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POWER ENGINEERING IN INNOVATIVE CHANGES IN THE NATURE OF ECONOMIC ACTIVITY

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Numerous studies of the processes of transformation of economic activities in Ukraine during the implementation of the policy of transition from a planned-distributive to a market-organized system have shown that the most significant changes took place due to the package of innovative changes, which involved both economic and social components. As a result, over a period of almost 15 years, the economy of Ukraine emerged and was recognized internationally, in particular, by the USA in 2006, as a market-oriented one. In the process of transition, a certain deindustrialization took place, primarily due to the decline in manufacturing, products of which had both low competitiveness and limited possibilities of sale in the domestic and foreign markets. At the same time, economic activities were gradually adjusted in the sectors, main features of which were, on the one hand, the expansion of traditional activities with a relatively low degree of technological complexity, and on the other, the need to ensure the functioning of the economy in market conditions. A special feature of the period was the limited role of the factors of economic growth based on innovative achievements, capable of contributing to the development of industries with a relatively high level of added value. Such activities include, in particular, nuclear energy, functioning and development of which, in the conditions of the "new reality", depends on timely replacement of capacities service life of which is ending and on the expansion of energy generation. In Ukraine's nuclear sector, there is a possibility of localization of certain activities at the expense of the capacities of the Ukrainian energy machine building in order to significantly reduce the cost of relevant projects, which is extremely important in conditions of limited financial resources and the growing cost of building new capacities. The paper, based on the identification of the features of "new reality" of exogenous economic activities, shows the possibilities and substantiates the feasibility of developing and using energy machine building for innovative changes in the nature of economic activities.

***Keywords**: economic activities, transformational shock, single market, nuclear energy, energy security, energy machine building, innovation and localization.*

Introduction

Economic activity in Ukraine over the past thirty-plus years, having gone through a long journey (almost 15 years) of its transformation from a centrally organized planned system to a market-oriented one, despite the initiation of GDP recovery processes, has not been able to reach the 1990 level of output. In the process of transition from the plan to the market, the economic decline was accompanied by the closure and bankruptcy of some types of activity and the limited emergence of others, which is mainly due to the need to ensure the institutional conditionality of the markets functioning. At the same time, the absence of achievements related to innovative change proved to be beyond the scope of what was possible within the framework of transformational policy. Moreover, state policy failed to allocate the necessary space for innovations that, in the long term, ensure the conditions for sustainable economic growth. The key role in the periodic acceleration of economic growth in the pre-war period was provided by traditional for Ukraine types of activity, which were able to enter global markets, the rise and fall of which was determined primarily by price fluctuations.

Under the conditions that were present in the economy of Ukraine on the eve of the war, it became obvious that it was necessary to concentrate efforts on economic policy, namely on the main role of the action and interaction of the state, business and science both in terms of generating innovations and, accordingly, creating

conditions for innovative activity in key sectors of the Ukrainian economy. These include, first of all, Ukrainian nuclear energy, the development prospects of which, on the one hand, are determined by the demand for electricity both on the domestic and external markets (in particular, the EU countries). On the other hand, they're determined by the ability of Ukraine to satisfy the said demand, namely on the innovative basis that exists and can develop in our country in the post-war period thanks to fundamental developments, for example, by the NAS of Ukraine. On this basis, a modernized national innovation system capable of expanding over time, which will ensure overcoming the existing structural and resource limitations of sustainable development, can be built.

The paper aims to substantiate innovative prospects for the development of national power engineering in the process of modernization of nuclear power in order to ensure the future energy balance. This should be done taking into account the conditions of the "new reality" and the peculiarities of the transformation of economic activity in Ukraine.

Nature of economic activity in Ukraine

Innovative transformations of economic activity lead to consistent changes in the economy, affect the state of its equilibrium, its stability and the dynamics of development. At the same time, such transformations can have both of scientific and technical origins and social and economic nature. Thus, the process of transition from a planned-distributive economy to a market one, which began in the 90s of the twentieth century and was characterized as a transformational transitional period, was distinguished by the special nature of the dynamics and structure of innovative changes in the politics and economy of Ukraine. In addition, it took place in several different stages, since the content of innovations underwent significant changes.

As is known, thanks to the political decisions that were made and the implementation of the so-called economic policy of transition to the market, an innovative package of changes was launched in Ukraine. It was integrated into the program of transition to the market in terms of including innovative changes in the policy of price liberalization, and, accordingly, the transformation of trade conditions, including foreign trade, on the basis of the simultaneous denationalization of property, which acquired the character of innovation. Innovations were also introduced to form new institutions of a market economy for the previous planned-distributive system. The program also provided for a package of innovations to ensure social protection of the population. Based on the objectives of this paper, we will focus on the results of the changes that occurred in the economy, primarily in economic activity, of Ukraine due to the abovementioned package in economic and partly social policy.

The economy of Ukraine at the stage of implementing innovative changes in economic policy was developed in industrial terms. In 1990, when Ukraine's GDP reached its maximum, the share of industry was the largest among existing types of activity and amounted to 35% of GDP in 1990, exceeding, in particular, the share of agriculture by 10 pp. The key role in industrial production was played by mechanical engineering, metallurgy, and the chemical industry. It was due to their development that the economy of Ukraine had an industrial character. Due to the implementation of the economic policy of transition to the market, which in the period from 1990 to 1999 was of a shock nature, the structure of industrial activity underwent special changes due to the increase in the specific weight of fuel and energy and metallurgical production, since their share increased from 21.0% in 1990 to 53.7% in 1999. This change was unprecedented, since at the same time, the production of mechanical engineering and metalworking products as key activities for the development of high-tech material infrastructure of the economy, which could possibly be used to ensure innovations based on the renewal of equipment and technologies in industry, fell from 30.7% in 1990 to 13.8% in 1999 [1]. The mentioned changes were not conditioned by large-scale technological innovations and the use of new equipment, but were the result of transformations in economic policy, which should be considered a shock to the market.

As the author's research on this topic of that period showed, during the period of transformations in the 90s of the twentieth century, an irrational economic structure began to form in Ukraine, with which, as was predicted for the future, it was impossible to expect rapid economic growth rates. This is explained by the fact that the Ukrainian economy has seen a decline in industries that create end-use products with a relatively higher specific weight of added value (machinery, chemical industry), that is, deindustrialization of industries has taken place.

