

Концептуальні засади інноваційного розвитку національної економіки у контексті технологічних укладів та енергетичних інновацій

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Анотація. Актуальність дослідження зумовлена зміною підходів до розвитку національної економіки на основі енергетичного новаторства в контексті аспектів екологізації економіки, енергетичної незалежності, енергозбереження та синергії інновацій. Метою наукової роботи є формування концептуальної моделі інноваційного розвитку національної економіки в енергетичній сфері в умовах усталених трендів збільшення обсягів споживання енергетичних ресурсів. Дослідження проводилося у два етапи на основі системного підходу з використанням загальнонаукових теоретичних методів, а саме аналізу, синтезу, систематизації, узагальнення та структурного методу. У роботі обґрунтовано необхідність дослідження інноваційного національного економічного розвитку в межах енергетичної сфери на основі праць зарубіжних науковців. Розглянуто основні підходи до визначення поняття «інновація» в контексті економічного простору, серед яких процесно-орієнтований і функціонально-результативний. Встановлено взаємозв'язок між етапами життєвого циклу інновацій і рівнем розвитку національної економіки. Надано характеристику зміни технологічних укладів суспільно-економічних відносин у межах історичної ретроспективи. Визначено структурно-функціональні особливості категорії «розвиток» з метою дослідження концептуальних засад інноваційного розвитку національної економіки. Виокремлено основні моделі інноваційного розвитку у світовій практиці. З'ясовано особливості функціонування базових концепцій інноваційного розвитку національної економіки в енергетичній сфері, серед яких «кластерна концепція», «альтернативна енергетика», «Smart Grid», «концепція сталого розвитку», на основі чого було створено авторську концептуальну модель інноваційного економічного розвитку енергетичної сфери. Перспективи подальших досліджень вбачаються в практичному застосуванні створеної моделі інноваційного економічного розвитку енергетичної сфери

Ключові слова: енергетична сфера, концептуальна модель, економічний розвиток, інноваційна діяльність, кластерна концепція, альтернативна енергетика

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Conceptual Foundations of Innovative Development of the National Economy in the Context of Technological Structures and Energy Innovations

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Abstract. The relevance of the study is conditioned by changes in approaches to the development of the national economy based on energy innovation in the context of aspects of greening the economy, energy independence, energy saving, and innovation synergy. The purpose of the study is to form a conceptual model of innovative development of the national economy in the energy sector in the context of well-established trends in increasing the consumption of energy resources. The study was conducted in two stages based on a systematic approach using general scientific theoretical methods, namely: analysis, synthesis, systematisation, generalisation, and structural method. The paper substantiates the need to study innovative national economic development within the energy sector based on the research papers by foreign scientists. The main approaches to defining the concept of “innovation” in the context of the economic space, including process-oriented, functional and effective, are considered. The relationship between the stages of the innovation life cycle and the level of development of the national economy is established. This paper describes changes in technological patterns of socio-economic relations within the framework of a historical retrospective. Structural and functional features of the category “development” are determined in order to investigate the conceptual foundations of innovative development of the national economy. The main models of innovative development in the world practice are highlighted. The features of operation of the basic concepts of innovative development of the national economy in the energy sector are clarified, including “cluster concept”, “alternative energy”, “Smart Grid”, “sustainable development”, based on which the author’s conceptual model of innovative economic development of the energy sector was created. Prospects for further study are seen in the practical application of the created model of innovative economic development of the energy sector

Keywords: energy sector, conceptual model, economic development, innovation, cluster concept, alternative energy

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Introduction

Growing globalisation challenges, digitalisation of the economy, total informatisation of relations, and continuous development of technological progress strengthen the transformational processes of socio-economic development of the state and society. This, for its part, aggravates the competition for resources between participants in socio-economic exchange and requires modernisation of established approaches to the organisation of effective operation of production and economic complexes based on the implementation of innovative development mechanisms, which will form prerequisites for ensuring the dynamic competitiveness of Ukrainian business entities of the national economy, both in national and foreign markets. The strategic basis for the effective implementation of such structural transformations is the innovative modernisation of the energy sector of the national economy, as a driving source of stimulating the socio-economic development of the state. Taking this into account, the expediency of forming theoretical, methodological, and applied aspects for the implementation of effective mechanisms for innovative development of the national economy in the energy sector is determined.

The need to substantiate the conceptual foundations of innovative development of the national economy in the field of energy is also increasing in the context of established trends of increasing consumption of energy resources due to the growth of the total world population; reduction of reserves of non-renewable energy sources (oil, natural gas, coal, etc.); increasing climate changes caused by global warming, increasing the volume of carbon dioxide emissions into the atmosphere and pollution of the environment and natural ecosystems; aggravation of the problem of physical and economic availability of energy resources for the population; deepening spatial and territorial imbalances in the development of energy infrastructure; systemic shifts in the segment of development of renewable energy sources, which forms a steady trend towards an increase in its share in the overall structure of energy consumption; strategic orientation towards achieving sustainable development priorities that provide for the balance of economic, social and environmental functional components. One way or another, Ukrainian and foreign researchers repeatedly turn to these aspects of the development of the national economy in the context of innovative improvement of the energy sector in their theoretical and empirical research. For example, D.I. Kurbatov and A.V. Prokopenko worked on creating an innovative mechanism for the growth of the national economy using alternative energy methods [1]. For her part, the researcher N.O. Ryazanova considered the problems of small alternative (non-traditional) energy within the framework of innovative economic development

