river basin geosystem. The increase in the contribution in the form of "O.D." determines the direction of the "arrow of time" with an increase in irreversibility. The practical measure of this contribution to the spatial limits of the river basin geosystem in the form of a new order on the hydrographic network, where the regulation of water flow and the selection of estimated costs (Q m3 / s) in technological systems of water use and water consumption occurs is Entropy, and the "arrow of time" determines its property.

Entropy system is inherently connected with the energy state. In general, Entropy (S) reflects the ratio of the amount of heat (Q) communicated to the system to the temperature (T) that the system has:

$$dS = \frac{dQ}{dT} \quad (1)$$

For example, one liter of hot water has a higher Entropy value than one liter of cold water.

From equation (1) it follows that the higher the value (T), the value of Entropy will be low, and its quality high, and vice versa, if the Energy of the system is stored at a lower temperature (T), then the value of Entropy will be higher, and its quality lower. Consequently, Entropy characterizes the conditions of storage and storage of Energy in the system.

Entropy characterizes the direction of the processes occurring in the system – reversible and irreversible.

The change in entropy in none-equilibrium systems, which include river basin geosystems, is determined by the Ilya Prigogine equation (Semenova, Bondarenko, Khetsuriani, Shtavdaker, 2020):

$$\frac{dS}{dt} = \frac{deS}{dt} + \frac{diS}{dt}, \quad (2)$$

Where is the total change in Entropy in the system over a period caused by irreversible processes within the system?$dSdt$

Change in Entropy caused by irreversible processes within the system under consideration or by the production of Entropy;diS

deS– Entropy imported from the surrounding external environment. According to the second law of thermodynamics, diS is always positive; deS can be both positive and negative.

In the natural environment ("P.S.") Entropy always tends to grow, but at the same time the "quality" of Energy deteriorates, which is important to take into account in the assessment of the "O.D." on the environment of the river basin geosystem.

According to the second law of thermodynamics, Energy constantly tends to dissipate, moving towards chaos and, accordingly, is accompanied by an increase in Entropy as a measure of disorder, chaos. Energy in the ordered movement of a water flow has a high quality, for example, at a hydroelectric power station in the process of converting the potential

Energy of a water flow into an electrical form of Energy.

With regard to the river basin geosystems under consideration, within the spatial limits of which multifaceted types of economic and other activities are carried out, the change in Entropy in the form of the bound part of energy (Esvz) in the balance ratio of the free part of Energy (Esvb) as part of the total energy (Epol) at the input to the system under consideration (Fig. 5):

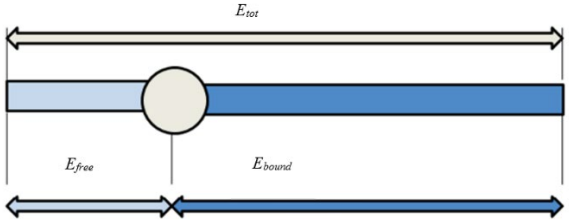

Figure 5: Energy balance diagram in the system.

The qualitative characteristics of the state of both individual structural formations and the system under consideration as a whole are determined by the balance of the ratios of the free (Esvb) and connected (Esvz) parts of energy, and the functional efficiency is determined by the efficiency coefficient (, determined by the expressionη)

$$\eta = \mathrm{E_{свб}}/\mathrm{E_{пол}} \leq 1 \quad (3)$$

Entropy, as a physical quantity is not measured, but calculated. Based on the current concept of Entropy, a real opportunity arises in the formation of the systemic essence of the functioning of the PTS "P.S.-O.D.-N." within the spatial limits of the river basin geosystem, as an element in the global moisture cycle associated with the use of water resources and protection from the negative impacts of natural waters.

The connection between the law of increasing entropy and the direction of time is important.

Of all the known properties of bodies, entropy is the only physical quantity that unambiguously changes with time in open systems (for example, in living organisms) and in the microworld processes with a decrease in entropy are possible, and time here also changes irreversibly from the past to the future. All these processes occur in time. Consequently, the growth of entropy cannot be considered the cause of the irreversibility of time.

Entropy— is just a particular property of the system, and time is just a particular property of matter.

Low Entropy is achieved by constant and efficient dissipation of easily used Energy, such as food, evaporation from water surfaces, etc., and by improving the structural elements in the "O.D."

The energy received in the form of solar radiation (light) within the boundaries of the catchment area of the hydrographic river network is balanced by the energy emitted from this surface in the form of thermal radiation.

The amount of Energy in any form is always proportional to the amount of the form of Energy into which it is converted. The growth of the Entropy level within the zones of influence of the "O.D." is determined by individual structural elements of the water intake structure, for example, the RZU, water filtration at individual "O.D." structures, processing of the banks and the riverbed, etc.

The quality of Energy is measured by its quantity, which it uses when converting into other forms of Energy, for example, the potential Energy of a water flow into electrical energy (cold water takes heat from the operating devices and mechanisms of thermal and nuclear power plants, thereby increasing the efficiency of the fuel used (coal, gas, etc.) when generating electricity.

The accumulated flow of connected Energy (Esvz), for example, in a section of a river basin geosystem during the execution of channel works or in a structural element of a water intake structure determines the level of its imperfection and, accordingly, the rate of growth of Entropy, which ensures a decrease in the level of quality Energy (Esvb), which is used to perform a certain functional work (Af), for example, to reduce filtration losses in water-transporting channels.