The ideology of the transformational transition from the plan to the market, which was used in Ukraine as in a number of other countries, cannot be perceived as not having an innovative feature in economic policy at its core. It is due to the fact that in such a situation the institutional environment fundamentally changes, along with the political regime in the country. Research on this topic shows that under the in-

fluence of trade shocks, it is important to consider the scale and nature of their impact in the process of liberalization of both trade and prices. It should be noted that for Ukraine the shocks were of exactly this nature, since there was a reorientation from the dominant trade relations with Russia and the former so-called union republics of the former USSR to the countries of Western Europe, where the free trade regime and significant price fluctuations dominate. According to T. Eggertsson, for effective adaptation to such shocks, it is sometimes sufficient to take measures of only financial and monetary nature. However, in most cases, especially in the transformation period, serious structural changes are necessary, especially in terms of inclusion in the development of new industries and the reduction of existing ones, which often have significant political influence [2], and therefore push the government to pursue a policy of supporting them.

At the time when the Ukrainian economy experienced both political and trade shocks when initiating the transition from the plan to the market in the early 90s of the 20th century, fiscal and monetary authorities did not have the experience of introducing relevant innovations in tax and monetary policy that would minimize the impact of transformational shocks. Ukrainian politicians of that period did not have the so-called "correct model" of economic policy for taking measures to neutralize the consequences of an external shock of a trade nature, and, as D. Rodrik has proven, those needed for the necessary neutralization of shocks [3]. The shock for Ukraine was quite powerful in the view of significant political influence of agents of traditional activities, such as mining and metallurgical industries. In the latter ones, in the course of transformational changes, corporate associations began to form, which had, in particular, experience of entering world markets. At the same time, the government did not succeed in developing or implementing a policy for the advancement of new competitive activities. On the contrary, the latter ones, which took place in Ukraine at that time, began to reduce their production and lose markets.

In addition, the author's research at that time allowed to state that at the end of the 90s, Ukraine, which was previously part of the former USSR (1986–1990), as a result of the implementation of a policy of financial stabilization and liberalization, which was already taking place in independent Ukraine on the path of transition to the market (1995–1999), did not have signs of transition to stable long-term economic growth on an innovative basis. On the contrary, in the process of transition to the market, the Ukrainian economy was lagging behind, which was primarily due to the structure of capital investments. Thus, according to the author's calculations based on the data of the Statistical Yearbooks of Ukraine for the relevant years, despite the fact that the share of capital investments in Ukraine's industry increased slightly to 37.6% as of 1999 compared to 34.5% in 1990, capital investments in mechanical engineering, chemical and petrochemical industries, products of which depend on the advanced nature of technological changes, fell from 34.9% in 1990 to 9.2% in 1999, i.e. more than 3 times. Such a trend of structural changes in capital investments in the 1990s indicates one of the worst scenarios of transformations in the content of the state's economic policy of that time regarding the prospects for economic growth, since activities important for the development of new industries remained outside the priority areas of investment. These are the industries that are primarily related to mechanical engineering and the chemical industry. In fact, to a certain extent, it can be argued that during this period, the expediency of eliminating, first of all, the foundations of the old system and the dominance of a policy of economic growth, which in the conditions of transformational changes would ensure economic growth, did not prevail over the previous canons. For details on the content of macroeconomic policy reforms that ensure conditions for controlling inflation in the context of expanding innovations in a transitional economy, see [4].

In economic activity and, accordingly, economic policy, which determined the content of the changes of that time, there were factors that were crucial in terms of restrictions on the technical development of those activities that would improve the transition of the economy to economic growth and recovery. As a result, time was lost during the years of transformation. In all the next 30 years of economic activity until the beginning of the full-scale war started by Russia against Ukraine in 2022, the level of GDP in 1990 was never achieved.

Moreover, the changes in the economy of Ukraine in the process of transition to a market-oriented economy, which was recognized, in particular, by the United States, acquired the character of a transformational shock only in 2006, which covered a period of almost 15 years. At this time, significant structural changes of even deeper meaning took place. The economy of Ukraine in the process of transition from a market perspective was formed as a small open economy, in which foreign trade turnover in some years was more than 100% of GDP, and in some – bat a level that was close to or more than 90% of GDP. This characterized the economy of Ukraine as one that has signs of marketability with fragile or intermittent growth,

which is determined, on the one hand, by exogenous features, primarily of a trade nature, and on the other – by shocks of social transformations and, accordingly, social technologies. The shocks of social transformations and the shocks of social technologies, as well as their impact on the economy, aren't studied in this paper. The results of research on this problem are presented in two of the author's publications [5–6].

The policy of financial stabilization and liberalization of the 90s of the 20th century and in the first ten years of the 21st century was characterized by further liberalization and a new structural transformation of foreign trade relations. But at the same time, efforts to innovatively renew the economy remain excluded. In particular, structural changes in foreign trade activity in the specified period were characterized by an increase in exports of mineral products and processed products from 17.8% in 2000 to 22.5% in 2010, but at the same time, the production of industrial products and mechanisms of equipment, vehicles fell from 73.8% in 2000 to 65.2% in 2010. The drop in the specified period amounted to 8.6 pp, that is, in the process of approaching the fact of recognition of Ukraine as a country with a market economy, economic activity was formed with its rooting, on the one hand, as a resource appendage, and on the other – as technologically dependent, since there was a decrease in exports of industrial products from 53.9% in 2000 to 47.9% in 2010, that is, by 6 pp. At the same time, import dependence on industrial products, mechanical equipment and vehicles increased from 38.8% in 2000 to 55.2% in 2010. As a result, the Ukrainian economy became import-dependent in those types of industry where the added value of products is high, as well as in the purchase of fuel and processed products, which had occurred before, although their share in the import structure fell from 43.6% to 32.3%, i.e. by 11.3 pp.

Thus, the Ukrainian economy in the conditions of transition to the market has retained the existing signs of import dependence on fuel resources, but has also increased in industrial products with a high specific weight of added value.

Analysis of the structure of exports and imports of Ukrainian products (Table 1) with the EU and SCO countries as a whole, and without energy materials, oil and products of its processing shows that the balance of foreign trade of Ukraine with the EU and SCO countries at that time was negative as well [7]. Thus, the negative balance of foreign trade with the SCO countries was formed earlier mainly at the expense of energy materials, gas, oil and products of its processing. In addition, during this period, the Ukrainian economy was dependent on imports of high-tech goods from the EU countries. Recently, the same dependence on such imports from the SCO countries takes place, too. In particular, this applies, which is especially important, to machines, equipment, mechanisms, land transport, aircraft, watercraft, devices and apparatus.