of the energy sector as a whole [2]. At the same time, the experience of foreign scientists is noteworthy. Thus, the German researchers F.V. Hackstein and R. Madlener in their study turned to the use of geothermal resources for electricity generation, which, in the future, contributes to the economically optimal operation of enterprises [3]. For their part, researchers from Chile, Colombia, Canada, and France conducted an online survey to determine the level of awareness and perception of the need for geothermal energy by representatives of the intellectual elite of five European and American countries (Canada, Colombia, Chile, Belgium, France), based on which the economic development of each specified individual country is formed [4]. Swedish researcher F. Libertson described the problem of lack of investment and innovation in some regions of Sweden to properly provide electricity, as a result of which the overall economic indicator of the country decreases [5]. At the same time, L. Friedstrom and V. Ostley conducted an empirical study aimed at estimating the ratio of CO₂ emissions from cars and vehicles with energy prices [6]. Finally, an unusual way to maintain eco-efficiency and a closed-loop economy was proposed by P.F. Borovsky [7]. The author suggests that at enterprises of various sectors of the economy, in particular energy, it is necessary to use the chemical and mechanical properties of bamboo [7]. However, it is worth noting that foreign scientists also trace a negative correlation between “green” innovations and the economy. Thus, Chinese researchers have proven that environmental regulations restrict the financial activities of companies [8]. The effect of income displacement caused by China's environmental regulations is greater than the effect of income compensation caused by stimulating technological innovation [8].

Returning to the European practices of sustainable development, it is advisable to pay attention to the UN global institutional programme “Agenda for Sustainable Development”, which defines the development of affordable and safe energy for the period up to 2030 [9]. It is well known that the burning of fossil fuels is one of the main sources of emissions that cause climate warming, and so far, it is with the help of it that approximately 80% of the world's energy consumption needs are met. That is why one of the twelve Global Sustainable Development Goals until 2030, approved at the UN summit on sustainable development in 2015, is Goal 7 “affordable and clean energy” [9]. Achieving this goal by 2030 involves a number of tasks, in particular, increasing the share of energy from renewable sources in the global energy balance, intensifying international cooperation to facilitate access to research and technology in the field of clean energy, improving energy efficiency, innovative and environmental technologies for using fossil fuels, encouraging

investment in energy infrastructure and clean energy technologies, etc. The issues of reducing energy intensity in industry are being updated in the context of the transformation of the national economy associated with the establishment of Industry 4.0. All this determines the relevance of the study of the conceptual foundations of innovative development of the national economy in the context of technological structures and energy innovations.

Consequently, *the purpose of the study* is to build a conceptual model of innovative development of the national economy in the energy sector.

Literature Review

It is worth starting with the fact that the study of innovative development of the national economy based on energy innovations provides for a clear definition of the concept of “innovation” directly, which has long remained the object of study by Ukrainian and foreign researchers. Thus, the term “innovation” is usually understood as the introduction of a qualitatively new idea in business practice based on the use of scientific and technological progress, which ensures an increase in the efficiency of the development of socio-economic processes between participants in public exchange. It is a well-known fact that for the first time the concept of “innovation” was introduced into scientific discourse by I. Schumpeter, by which he understood the historically irrevocable change in the ways of producing things [10]. The scientist made a significant contribution to the establishment of the modern scientific paradigm of innovative development, which includes substantiation of the theoretical and methodological basis for introducing innovations into business practice, systematisation of key stages of development of the innovation process, the study of the relationship between the effectiveness of innovation activity and the duration of economic cycles. I. Schumpeter in his study identified such types of basic structural changes as the introduction of new equipment and technology in the practice of management, the manufacturing of products with qualitatively new consumer properties, the involvement of new raw materials in the economic process, the modernisation of resources and facilities and production and technological process, the emergence of new markets [10]. Thus, the development of the national economy based on the implementation of systematic innovation activities provides prerequisites for the establishment of unique competitive advantages of production and economic complexes of the state, which allows maintaining their leading positions in world markets, both in spatial and temporal dimensions.

The works of the outstanding Ukrainian economist M. Tugan-Baranovsky are devoted to a comprehensive study of innovations [11]. The researcher was able to

establish a clear relationship between the level of innovation activity and the pace of development of economic cycles of the socio-economic system. He argued that innovation is a powerful driving tool for implementing structural changes in the activities of economic entities, the consistent use of which ensures the effective development of the state economy and supports the processes of expanded reproduction [11]. The tangential scientific position on the existence of direct interdependence between innovations and the life cycle of the so-called “long economic waves” is justified by the outstanding Russian scientist M. Kondratiev, who considered the level of technical and technological equipment of production and economic complexes to be a strategic determinant of the efficiency of the state economy [12].