It has been established that Entropy in the considered PTS "P.S.-O.D.-N." reflects the level of perfection of the used structural elements in the "O.D.", for example, at the water intake structure to ensure the protection from the ingress of living matter in the form of ichthyofauna (fish, microorganisms, etc.) into the technological processes of water consumption or water use.

Based on the basic principle of the "leading role of the whole" in the processes of water-water balance between the system components ("P.S.", "O.D.", "N.") with the elements included in them, in which: - the "natural component" in the "P.S." is formed by the processes of global water cycle, the vital activity of flora and fauna within the spatial limits of the considered river basin geosystem; the "technogenic component" is a complex of hydraulic structures, associated buildings and service roads in the "O.D." The "technogenic component" in the "leading role of the whole" is completely dependent on the functional, design characteristics of the "O.D." and the level of

its environmental acceptability in the processes of water-water balance with the natural component of the "P.S." with its constituent elements in the form of flora and fauna, microorganisms, providing biodiversity in the zones of influence of "O.D.", and in the energy-entropic consideration it is a converter of solar energy into organic matter, being at the same time an elementary link in the cause-and-effect chain of movement of flows of VEI, which determine the processes of production of the free part of Energy (Esvb), which is capable of producing work, providing systemic equilibrium and, accordingly, the processes of life activity and development of living matter within the spatial limits of the river basin geosystem. The results of long-term studies of the assessment of environmental acceptability at existing water intake structures, irrigation systems, and technological water supply of hydroelectric power plants, pumped storage power plants, thermal power plants, etc. with a capacity of 50 m3 / s revealed a low level of environmental acceptability, for example, at fish protection devices RZU.

Energy, as a general measure of the movement and interaction of matter, the change of which is determined by the difference in its values in the initial and final state of transition and Entropy, as a measure of the dispersion of Energy, are properties of matter and can neither be identified with it nor separated from it. On this basis of the doctrine of Energy and Entropy, as a particular property of matter, a methodology for the use of water resources in economic and other activities is created.

Within the spatial limits of a river basin geosystem, where quantitative and qualitative indicators of water resources are formed, according to the second law of thermodynamics, Energy constantly tends to dissipate, moving to chaos and, accordingly, to an increase in Entropy, as a measure of disorder and chaos and, accordingly, to a decrease in the quality of Energy. The relationship between the concepts of Energy and Entropy occurs in the processes of using water resources, the quantitative and qualitative indicators of which are formed in space and time of river basin geosystems under continuous flows of solar Energy.

The concept of Entropy, as a particular property of matter, from the energy point of view, determines a certain part of Energy (Esvb) from the total (Epol) at the input to the system under consideration (Fig. 5), which comes from the primary source - the Sun to the spatial limits of the river basin geosystem, in which the energy balance of Energy is represented as the sum of the free part of Energy (Esvb), used in the performance of various types of work (A) and the bound part of Energy (Esvz) of low quality, incapable of performing the necessary types of work and determining Entropy. The accumulated flow of the bound part of Energy (Esvz) in the system under consideration, for example, on a section of the river basin geosystem or in the structural elements of water intake, water transportation and other types of structures determines the level of imperfection and, accordingly, the rate of growth of Entropy and a decrease in the level of the free part of Energy (Esvb) when performing functional types of work. Therefore, it can be concluded that the Entropy of the operating "OD" as part of the PTS "PS-OD-N" reflects the level of perfection of the used designs of hydraulic structures and the functional elements included in them as part of the "OD", as established by research, determines their environmental acceptability as an important factor in ensuring environmental safety (ES).

Therefore, it is possible to make an important conclusion that Entropy, as an integral shadow of Energy, which is used in the creation and operation of "OD" as part of the PTS "PS-OD-N." manifests itself at all stages of the creation and further operation of these systems associated with the use of water resources in multifaceted types of economic and other activities:

- engineering and environmental surveys at the preliminary decision-making stage;
- design of a complex of hydraulic structures (CHS) as part of the “OD”, associated buildings, service roads, etc.;
- implementation of a set of environmental monitoring in the zones of influence of "OD" during the operation of the water management facility.

4 CONCLUSION

1. The modern scientific and practical problem of Entropy in one of the most important branches of economic and other activities on the use of water resources has occupied a special place since the introduction of the concept of Entropy into science by Claudius in 1864.

2. From an energy point of view, the concept of Entropy determines a certain part of the total Energy (Epol), which comes to the earth's surface from the primary source of all Energy on Earth (99.98%) and provides global moisture circulation in the volume of 577 thousand km3.

3. Entropy, as an integral and important component in the processes of using water resources in almost all sectors of economic activity, as a natural

component, has the property of changing in one direction and always being irreversible, which Eddington called the “arrow of time”, which determines the direction in which new areas of knowledge are opened, and in particular, the use of water resources taking into account environmental acceptability.

4. Based on the formed concept of Entropy for the existing PTS "P.S.-O.D.-N." associated with the use of water resources, where the energy-entropy methodology is based on the study of the processes of the VVV components with the elements included in them in the considered spatial limits of river basin geosystems, for example, at reservoir hydroelectric complexes for the preservation of living matter in the form of ichthyofauna (various species of fish) by improving the designs of water intake structures as part of the "O.D." with a capacity of up to 50 m3/s or more.

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