Table 1. Ukraine's trade balance with the SCO and EU countries in mechanical engineering products during 2002–2018, million USD

Indicator	2002	2005	2010	2015	2018
Total export-import	-1160	-5430	-3532	-3702	-11970
Export-import from SCO countries	354	-1305	-2557	-1365	-3844
Export-import from EU-28 countries	-1351	-4351	-4010	-1722	-4837

Source: calculated according to data from the State Statistics Service of Ukraine

Thus, in the period from 2000 to the 21st century, the Ukrainian economy has become increasingly technologically dependent on the markets of the countries of the two mentioned associations, although in previous periods the situation was somewhat different. Ukraine has long imported products of industrial and technical purpose mainly from the West, that is, it had a negative trade balance, and sold such products of its own origin to the East and to "third world countries", which had a positive effect on the trade balance. The change in trend is explained primarily by the fact that the Ukrainian economy in the first 10 years of the 21st century has become exogenously dependent in technological terms on the import of products important in terms of investment and innovation, since the export of the latter significantly exceeds their export, as well as from fluctuations in prices on world markets for the main export goods of Ukraine, which are represented by products with a relatively low specific weight of added value, which, of course, was unfavorable for the future of the Ukrainian economy. Such changes indicate the formation of an economy with signs of semi-periphery in Ukraine. Overcoming the lag, including exogenous dependence, in order to prevent the threat of transition from a country with a semi-peripheral status to a peripheral one, in our opinion, is a guideline for the future development of the Ukrainian economy for the period of post-war recovery and a component of the content of the economic policy of the future, while, of course, international experience should be taken into account. The author's vision of the above is set out, in particular, in the monograph devoted to the prospects for the development of the titanium and aluminum industries of Ukraine [8], but is not limited to it, since there are other possibilities, which will be discussed later.

Ukraine's orientation in importing investment goods to the West is justified, because, as a rule, we are talking about competitive products, therefore, in the next 5–10 years, there are no prospects for changes in the course to the opposite. However, it is possible only if at this time, in particular, the process of expanding cooperation and participation of Ukrainian enterprises in value-added chains and localization of production of a number of types of manufacturing products does not take place. Given that the economies of Western countries tend to slow down economic growth amid a decline in production, achieving cooperation will not be easy. Thus, in Germany, as one of the technological leaders of the EU in the manufacturing sector, according to U. Malmendier and K. Schaffranka, there has been a decline since 2018, and, as expected, the growth of the entire German economy will be weak at least in the coming years [9]. In addition, we can expect an expansion of imports of high-tech goods from Eastern countries, in particular, China, India, which have increased the competitiveness of their economies, including to the EU.

Based on the above, we can argue that Ukraine, in order to get rid of the constant emergence of a foreign trade deficit on the basis of achieving technological development [10], needs, on the one hand, to look for ways out and penetrate the markets of "third" countries, and on the other hand, to look for and realize its opportunities in satisfying domestic demand in high-tech areas of national production development, in particular, by implementing high-tech projects, expanding the share of localization in them.

Nowadays, when Ukraine is waging an exhausting war for independence, it, while meeting the existing criteria of semi-periphery, at the same time has a sufficiently strong innovation potential due to the achievements primarily of fundamental science, which, developing further, can ensure the reduction of the existing backlog if its results are used as one of the components of the national innovation system in order to prevent the loss of the existing semi-periphery and move towards further development. The problem of ensuring changes in innovation activity, based on fundamental science, is also recognized as extremely important.

Moreover, even in wartime, experience has been gained in successfully modeling existing gaps in the nature and content of innovation activity by ensuring the development of national production in the defense industry and the corresponding tasks of increasing domestically produced weapons in Ukraine in the future. Some progress in weapons manufacturing in Ukraine during the war years allows to increasingly meet existing demand on the basis of establishing the production of modern types of weapons. This is a good example of an innovative path of development in the future.

Currently, Ukraine is carrying out activities aimed at solving already identified tasks, the implementation of which will contribute to meeting the conditions associated with the expected integration into the EU in the economic sphere. Among them are those that arise from the traditional requirements that must be met upon joining the EU, which, of course, are now clearly defined. In view of this, working groups have been created in Ukraine to carry out such activities. In the given paper, we do not set as a task to analyze them, assess the degree of implementation and expected consequences. This is beyond the scope of our study. We consider it appropriate to dwell on those priority problems that the Ukrainian economy and economic policy will need to solve, since they will have priority in the program of post-war revival and reconstruction.

The post-war development of Ukraine's economy is not just the restoration of what was destroyed, but the revival of our state and its economy (this, of course, will be after the war, that is, a "new reality" that has both exogenous and endogenous character, both traditional and special in content), and therefore the results must be groundbreaking [11].

Features of the "new reality" of an exogenous nature

I. The uncertainty in the ideology of further economic growth, which has acquired a global character, is due to changes in the "world order", which is accompanied by large-scale (sometimes even critical) shocks. This is, in particular, the current unattainability of the UN Sustainable Development Goals. As a result, the UN Resolution 2024 "Pact for the Future" indicates that if the course remains unchanged, there is a risk of finding ourselves in a state of crisis and decline, since the current system and method of governance are outdated, unfair and dysfunctional. There are still no fundamental answers to the question of what this system will be.

II. Uncertainty on the European continent, despite the existence of the EU as a governing body, is caused by an energy shock for EU countries; manifestations of "economic nationalism", which started, as is known, as "vaccine nationalism"; low level of competitiveness of the European economy; the largest war since 1945 in Ukraine and a number of others. In particular, the conclusion on this issue was made by the former President of the ECB Mario Draghi: if nothing changes, a slow agony awaits the EU.

III. The globe population, as is already well known, expects, so to speak, a "demographic brake", the essence of which, on the one hand, is a reduction in the birth rate, and on the other, in the formation of the so-called "longevity dividend" in the form of an aging population. To neutralize such challenges, it is necessary to find ways of resocializing the population, which will ensure its adaptation to the conditions, the formation of which will inhibit the tendencies towards, firstly, a decrease in economic growth and, secondly, an increase in budget expenditures for social support and protection of the older generation, otherwise we should expect a decrease in the growth rates of the world economy.

IV. The existing turbulence, which is global in nature and has uncertain consequences, is leading to an aggravation of the contradiction between large-scale transnationalization of the economy and the deepening motivation for manifestations of economic nationalism [6].

V. The results of the world's economic growth are "unquestionable", but its nature has led to climate change and a decline in biodiversity. Even these two components are enough to increase the threats to the existence of the material world. In turn, the increase in the number of people living in poverty and the narrowing of the middle class threaten the social environment, which is why the "Pact for the Future" proclaimed in the world has put the elimination of poverty at the top of the agenda.

Conclusion! A change in the paradigm of economic development is necessary, since instability in the economy has gone beyond the limits of economic existence during phases of economic crises, familiar and sufficiently studied forms and existing experience, acquiring the character of a transcendental phenomenon to a certain extent. **Instability and uncertainty** – signs of the times.