The American economist P. Drucker interpreted “innovation” from the standpoint of a specific means of entrepreneurs, the use of which forms prerequisites for the implementation of structural changes in the sphere of socio-economic development of the state and society. At the same time, innovation activity, according to the scientist, is not stochastic and random, but is marked by a systematic, consistent and rationally organised character [13, p. 20]. For his part, the Hungarian economist B. Santo defines innovation as an important functional component of the socio-economic process, which through the use of mechanisms for introducing new ideas, scientific and technical developments and technologies is transformed into an increase in labour productivity, the creation of new jobs, the intellectualisation of socio-economic relations, which together ensures the improvement of the well-being of the population and socio-economic progress of the state [14, p. 127]. In this context, innovations are assigned not only a purely economic role, but also a deep social significance in ensuring support for the processes of socio-cultural transformation of socio-economic relations. A related approach is taken by G. Barnet, which determines the strategic importance of the aspect of spiritual creativity and defines this concept as a new idea that is qualitatively differentiated from existing ones [15].

Turning to legislative documents, it is worth pointing out that Article 1 of the Law of Ukraine “On innovation activity” defines innovation as “newly created (applied) and (or) improved competitive technologies, products or services, as well as organisational and technical decisions of a production, administrative, commercial or other nature that significantly improve the structure and quality of production and (or) the social sphere” [16]. Having worked out the existing scientific views, two strategic approaches to the interpretation of the theoretical essence of the concept of “innovation” can be distinguished, among which: 1) process-oriented (based on the mobilisation of scientific and technical activities

and resource capacities in the segment of project and experimental activities); 2) functional and effective (aimed at positioning innovations through the prism of a qualitatively new product, differentiating from existing ones, and can significantly improve the level of satisfaction of interests and needs of society). The interdisciplinary phenomenon of innovation is not limited exclusively to the economic sphere, but goes far beyond it and is extrapolated to almost all spheres of public life (social, cultural, political, spiritual, etc.), which a priori increases the strategic importance of this category in the development of socio-economic transformations and expanded reproduction of the state.

Materials and Methods

The study of the issue of innovative development of the national economy in the context of improving the energy sector was conducted in two stages. The first stage provided for the development of legislative, regulatory, scientific, and methodological literature to determine the general characteristics of the concept of "development" in the field of innovative economic activity in general and in the energy sector in particular. The essence of the second stage was to form a conceptual model of innovative development of the national economy in the energy sector based on the analysed papers, taking into account the basic concepts in world practice.

The study used general scientific theoretical research methods, including analysis, synthesis, systematisation, generalisation, and a structural method. Thus, the methods of analysis and synthesis were used in the processing of research papers by Ukrainian, Swedish, Chinese, Norwegian, and Polish researchers to determine the main approaches to the interpretation of the concept of "innovation"; characteristics of the main aspects of the development of the national economy in the context of innovative improvement of the energy sector; establishing the order of evolutionary changes in the development of technological ways of socio-economic relations with a focus on the features of the energy sector; highlighting the functional characteristics of the category "development", and describing the basic concepts of innovative development of the national economy in the context of technological ways and energy innovations. Methods of systematisation and generalisation were used to provide comprehensive definitions of the concepts of "innovation" and "development" in the context of economic activity; to reproduce the evolution of technological ways of socio-economic relations, and to create a conceptual model of National Economic Development based on the introduction of innovations in the field of energy activity.

The structural method contributed to the reproduction of the relationship between the stages of the innovation life cycle and the level of development of the national economy. In addition, in the process of exploring the chosen issues, legislative and regulatory documents were used as a theoretical basis, such as the UN institutional programme "Agenda for Sustainable Development", which defines the development of affordable and safe energy for the period up to 2030 [9], and the law of Ukraine "on innovation activity" [16] to confirm the relevance of the introduction of an innovative approach in the energy sector and defining the concept of "innovation" within the economic space.

In general, the study of the conceptual foundations of innovative development of the national economy in the context of technological structures and energy innovations was conducted based on a systematic approach. It is this approach that allowed studying such aspects as "innovation", "development", "economic system", "energy sphere", and the basic concepts of innovative development of the national economy in the energy sector, including "cluster concept", "Smart Grid", "alternative energy", "concept of sustainable development", "concept of ensuring energy security", as a result of which the author's conceptual model of innovative development of the national economy in the energy sector was formed with the prospect of its further implementation in practice.

Results and Discussion

General characteristics of the category "development" in the field of innovation

Systematic development and implementation of innovations in the practice of management is transformed into a segment of innovative development of the national economy, which is formalised through the prism of such manifestations of a useful effect as constant technical and technological modernisation of production and economic complexes, increasing the dynamic competitiveness of sectors of the national economy, the establishment of preventive mechanisms to ensure the economic security of the state, improving the quality of life and well-being of the population, balancing the economic, social and environmental components in the context of ensuring sustainable development of the state.

The relationship between the innovation life cycle and the level of development of the national economy is shown in Figure 1. Structural and functional parameters of innovative development of the national economy determine the competitive position of the state in the system of the international division of labour and in strategic global consumer markets.