Among the abovementioned five features of "real time", the most important for the economy of Ukraine is that there is uncertainty about the future of the EU, the economy of which, in the absence of changes, awaits, according to M. Draghi, a slow agony. Of course, prolongation of the existing uncertainty about further development is also possible. Moreover, this will deepen the contradictions that need to be resolved. It should be noted that according to the studies conducted to date, in particular, under the auspices of the IMF, they can be resolved through further integration of the EU countries, its deepening. For example, the Director of the European Department of the IMF, A. Kammer, believes this. His evidence on the usefulness of a closer economic union in the EU becomes more convincing as the number of external threats increases [12]. In the conditions that have developed in the EU economy as a result of the Covid19 pandemic and especially after the full-scale war with Ukraine launched by Russia in 2022, one should not expect a narrowing of the possibilities for its growth both at present and in the medium term against the background of extremely low economic growth dynamics. Such trends limit certain financial resources of the budgets of the EU countries, on the one hand, for the necessary increase in defense spending, and on the other hand, for supporting the social security of the population, which is aging and requires increased spending on its social protection. Thus, it can be argued that there is a certain dualism in the growth of costs, which is caused by the already well-known limitations on the further development of the EU economy due to existing conditions, namely the insufficiency of: firstly, the available critical resources and access to them; secondly, the existing practice of resolving the problem, which is also complicated by trade wars, as well as the fact that the EU, and this is thirdly, is currently experiencing, according to S. Nixon, "... a serious crisis that has gripped the continent today", it is about "the presence of three interrelated aspects: geopolitical, economic and institutional ..., which requires a complete change in the way of thinking" [13]. Of course, this also applies to Ukraine, which is moving towards the EU and must organize activities not only in conditions of war, but also of post-war reconstruction of the economy.

Financial and labor resources in the post-war revival

Currently, there is an active process of finding an answer to some of the abovementioned problems, in particular, how to finance the defense and security of Europe. In order to level this challenge, it is proposed to recognize the expediency of launching the activities of three large European institutions that have financial resources and have the ability to consolidate and increase them. The solution is seen, in fact, in deepening cooperation among EU countries by using the mechanisms established in the EU for finding answers to challenges through deepening unity. In this case, "... three key European institutions should come into play – *the European Commission, the European Investment Bank and the European Stability Mechanism (ESM).* ... If the ESM and the European Commission use their credit capabilities to the fullest extent, as well as with an increase in the EIB balance sheet, an additional 1 trillion euros can be allocated to support European investments in defense and security" [14].

This will give the necessary impetus to development and will adequately open up opportunities for Ukrainian industrial activity, in particular in the defense industry.

In the EU economy, along with limited financial resources, there are problems in the field of labor resources and their employment, which can form structural imbalances in the economy as a whole. On the one hand, in the interests of increasing the efficiency of economic activity, production will be transferred from some countries to other countries, and, accordingly, the labor force will be released, which will require both additional costs for retraining and costs for social protection. However, when production is reduced as a result of its relocation, budget revenues will decrease. On the other hand, the labor force will be forced to move to other countries by migrating to those regions of the EU where jobs have already been created, but which are not occupied due to an insufficient number of workers. In particular, this problem, by EU standards, is of a large-scale nature. For example, "... in the next 10 years, the situation in Germany will worsen, as 20 million workers are expected to retire, while only 12.5 million will enter the labor market. ... The population aging will worsen the labor crisis that the country is experiencing today, further increasing the cost of labor" [9], and therefore, competitiveness will decrease. At the same time, for example, China, which has raised the technological level of relevant industries and, having no restrictions on access to resources, especially those in rare earth deposits, as well as skilled labor, is increasingly conquering the global market, gradually taking Germany's place in the global economic space.

The situation on the European labor market is also typical for Ukraine, where the same problems exist, but they have significantly worsened in wartime due to mass emigration abroad. In particular, more than 6 million people have left for the West, to the countries of the European continent. This is mainly the working-age population and children, the younger ones of whom went to school, and the older ones are studying the language. As of now, according to the Federal Institute for Demographic Research, in 2024, 43% of Ukrainians in Germany were already employed, although in the summer of 2022 there were only 16%. According to the conclusions of German experts, the participation of refugees from Ukraine in Germany demonstrates the large-scale potential of Ukrainians for the German labor market. In addition, another 24% of refugees are ready to enter the labor market immediately [15]. So far, only the inaccessible level of language proficiency at the B2 level limits such opportunities and desires, which can be satisfied over time, since language restrictions are usually minimized.

The results of the employment of Ukrainian refugees in Germany are indicative for the entire European continent, whose population is aging, and therefore in the post-war period Ukraine will most likely have limited opportunities for the return of its population, and therefore, the Ukrainian labor market will experience a deficit that will be caused by the need for a large and qualified number of workers for the post-war reconstruction of the country. At the same time, "the aging of the population should not become the cause of a sharp decline in economic growth and increased pressure on the budget" [16]. The latter is possible primarily due to improvements in the health care system, the reform of which is taking place even in wartime. The calculations of the above-cited authors and the study of existing trends in the world have indicated the need to use the opportunities of the so-called healthy aging, because this provides grounds for a certain improvement in the situation with human capital, including in the Ukrainian labor market, although the results of the latter can be expected only in the medium term.

The abovementioned problems for Ukraine in the process of its post-war revival in terms of providing the economy with resources on the labor market can be balanced by the positive consequences of aging and falling birth rates, since "... a decrease in the number of children and the size of the population means a decrease in the need for housing and childcare costs. These resources can be redirected to scientific research and development, the introduction of advanced technologies and improving the quality of education... The productive characteristics of the population play a more important role than the size in determining its ability to create knowledge and innovation" [17]. Ukraine in the post-war revival conditions must first of all rely not only, and not so much on labor resources, but primarily focus on increasing the production characteristics of the working-age population, especially in that part that is associated with the so-called skill shift, which is necessary to meet the growing demand for highly skilled labor. In particular, Ukraine can receive large-scale benefits from the expected expansion of the use of artificial intelligence thanks to the Digitalization of Ukraine Program, for the successful implementation of which the EU allocates 17.4 million euros, taking into account the fact that Ukraine, in terms of ICT technologies and, accordingly, exports of ICT services,

according to the UN Economic Commission for Europe, is in the first half of the ranking of countries covered by foreign direct investment (FDI), while Ukraine entered the top 20 countries in the world according to FDI data in 2019 [18]. Such dynamics and interest of foreign investors in the development of ICT in Ukraine open up opportunities to expand the use of artificial intelligence (AI). Large-scale benefits from digitalization and the use of AI (which can occur under different scenarios) can be obtained by both less qualified and highly qualified workers. In our opinion, the use of AI will expand in parallel in both directions. At the same time, the conclusion is unequivocal that with the scaling up of the use of artificial intelligence in economic activity, it is assumed that the latter will form a workforce that will transform a wide range of economic activities, although the consequences in the socio-humanitarian plan are still unclear due to their contradictory nature, that is, that in the future artificial intelligence will function and act as one that will prevail over humans. The question is – so what if that happens?