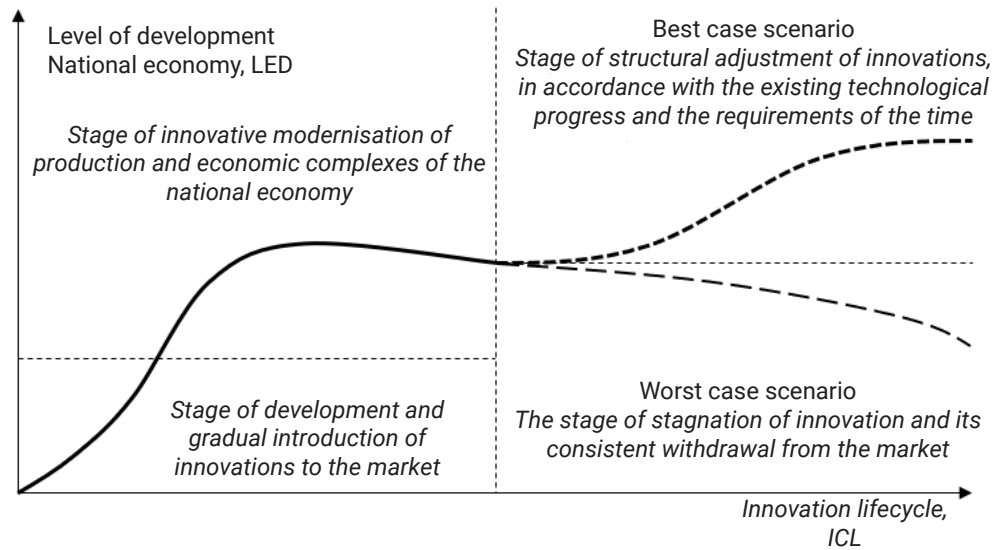


Figure 1. Relationship between the stages of the innovation life cycle and the level of development of the national economy

Source: compiled by the author

Structural and innovative restructuring of production and economic complexes of the national economy through the prism of the development of economic cycles is formalised in the technological ways of socio-economic relations. According to Yu. Bazhal, the concept of technological waves is based on the fact that the pace of technological progress and the introduction of innovations in business practice outstrip the pace of institutional development of the state, which leads to the implementation

of structural changes in the management processes of the latter and, as a result, determines the innovative transformation of socio-economic relations, which is formalised in technological ways, the duration of which coincides with the theory of “long economic cycles” by M. Kondratiev [17]. Table 1 shows the evolutionary change in the development of technological systems socio-economic relations.

Table 1. Characteristics of changes in technological structures

Technological structures	Key innovations	Characteristics of the development of the technological way of life
The 1 st technological wave (1770-1830)	Water engine, textile machines	Textile industry, pig iron smelting, mill construction, factory production, labour mechanisation
The 2 nd technological wave (1830-1880)	Steam engine, machine tools, transport, railway, metallurgy, coal industry	Deepening of labour specialisation, development of transport infrastructure, development of horizontal and vertical economic relations, development of sea and railway communication
The 3 rd technological wave (1880-1930)	Electric motor, rolled steel, heavy machine building, inorganic chemistry	Development of the electric power industry, electric networks, military-industrial complex, automotive and aircraft construction
The 4 th technological wave (1930-1970)	Internal combustion engine, organic chemistry	Development of the oil refining industry, mass production of cars and aircraft, development of transport infrastructure
The 5 th technological wave (1970-2010)	Microelectronics, information technologies, telecommunications, biotechnologies	Adaptation of military technologies to use in civilian life, informatisation of society, development of the Internet, computerisation, development of space technologies
The 6 th technological wave (2010 and continues to this day)	Nanotechnology, genetic engineering, robotics, artificial intelligence, alternative energy	Total automation of human labour, development of hydro-, bio-, wind - and solar energy, globalisation of socio-economic relations, development of neural networks, social media

Source: developed based on [17-22]

In the cross-section of each technological wave, specific features of the development of the energy sector are characteristic, the evolutionary transformation of which, on the one hand, supported the structural innovative modernisation of production and economic capacities, and on the other – progressive scientific progress provided an impetus to the search for new sources and technologies for obtaining energy resources. Today, the development of the energy sector within the current 6th technological wave is marked by such specific features as: reduction of the share of non-renewable energy sources in the overall structure of its consumption; development of green energy and the establishment of the principles of rational use of energy resources of natural ecosystems; strategic focus on improving the efficiency of green energy technologies; reduction of the level of harmful material emissions into natural ecosystems from the operation of the network of energy infrastructure facilities; development of bioenergy capacities and establishment of a closed cycle of waste processing from production and economic activities for energy needs; reduction of the anthropogenic load in the process of management and using the natural resource potential of ecosystems; development and implementation of energy-saving production and processing technologies in the process of creating added value.

It is advisable to study the conceptual foundations of innovative development of the national economy in the energy sector through the prism of identifying structural and functional characteristics directly of the category “development”. Researchers D. Joy-Matthews, D. Megginson, M. Surte interpret the concept of “development” as a process of improving the organisational component of an object based on consistent movement to its more complex state, taking into account the possibility of implementing potential opportunities [23, p. 20]. R. Chambers associates development with the process of moving forward in the space-time dimension [24]. For his part, L. Melnik identifies such specific characteristics of the category “development” as orderliness (despite constant changes, development is the antipode of the processes of destruction, since the introduction of these changes is marked by a logical sequential order); stochasticity (basic changes in the development process occur in conditions of environmental uncertainty and under the influence of poorly controlled factors of internal and external nature); self-organisation (changing the parameters of an object based on the use of its internal resource capacities). Thus, development is an irreversible, purposeful change in the socio-economic system (object) based on the implementation of its internal mechanisms of self-organisation [25, p. 12-14].