Studies related to the most likely global trends in the development of artificial intelligence confirm the broad possibilities of its use, on the one hand, in innovative activities, and on the other hand, in ensuring the innovative nature of changes in the economy as a whole. According to the data provided by the academician of the National Academy of Sciences of Ukraine M. Z. Zghurovskyi, such a standard is called "Managed Competition and Adaptation (2025–2035)" with the highest probability of its implementation among others at 50–60%. In this state of affairs, the ecosystem (according to the most likely scenario) will slow down the development of autonomous systems, and the automation of the economy will continue. In view of this, in 2035 it is expected that up to 50% of jobs will be automated or transformed into high-tech ones [19]. Actually, such a scenario in the context of the existing problems for Ukraine regarding the limited resources of the working population necessary for the revival of the economy in the post-war period on the basis of its competitiveness is quite optimistic and desirable, although its implementation in our country will lead to the emergence of a number of challenges that are important for the economy of Ukraine. In particular, we are talking about the fact that the expansion of the use of AI, on the one hand, creates energy challenges and a challenge in the field of ecology, and on the other hand, has a high cost like a number of others [19]. In the conditions of the existing limitation in the working population necessary to solve the problems of the post-war revival of the economy on a new technological basis, Ukraine, in accordance with the challenges that provoke the next industrial revolution, will need the expanded use of AI both for the purposes of automation of production and a direct change in the level of its technological capabilities. Thus, the workforce can be replaced by modern technologies, in particular, those that artificial intelligence opens up, but this requires an increase in the energy capabilities of the economy. The latter may be real under conditions when energy capacities will be expanded by solving existing problems in the energy sector or by restructuring and developing nuclear energy. Currently, the Institute of Economics of the NAS of Ukraine is considering two possible scenarios, the content and nature of which will be discussed below.

Nuclear energy in the energy balance of the future development

Currently, two scenarios of a predictive nature regarding the growth of electricity production are under consideration at the Institute for Economics and Forecasting of the NAS of Ukraine. One of them is a ***progressive one***, according to which all electricity production by 2030 (compared to 2020) will grow slightly – by 2.4%, and for the period until 2050 – by 2.3 times. However, electricity production at operating nuclear power plants for the period until 2030 will grow by 25%, and by 2050 will fall to 27% of the 2020 level, that is, by 2050 the decrease is 3.6 times. At the same time, the growing demand in the world will intensively begin to be satisfied at the expense of new large capacities, which will be put into operation from 2035, and by 2050 their growth will amount to a third of all electricity production. New small capacities, meaning small modular reactors (SMRs), are projected to generate 6.0% of all electricity, and in general nuclear power in the progressive scenario will produce 43% of the total volume (Table 2).

Analysis of the forecast data in the ***baseline scenario*** (Table 2) shows that nuclear power will increase its role to 57%, i.e. its share compared to the progressive scenario will be higher by 14 percentage points. At the same time, as in the previous scenario, the role of operating nuclear power plants will decrease, and generation at large capacities will increase. It is noteworthy that under this scenario, generation at SMRs is not expected, which means a significant expansion of construction at large-capacity nuclear power plants.

Both scenarios for the development of electricity production and consumption in the world will clearly affect the energy sector of Ukraine, since the above trends are largely similar for Ukraine, in the energy balance of which the share of nuclear energy as of 2020 reached 51.3% (Table 3). That is, our country is ahead of the expected global changes in its overall production. During this period, the capacities operating in Ukraine will be decommissioned. In addition, the expansion of new, primarily large capacities is expected, although the development of low-power nuclear energy is not excluded. The prospects and details of changes in the dynamics and structure of electricity production in Ukraine, its role and interrelationships with changes in other types of industrial activity, in particular, power engineering, which is key in this area, will be discussed further.

As follows from the currently existing strategy for the development of Ukraine's energy sector, in particular its nuclear component, developed (under two scenarios) with the participation of the Institute of Economics and Forecasting of the National Academy of Sciences of Ukraine in accordance with the "National Energy and Climate Plan for the period up to 2030" and linked to the five dimensions of the Energy Union, under the baseline scenario (WEM, Table 3), the share of nuclear energy will increase to 58% in total production. At the same time, Ukraine plans to decarbonize the energy sector by 2050 [20]. At the same time, from the above forecast, but already under the WAM scenario, according to which, along with the existing ones, it is possible to implement additionally envisaged policies and measures for the decarbonization of Ukraine's energy sector. In this case, the share of nuclear energy in its total production will remain the same until 2040, and then begin to decrease to 43.3%. These structural changes will occur due to the dynamic growth of the share of renewable energy sources (RES) to 52.2% in 2050.

Table 2. Forecast of the dynamics and structure of electricity production in the world in 2020-2050, %

Production Dynamics	Year				%**
	2020	2030	2035	2050	
Progressive scenario					
Total	100	102.5	127.4	228.3	100.0
Operating nuclear power plants	100	125.0	126.6	27.6	6.1
Large-capacity nuclear power plants	–	–	100.0	942.0	31.0
New small-capacity nuclear power plants	–	–	100.0	589.1	6.0
Baseline scenario					
Total	100	98.7	110.3	153.4	100.0
Operating nuclear power plants	100	125.3	125.8	27.6	9.1
Large-capacity nuclear power plants	100	–	100.0*	230.4	48.1
New small-capacity nuclear power plants	–	–	–	–	–

* – 2040; ** – share in total production, %

Table 3. Development scenarios and structure of electricity production in Ukraine for the period until 2050, %

Production Structure	Year			
	2020	2030	2040	2050
WEM scenario (baseline)				
Electricity generation	100.0	98.7	127.4	152.2
Atomic energy	51.3	65.0	58.4	57.4
Share of RES	10.8	17.8	25.2	28.1
WAM scenario				
Electricity generation	100.0	102.4	157.9	228.0
Atomic energy	51.3	62.6	51.1	43.3
Share of RES	10.8	30.1	46.8	52.5

WEM – scenario under existing policies and measures;
WAM – scenario with planned additional policies and measures.
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Electricity production under the baseline scenario, under which the role of nuclear power is to increase, could reach a capacity level of about 8 GW by 2050. At present, in our opinion, this is a realistic scenario, for the implementation of which it is necessary to build new capacities. Under the so-called "Five Zero Emissions" scenario, under which the role of renewable energy sources is to increase as much as possible, the required nuclear power capacities will be less than 3 GW. The modeling conducted at the Institute of Economics and Forecasting of the NAS of Ukraine using the developed TIMES Ukraines model indicates that under such a scenario, new nuclear power plants will not be built. It should be noted that both scenarios calculated at the Institute of Economics and Forecasting of the NAS of Ukraine will require large-scale investments, which, in the conditions of the existing shortage of financial resources and their economy and rational use, are extraordinary problems for both Ukraine and the entire EU. It is important to understand them in the context of possible changes in the energy sector of EU countries, as well as in the EU economy as a whole and Ukraine in particular.