Development is uniquely characterised by the dynamic nature of changes in the structural and functional

characteristics of the target object (system). On the one hand, development is the result of using the resource capacities of the socio-economic system, and on the other hand, it directly determines the improvement of the resource potential of this system. At the same time, development can be accompanied not only by purely positive changes, but also have a negative stagnation character for the operation of the system in cases of managerial miscalculations and mistakes. Thus, it is advisable to interpret development from the standpoint of evolutionary or revolutionary changes in the operation of the socio-economic system (object) in the space-time dimension based on the use of its existing resource and functional apparatus.

It is quite natural to extrapolate the specific characteristics of the category “development” to the sphere of innovation activity. According to Y. Morozov, innovative development balances between uncertainty and risks, on the one hand, and the advantages and benefits of innovation, on the other. Such symbiosis is an internal source of innovative transformations in the context of dynamic changes in the economic environment of development. Innovative development is a qualitative leap through the implementation of means of structural changes in the economic system, which leads to an increase in the efficiency of its operation based on improving technology, technological base, labour organisation, improving product quality [26, p. 126]. Researchers M. Rogoza and K. Vergal structure the properties of innovative development through the prism of: 1) purposeful process, which is marked by a motivated orientation, irreversibility of changes, and reorganisation of operation; 2) driving source of transformational transformations, which are accompanied by parameters of uncertainty, risk, and dynamism; 3) implementation of quantitative and qualitative changes, which are characterised by regularity, adaptability, and cyclicity; 4) implementation of changes in the time dimension, which are determined by unevenness, discreteness, and frequency [27, p. 11]. Admittedly, such a complex nature, on the one hand, formalises the multi-functionality of innovative development, and on the other, complicates the substantiation of theoretical, methodological, and applied foundations for building effective mechanisms for purposeful management of this development. Innovative development is a complex process of structural adjustment of the national economy, which is achieved through the practical use of new knowledge to increase the volume of gross production, improve the quality of the social product, improve the competitiveness of the national economy, and accelerate socio-economic progress in society.

Innovative development is a continuous process of implementing structural changes in the production and social sphere based on the development, use and

dissemination of new knowledge, machines, technologies, materials, types of energy, methods of organisation and management, improving the level of education and professional qualifications of employees, carried out to increase the level of economic efficiency of the operation of socio-economic production systems and improving the quality of life of the population in the process of socio-innovative transformations. The Great Depression, which took place in the history of the United States of America in 1929-1933, played a significant role in the establishment and approval of the model of innovative development of the national economy. Overcoming deep stagnation processes objectively required the implementation of strategic management decisions in the field of innovative modernisation of US production and economic complexes, structural adjustment of the latter and the introduction of scientific and technical developments in business practice. It is quite logical that ensuring an appropriate level of efficiency of innovative development of the national economy requires the establishment of adequate organisational and managerial support. In this context, the opinion of L. Fedulova regarding the fact that the complex interaction of innovative resources and institutions in the management system of innovative development of the state is formalised through organisational innovations and positioned as the final result of the processes of development and implementation of innovations, and institutions, for their part, manifest as established norms and forms of innovative interactions aimed at implementing innovative solutions in the field of socio-economic exchange, which together ensures the transition of the state to the highest technological level of development of its national economy [28, p. 31-32]. Thus, ensuring the effective innovative development of the national economy requires the presence of the following basic institutional prerequisites: 1) the absence of institutional contradictions in the development of scientific and technical activities, support for innovations and conduct experimental research; 2) ensuring the financing of the scientific and educational sphere at the level of not less than 5% of the GDP of the state; 3) approval of the intellectual component of the establishment and development of the state's personnel potential in the process of socio-economic exchange; 4) the presence of a favourable investment environment for the development of innovation activities; 5) developed regional network of infrastructure facilities for innovation activities.

The conditions of global transformation and the establishment of a post-industrial information society strengthen the strategic importance of establishing systematic interaction between innovators, innovation institutions, the state, and the consumer market. At the same time, people remain the main source of innovation

development. For their part, innovation institutions create conditions for establishing effective innovation activities and implementing their results. While the market provides social selection and commercialisation of innovations, transforming them into a factor of economic development [29]. Such an institutional balance of state management of innovative development ensures the implementation of the basic function of innovation, which is to obtain a strategic competitive advantage of the national economy in the context of globalisation of trade and economic relations and the aggravation of competition for resources.

Researcher L. Marchuk in her studies identifies the following main models of innovative development in world practice: 1) the American model of technological leadership, characterised by limited state intervention in the processes of innovative development, the strategic importance of private capital in the processes of implementing innovative projects, developed vertically integrated relationships between educational institutions, research institutions, and business structures, support for the development of innovative infrastructure; 2) the European model of innovative development, marked by active state intervention in innovation processes, systematic institutional support for innovation activities, powerful budget allocations for innovative development, the use of indirect methods of financing innovation activities (concessional lending, accelerated depreciation policy, tax incentives), the active use of opportunities for international cooperation and the organisation of joint research within the relevant scientific and technical programmes; 3) the Asian model of innovative development, which is characterised by the evolutionary foundations of innovative transformations, strict state regulation of the innovation sphere, the widespread practice of importing promising innovative developments [30, p. 201-203]. It is obvious that the optimal model of innovative development of a particular national economy is formalised under the influence of a number of factors, including the existing natural resource potential of the state, the monetary and budgetary ability of the country to finance innovative projects, the capabilities of the research network and innovation infrastructure, the parameters of the intellectual component of human capital, the perception of innovations by the population and the readiness of society for change.

Innovative economic development of the energy sector: Basic concept

Innovative development of the national economy is a priori impossible without a comprehensive implementation of an innovative management model in the energy sector. Researchers O. Vlasyuk and D. Preiger note that the state of civilisation is determined by the development parameters of many problems, however, solving any of

them, humanity faces the problem of forming energy supply, which makes it a fundamental basis in maintaining the viability of socio-economic development processes [31, p. 89]. The strategic importance of ensuring the innovative component of the development of the energy sector is enhanced in the conditions of total deterioration and obsolescence of technical and technological capacities of production and economic complexes of the national economy, which increases the need for consumption of energy resources and, a priori, causes an increase in the cost of production of a unit of production; objective expediency of introducing energy-saving technologies for the development of the national economy in the context of implementing the principles of sustainable development, rational use of natural resources and reproduction of the resource potential of natural ecosystems; improving the physical and economic availability of energy resources for subjects of the national economy and households; phased implementation of the strategy of transformation of energy resources areas in the priority segment for the use of renewable energy sources.

Growing global challenges in the energy sector formalise the strategic vectors of the conceptual foundations of its innovative development. For their part, these vectors depend on the complex action of a number of parameters, including the available supply of energy resources on the market, the network of energy infrastructure facilities, logistics of energy resources supplies, the established demand for energy carriers, and the volume of available proven reserves of non-renewable energy resources. Innovative development in the energy sector is based on the following two aspects: 1) development and implementation of its own high-tech products and technologies created based on the resource capacities of the Ukrainian scientific and technical potential; 2) attraction and use of existing innovative developments abroad [32, p. 16]. The fundamental principles of transformation of the energy sector of Ukraine are enshrined in the energy strategy of Ukraine for the period up to 2035 "Safety, energy efficiency, competitiveness", the implementation of which was approved by the Order of the Cabinet of Ministers of Ukraine No. 605-R of August 18, 2017 [33]. The main goal of the strategy is to ensure energy security and energy efficiency based on innovative renewal of the energy sector and activate the processes of its integration into the energy sector of the EU countries. To achieve this goal, at each stage of the strategy implementation, basic priorities were defined, the main of which are: 1) priorities of the first stage (implemented until 2020) – institutional integration of Ukraine into ENTSO-G (European Network of Transmission System Operators for Gas), increasing the volume of own gas production, reducing the energy intensity of the national economy, compliance with high environmental standards in the

energy sector, increasing the share of renewable energy sources to 11%. 2) priorities of the second stage (optimisation and innovative development until 2025) – improving accounting and attracting consumers to manage their own demand for energy resources, meeting domestic demand for natural gas through own production, attracting investment in renewable energy, infrastructure development for electric transport. 3) priorities of the third stage (ensuring sustainable energy development until 2035) – systematic implementation of innovations in the energy sector, reduction of emissions into natural ecosystems, modernisation of thermal power plants, adaptation of capacities of gas transport systems to the requirements of EU member states, attracting innovative gas production technologies (shale gas, offshore production, etc.), increasing the share of renewable energy up to 25% [33]. Admittedly, the institutional basis for regulating the energy sector is formed through the prism of changes in technological ways and scientific and technological progress, which together determine the system of views on the problems of transformation of the energy sector and formalise the corresponding concepts of its innovative development.

One of the basic concepts of innovative development of the national economy in the energy sector is the *cluster concept*, which provides for ensuring a strategic focus on resource mobilisation, activating horizontal-vertical cooperation and establishing systematic interaction between interested stakeholders in the context of strengthening the competitive advantages of the energy sector. The idea of the cluster concept of innovative development of the energy sector is presented in the scientific works of such scientists as M. Voynarenko [34], A. Polishchuk [35], L. Ptashchenko [36]. The establishment of an innovation cluster creates prerequisites for building stable relationships between the transformation of inventions into innovations and consequently – into competitive advantages. For its part, the innovative structure of the cluster forms the basis for minimising the gross costs of developing innovations with their subsequent commercialisation through the use of the capacity of the production and technological structure of the cluster [37, p. 227]. The cluster concept of innovative development of the energy sector, on the one hand, requires the creation of a favourable institutional environment for establishing cooperation between the participants of the cluster association, and on the other – the implementation of structural changes in the energy sector obtained based on the cluster approach, forms a multiplier effect of structural modernisation of sectors of the national economy and qualitative transformation of the institutional model of the state.