In its development, the EU economy is going through a period of trade war and the war launched by Russia in Ukraine, due to which it has faced the problem of access to the resource market, including energy, which, in the context of rising electricity prices, significantly reduces its competitiveness. To increase the latter, it is necessary, along with the above, to overcome the barriers that stand in the way of ensuring low-carbon development of the economy of the entire EU, as well as those that are built by the governments of national states to protect their own interests in a situation of instability and threats to its development. The latter are the result of the manifestation of national protectionism, since with further deepening of European integration, individual countries are threatened with the loss of the functioning of certain types of activity due to their relocation to other countries, where more successful conditions for development have been created, which is often due not only to political, but also to natural conditions. Changes of this nature, on the one hand, threaten the growth of unemployment and additional costs for its reduction and social protection of the population in a particular country, and on the other hand, they create additional problems in the issue of ensuring economic security of development.

Particularly problematic according to the topic of this paper is the existing trend in the EU towards "... an integrated energy market (in particular, for the capabilities of a separate EU country – V.H.), which is vulnerable to price increases or even the emergence of deficits, in the event of a crisis in other countries of the continent" [13].

At the same time, existing studies, conducted in particular in Germany, indicate that for "... stimulating growth in Germany and other European countries ... (i.e. for the entire EU economy – V.H.) large integrated markets that will allow companies to increase production are needed... Germany should actively strive for greater European integration in the markets of goods, services, capital and energy markets" [9].

Ukrainian energy is already technologically integrated to a certain extent into the energy system of the EU countries. It is important to take into account the existing need for economic integration, including the electricity market and the EU's interest in Ukraine's integration and energy capabilities, to economically and technologically use the opportunities that are opening up in the field of Ukrainian energy and its economy as a whole.

The economy of the EU countries, which is consistently reoriented towards its low-carbon development, has limited opportunities to meet the growing demand for electricity at the expense of traditional fossil fuel resources, which are also unable to compete in price with electricity generated by nuclear energy. According to A. Kammer, "Europe needs integration. The arguments in favor of a closer economic union are becoming increasingly convincing as external threats grow. ... Geopolitical conflicts have shaken supply chains, disrupted trade and revealed serious vulnerabilities in energy security" [12]. The above means that in the future there is a clear need for the EU to focus on: stabilizing trade, including through the formation of a single energy market; reviving capacities in the use of nuclear energy, the electricity of which is competitive with other sources of generation and satisfies the conditions for the transition to clean energy and entering the "zero emissions" scenario, which will support the declining competitiveness of the European economy.

In the EU, the share of nuclear energy production has decreased, although the demand for electricity is growing, especially in terms of the development of such a technologically promising direction of economic development, which, in accordance with the conditions of the next industrial revolution, requires an orientation towards the use of artificial intelligence in the development of energy-intensive data centers. The functioning of the latter generates dynamically growing needs for electricity. Meeting the demand for it, in turn, requires increasing its competitiveness in terms of price and quality. At this stage, according to the forecast presented in Table 2, electricity needs will be met by nuclear energy. The latter in the EU countries has relatively worn-out capacities, and new construction is needed to replace them.

At present, it is believed that the construction of new large-scale reactors, according to the International Energy Agency, only slightly compensates for the effects of the equipment aging. In the European Union, the share of nuclear power in the electricity structure peaked at 34% in the 1990s and has continued to decline steadily. Overall, the momentum of nuclear power is unbalanced, and therefore, the renewal of the equipment will not be easy, because, for example, France - one of the market leaders in the world and above all in the EU – has in recent years been forced to delay projects due to cost overruns for all new large-scale reactors [21], the construction of which in developed countries has also experienced significant delays and cost overruns in recent years. The highly concentrated market for nuclear technology suppliers may hinder development [21]. At the same time, according to the International Energy Agency, 8 GW of new nuclear capacity was commis-

sioned in 2022, and the "zero emissions" scenario assumes more than four annual deployments by 2030 [22], which is quite a difficult task given the abovementioned problems.

In the current situation, a new Energy Strategy is being developed in Ukraine, taking into account the formation of the Energy Union in the EU and in accordance with the terms of the Memorandum on the full integration of EU energy markets signed by Ukraine. Ukraine, on the path to ensuring its own energy independence, while improving its energy sector, has the opportunity to adequately join the EU common market in the energy sector, in particular, on the basis of its nuclear component. To be able to do this, the country can develop capacities in both technological and resource terms that will provide it not only with an equal and mutually beneficial partnership, but also with the opportunity to become an energy hub for the entire EU.

Leaving aside geopolitical and security risks, the direction of nuclear energy development in Ukraine will depend on a number of key factors:

– the price competitiveness of nuclear energy compared to the prospect of its transformation into a single electricity market model in the EU;

– overall demand for electricity and heat, including the expected growth in demand for "green" electricity and "green" hydrogen;

– actual (residual) potential of production capacities and organizational resources for improving and localizing the production of new reactor plant equipment, turbine and power generator equipment of NPPs due to the localization of the construction of new NPPs in Ukraine, for which there is a necessary industrial base, in particular, national power engineering, which can make Ukrainian nuclear power competitive in terms of electricity prices.

Nowadays, the cost of electricity that can be produced by new nuclear power plants, provided that the declared budget and construction deadlines are not exceeded, is "marginal" at the level of DAM and IDM prices and is significantly inferior to the cost of electricity from other types of generation, including from renewables, even taking into account the technical complexity and additional costs associated with the integration of power plants with non-guaranteed capacity into the Unified State Electric Power System of Ukraine. The possibility of including new nuclear power plants (in particular, SMR) to cover peak load, as well as operation in maneuvering modes, will create the prerequisites for expanding the list of energy services of nuclear power plants and their better adaptation to new market conditions. However, it is obvious that a complete renewal of the equipment of nuclear power units in Ukraine can lead to an increase in the cost of baseload electricity and, under unchanged conditions, increase the price in all segments of the domestic market. Therefore, the justification for such an upgrade will be determined not so much by the financial component of the investment project, but by the sufficiency of compensatory effects in the field of technology and economics, ecology, safety, etc., in accordance with the capabilities of Ukraine, using the existing opportunities to reduce the cost of building new units by localizing the production of power equipment in Ukraine.