The development of IT has predetermined the prerequisites for the establishment of the concept *Smart*

Grid in the energy sector, which provides for improving the efficiency and economy of the use of energy resources based on the introduction of computer-intelligent systems for controlling energy consumption processes. The strategic role of the Smart Grid concept is strengthened in the context of the expediency of forming rational approaches to energy consumption, taking into account the established trend of increasing the cost of energy resources, the growing threat of climate change and the urgent need to reduce the volume of emissions of harmful substances into natural ecosystems, the need to optimise energy consumption in the global dimension and minimise the risks of emergency disconnections from power supply systems. The structural and functional parameters of the Smart Grid concept forms effective mechanisms and tools for timely response to the above-mentioned challenges based on the introduction of automated intelligent control systems for the generation and consumption of energy resources.

The gradual depletion of reserves of traditional energy sources objectively led to the formation of the concept of *alternative energy* development, the relevance of which has increased in the context of worsening environmental imbalances in the process of socio-economic exchange. Among the proponents of this concept, it is advisable to single out such researchers as J. Goldemberg [38], O. Voloshin [39] et al. The fundamental principles of the concept of alternative energy development are based on a gradual increase in the share of renewable energy sources (wind-, hydro-, bioenergy, solar energy, etc.) in their overall structure with a gradual rejection of traditional energy capacities (coal-fired thermal power plants, nuclear power, etc.). For its part, this requires significant investment in the development of innovative energy projects and the implementation of mechanisms for state support for the development of alternative energy. Given this, the effective implementation of this concept is a priority, first of all, for rich, highly technologically developed countries that have powerful budgetary and financial resources to abandon traditional energy carriers, which, quite naturally, are cheaper than alternative energy sources. Usually, one of the basic tools for supporting the development of alternative energy is the so-called "green" tariff (institutionally approved higher cost of consumed unit of energy obtained from alternative sources), which, on the one hand, forms prerequisites for increasing investment and innovation activity in the

field of alternative energy, and on the other, increases corruption risks in the process of concluding contractual transactions for the supply of energy resources.

The strengthening of international geopolitical confrontation and systemic manifestations of hybrid aggression between states have led to the establishment of the foundations of the concept of energy security, within which ensuring access to energy resources becomes a priority weapon in the process of allocating strategic spheres of influence and interests on a global scale. The concept of energy security is formalised through the prism of the creation of monitoring system for identifying challenges and threats in the energy sector, the development of a set of indicators and methods for assessing the level of energy security (both in quantitative and qualitative dimensions), the development of institutional infrastructure for ensuring energy security, the development of organisational and managerial impacts of a complex transformation of the energy sector on innovative principles in the context of strengthening its competitive advantages in the market.

The *concept of sustainable development* of the energy sector is fundamental. This concept is based on ensuring the physical and economic accessibility of energy resources for all participants in economic relations in the context of balancing the energy aspects of the economic, social, and environmental spheres of public life. The concept of sustainable development of the energy sector is aimed at innovative modernisation of energy capacities of the national economy, establishing the principles of rational use of energy resources, development of a closed cycle of processing industrial waste for energy needs, diversification of sources of energy resources, by balancing the ratio of volumes of non-renewable and renewable energy in its overall consumption structure, reducing the anthropogenic load on natural ecosystems in the process of energy consumption, improving the efficiency of developing energy resources based on the introduction of energy-saving technologies. The concept of sustainable development of the energy sector is the most comprehensive and rational to use because it maximally aggregates the structural and functional components of the previously mentioned concepts and is focused on innovative modernisation of the energy sector. Figure 2 shows a conceptual model of innovative development of the national economy in the energy sector.

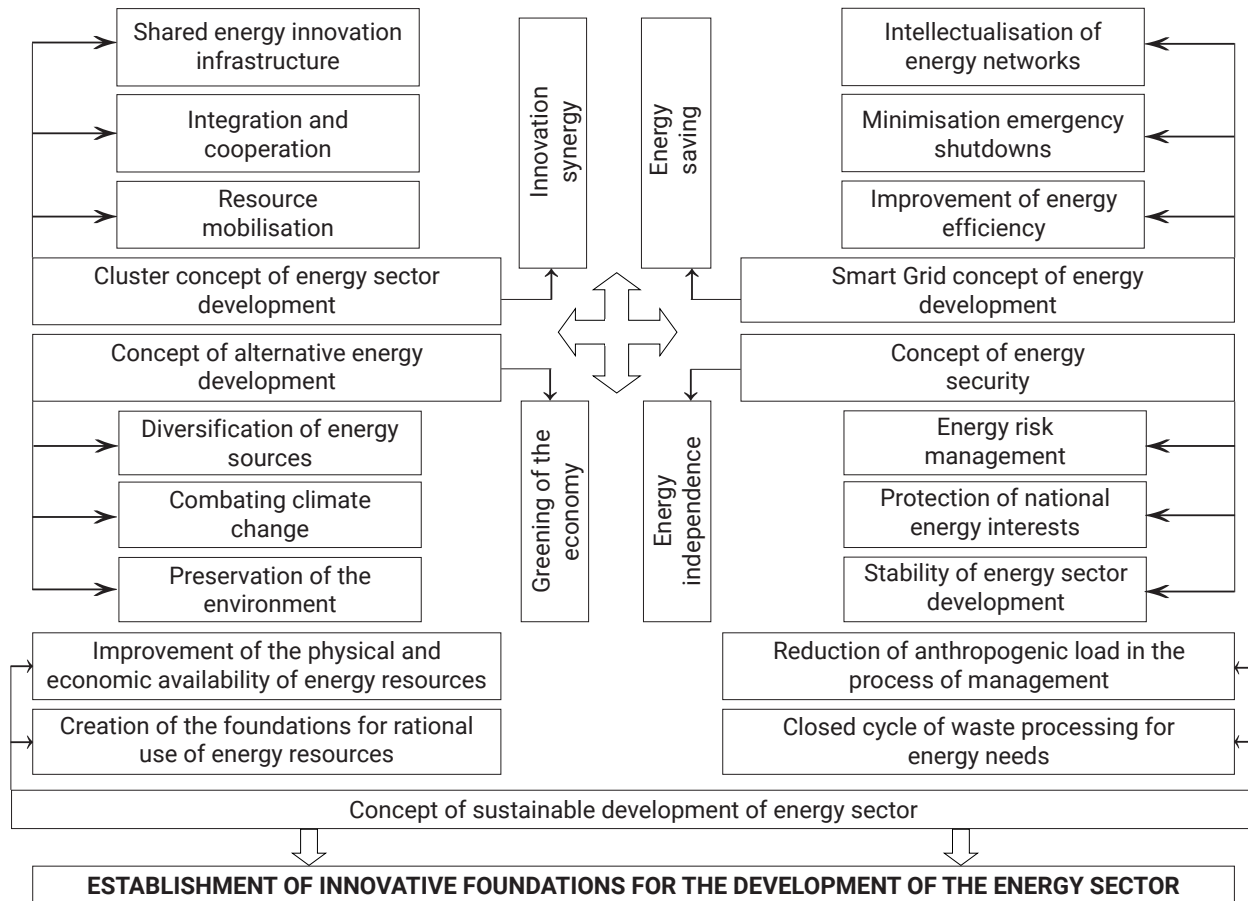


Figure 2. Conceptual model of innovative development of the national economy in the energy sector

Source: compiled by the author

Solving the problem of ensuring the innovative orientation of the development of the Ukrainian energy sector is a strategic task of strengthening not only the economic, but also the national security of the state. The implementation of innovative projects in the energy sector is a significant unused resource reserve for improving the efficiency of the operation of production and economic complexes of the national economy, reducing energy costs, and minimising the cost of production per unit of production, greening production and economic processes, improving the environment in the context of establishing the foundations of rational management and sustainable development of the state. Given the above, the innovative development of the national economy in the energy sector is advisable to position through the prism of: 1) generation, development, and implementation of new ideas in the management practice, which forms the prerequisites for creating a qualitatively new approach to the organisation of the development of energy business processes; 2) establishment of organisational and economic tools for activating the processes of transformation of socio-economic relations and accelerating the pace of transition from one technological way to another; 3) means of structural adjustment of technical and

technological capacities of production and economic complexes of the national economy in the conditions of aggravation of global competition for energy resources; 4) resource and functional apparatus for diversifying the risks of the national security of the state and protecting the interests of the latter in the context of increasing manifestations of threats of hybrid aggression in geopolitical confrontation; 5) systems for managing the efficiency of the national economy and strengthening its competitive position in the global market. Therefore, the innovative development of the energy sector is a significant unused resource reserve for increasing the efficiency and scale of functioning of production and economic complexes of the national economy, the provision of which requires further formalisation of the theoretical, methodological, structural and analytical, and instrumental and applied basis for organising scientific research.

Conclusions

Innovative development of the national economy in the energy sector is a strategic basis for ensuring the dynamic competitiveness of the state in the context of escalating geopolitical confrontations and manifestations of hybrid

aggression in the world. The growth of energy consumption, the reduction of reserves of non-renewable energy sources, and the deepening of natural and climatic imbalances make it advisable to restructure existing approaches to substantiate the conceptual foundations of innovative development of the energy sector. Energy innovations provide a structural boost in the context of the transition from one phase of the economic cycle to another in the context of existing technological structures. The conceptual foundations of innovation in the energy sector are formed from such concepts as the cluster concept of energy development (cooperation and mobilisation of resource capacities in the process of creating innovations), the concept of Smart Grid (intellectualisation of

energy resource consumption processes), the concept of alternative energy development (greening of energy capacities), the concept of energy security (ensuring the energy independence of the national economy), and the concept of sustainable development of the energy sector, which is aggregating and provides for improving the physical and economic availability of energy resources in the context of the rational use of natural resources in the energy sector. Thus, the study proposed a scientific approach to the substantiation of the conceptual foundations of innovative development of the national economy in the energy sector, which, unlike others, provides for a complex aggregation of structural and functional components of basic concepts.

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