The dynamics of the increase in demand for electricity in the post-war period and in the long term will largely determine the role of nuclear generation and its structure in the baseline scenario, which will likely consist of units of existing nuclear power plants (in the event of an extension of their service life), new high-power units and small modular reactors. In the case of slow post-war recovery and limited reconstruction of destroyed industrial facilities, the demand for electricity by the middle of the century may only slightly exceed the pre-war level, so there may not be a special need for the maneuverability of nuclear generation. However, under optimistic assumptions – rapid and sustainable economic growth, decarbonization of all sectors of the economy, expansion of electricity exports, which is possible in the case of competitiveness at the market price, etc. – the need for electricity production may increase threefold compared to the pre-war years. Under such conditions, Energoatom's announced plans to increase nuclear generation capacity by almost twofold, in particular at the expense of the SMR, seem justified. Moreover, it is on this basis that the formation of an energy hub in Ukraine, integrated into the European energy system, is possible.

According to scientists of the National Academy of Sciences of Ukraine, if today Ukraine does not have the opportunity to develop and build nuclear reactors and plans to purchase them from Westinghouse Electric, then there is sufficient domestic scientific, engineering and production potential for the production of the main power equipment of the second circuit (namely, turbines and electric generators). In particular, JSC "Ukrainian Power Machines" (formerly "Turboatom") is a manufacturer of products for nuclear, thermal and hydraulic power plants. According to academician of the National Academy of Sciences of Ukraine A. V. Rusanov, during

the expected construction of the 3rd and 4th power units of the Khmelnytskyi NPP, the 5th and 6th power units of the Khmelnytskyi and South Ukrainian NPPs, the installation of steam turbine power generating units of foreign production on them is inexpedient, since there is a possibility of localizing their production in Ukraine. It would significantly reduce the capital investment and cost of one power unit compared to its counterpart in the USA, which can significantly reduce its total cost. China's experience shows that the development and manufacture of the non-nuclear part of the power unit will make the project economically attractive.

Currently, the Institute of Economics and Forecasting of the NAS of Ukraine, deployed together with the Anatolii Pidhornyi Institute of Power Machines and Systems named after of the NAS of Ukraine (IEMS NAS of Ukraine), is studying the economic consequences of such changes in the organization of financing and construction, during which attention is paid to identifying multiplier effects for the Ukrainian economy, as well as assessing the attractiveness of such changes due to innovations and, accordingly, assessing the dynamics of electricity prices in the conditions of organizing such activities and its competitiveness in the Single European Market.

However, uncertainty, primarily regarding the pace of economic recovery and further growth, currently does not allow to substantiate and predict more or less realistic expected results and accurately provide a quantitative assessment of the capacities of nuclear power plants in the long term. However, the introduction of new nuclear power plants no earlier than 2035–2040 in any case seems justified. This creates a certain margin of time and allows Ukraine to rationally approach the choice of technological and financial solutions for the long-term development of nuclear energy, thereby avoiding sunk costs, and instead creating the basis for a multiplier effect in related sectors of the economy, using the opportunities that open up if Ukraine manages to obtain a solution in terms of the necessary fuel production and reaching the technological level of electricity generation, in particular, at the capacities of small modular reactors, which can be launched in generation.

The popularity of small modular reactors in the world and in Ukraine is growing, but their role is still difficult to assess, since no country has the necessary amount of real practical data on their full-fledged functioning.

The Institute of Economics and Forecasting conducted a study of nuclear energy in general, which assumed that their construction (SMR) will develop intensively. In addition, this study assessed sensitivity scenarios, in particular, with reduced and increased prices for nuclear generation, as well as simulated scenarios with optimistic GDP growth and post-war recovery rates (average GDP growth per year in the period 2020–2025 – 3.7% compared to 1.8% under baseline assumptions and from 2025–2050 – 5.3% compared to 3.1%). Under these conditions, i.e. under the scenario of comprehensive nuclear energy development (and the base price of nuclear power plants), in 2050 the power system capacity will reach 212 GW compared to 122, and in the case of the scenario with basic macroeconomic drivers and SMR capacity –7400 MW already (but taking into account reaching the maximum in wind power capacity), and under the scenario with a reduced cost of nuclear power plants – 10250 MW SMR (and 11620 MW of new large units) with a total capacity of 172 GW.

During our current study, the prospects for hydrogen exports to the EU were also assessed. During its conduct, preliminary but interesting findings emerged. The model has undergone some changes compared to the one in the previous study, we are talking about biomethane thermal power plants with carbon capture to generate negative GHG emissions and offshore wind power plants. Due to the introduction of these same biomethane TPPs under the decarbonization scenario, where no export of green hydrogen (produced exclusively from RES electricity) is envisaged, there are also no SMRs. However, as soon as we force the model to export the smallest amounts of hydrogen, i.e. to take RES from electricity generation in favor of electrolyzers (an increase in electricity production by 6.5%), up to 500 MW of SMRs are immediately introduced by 2050. As the volumes of hydrogen exports in the scenarios and, accordingly, the total electricity production in the UESU increase by 61.5% and 123%, an additional 640 and 2500 MW are introduced in the future (i.e., the maximum among the scenarios is 3 GW), and the generation from these SMR capacities in the three scenarios relative to the absolute increase in electricity production in 2050 is 29%, 6.8%, and 9.3%, respectively. It should be noted that a relatively small increase may also occur due to the introduction of new large power units up to 4 GW. We continue our research in these areas.

The price of large and small units for all simulations is set at the same level due to the presence of very different assumptions in the world. On the one hand, a higher price of SMR is assumed compared to new large reactors for the reasons that it is always cheaper to produce a large product than the same small one, and also because they are new developments compared to large reactors III and III+, which are in operation or under construction around the world. On the other hand, it is argued that with the mass sequential construction of SMR,

which will take place at a much higher speed than the construction of large NPP units, there will be much more reference data on the basis of which the technology will become cheaper and scalable over time (learning curve).

In conclusion, we emphasize that all the above results may indicate the potential importance of SMR technology for power generation in the Ukrainian power system SMR and their prospects compared to the construction of large reactors. Under the conditions of optimistic post-war growth and optimistic prices of SMR, rapid spread of technology and high competitiveness compared to wind and solar power plants is possible. It can also be stated that new nuclear power units are not key to achieving carbon neutrality, but *under the conditions of active development of bioenergy technologies and carbon capture technologies*. Further targeted modeling is needed on the most advanced version of the model to determine the probability of approaching the technological level of SMR to perfection. It is seen that prospective studies will take into account all aspects of the abovementioned studies, namely the price sensitivity of the cost of separate small and large nuclear power plants, the price sensitivity of renewable energy, the price sensitivity or different potential of bioenergy technologies, carbon capture technologies, various macroeconomic forecasts, the volumes of guaranteed exports of green hydrogen.

The prospects that open up for the Ukrainian energy sector, according to the possible localization of steam turbine power generating units on new nuclear units in Ukraine, lead to a significant reduction in the cost of construction, and therefore, their operation, and the corresponding emergence of a multiplier effect from such a development scenario. The above confirms not only the expediency of designing and using such equipment, but also the assessment of the consequences of its impact on the development of power engineering in Ukraine as a whole and, accordingly, supporting the development of the Ukrainian economy as technologically advanced and competitive, as well as one that generates and implements innovations of national origin in industrial activity, and gets rid of technological dependence.

Power engineering is the production of equipment for industrial and municipal power engineering, the support of the development of which is strategically important, because over time it is necessary, if not to completely get rid of the existing import dependence, then at least reduce it. The latter began to take place in 2017. If in 2016, exports of power engineering products, as well as steam boilers, except for central heating boilers, exceeded imports by 1.1 times, then since 2017 the situation has changed, and as a result, imports exceeded exports by almost 1.4 times and continued to grow further to 2.7 times in 2021, and in 2024 reached 15.4 times, which is not surprising in the years of war.

It is extremely important that during the specified period there was a significant transformation in the geographical structure of the abovementioned power engineering products (Table 4). In the period from 2016 to 2024, Ukrainian exports in terms of share to the EU-27 grew from 12.9% to 45.5%, and imports decreased from 41.4% to 33.8%, but at the same time, imports of power engineering products to China significantly increased - from 26.5% in 2016 to 43.5% in 2024. In contrast, exports to the CIS countries fell from 48.4% to 17.7% and were reduced to 0% already in 2023.

Table 4. Geographical structure of exports and imports of power engineering products (KVED (Ukrainian Classification of Economic Activities) codes 27.11 and 28.11), as well as steam boilers, except central heating boilers (KVED 2010 code 25.3), %

Countries	Year		
	2016	2021	2024
Export	100.0	100.0	100.0
EU-27	12.9	29.5	45.5
CIS	48.4	46.6	17.7
Russia	42.3	33.1	0.0
China	1.3	8.2	5.1
Import	100.0	100.0	100.0
EU-27	41.4	36.5	33.8
CIS	14.6	8.0	0.0
Russia	12.8	6.0	0.0
China	**26.5**	**34.0**	**43.5**

Source: compiled from data [23]

Thus, during the specified period, there was a structural diversification of export-import activity in Ukraine for power engineering products against the background of a significant dependence of its production on export-import activity. Moreover, such dependence is special. Thus, exports mainly of those types of products that (according to the data available for 2021) are produced by Ukraine, in the structure of industrial and final consumption for electrical equipment reached 66.2%, and gross fixed capital formation was only 7.4%, that is, domestic production was export-oriented while domestic consumption depended on imports. Such a structure of interdependence of power engineering products on exports and imports, on the one hand, is determined by fluctuations in global markets, and on the other hand, indicates a high degree of both technological dependence and price fluctuations. It is important to note that, despite the war, the production of equipment in Ukraine, which by classification includes the production of electric motors, generators, transformers, turbines (ex-

cept for aircraft) and engines (except for aircraft), motor vehicles and motorcycles, in 2024 according to the index of industrial production by type of activity was restored to the level of 2024. Such dynamics gives grounds to argue that to reduce import dependence it is possible, in particular, develop national production of the abovementioned steam turbine power generating units. It should be noted that the possible scale of their production in Ukraine will significantly reduce the cost of construction of one power unit. Establishing the production of the abovementioned products, which are classified as power engineering, will be a significant contribution to reducing Ukraine's dependence on imports of power engineering products. In the case of uniform distribution, the expected savings on the construction of a new power unit, which, depending on the complexity of the project, can last from 5 up to 10 years, is comparable to a certain extent with the current volume of imports of the relevant power engineering products. On average, over the past 5 years, the number of imports paid for has fluctuated at the level of 1 billion USD. Such a reorientation of domestic demand from dominant import dependence to meeting the needs in the development of national power engineering for the production of electricity using nuclear technologies will undoubtedly increase the level of technological independence of the Ukrainian economy and, accordingly, ensure both its energy and economic security. The latter is extremely important, since in Ukraine, for example, the share of imports in intermediate consumption for the production of machinery and equipment in 2021 was 93.2%. This is the highest and most critical value among all other types of industrial products for domestic consumption.

Conclusions

1. The scale of liberalization of economic activity in Ukraine during the transformation period of transition from a planned to a market economy, which had the character of a shock, led to structural transformations in the economy, when products with a relatively lower added value were able to play a dominant role, which turned out to be competitive in price and capable of ensuring export growth in the conditions of post-transformation recovery.

2. In reality, the recovery of economic activity after the recession of the 1990s took place with the dominance, on the one hand, of products with relatively low technological levels in exports, and on the other, of high-tech imports, which formed technological dependence, which in the new conditions led to the fact that the Ukrainian economy became characterized by an extremely high degree of openness and the dependence of economic growth of the economy as a whole on price fluctuations in world markets for natural resources and products with a low specific weight of added value.

3. In the global dimension, the "new reality", characterized by instability and uncertainty, means that for the further development of the economy based on innovative solutions, which will reduce both the degree of openness and technological dependence, it is necessary to dominate the processes of accumulation of production factors.

4. To solve a number of key problems of further growth of economic activity on the basis of its innovation, it is necessary to achieve energy saving, which can be ensured, in particular, by modernizing the nuclear power industry of Ukraine with the expansion of the scale of its localization at the expense of Ukrainian power engineering, in particular, by the production of power generating units of national production. The scale of use of the latter in the process of building new ones and expanding the capabilities of existing nuclear power plants is able to both implement import substitution equivalent in cost and ensure the investment attractiveness of energy projects, in particular, for investors from EU countries, where there are opportunities for accumulation, as shown in the paper, of the necessary innovative resources.

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Енергетичне машинобудування в інноваційних змінах характеру економічної діяльності

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Вивчення процесів трансформації економічної діяльності в Україні під час реалізації політики переходу від планово-розподільної до ринково організованої системи підтвердило, що трансформації відбулися завдяки пакету інноваційних змін, що стосувалися передусім економічних і соціальних складових. Як результат, протягом періоду майже в 15 років було сформовано і визнано на міжнародному рівні, зокрема, з боку США у 2006 р., економіку України ринково орієнтованою. У процесі переходу відбулися певні зміни в економічній діяльності, що мали ознаки її деіндустріалізації, перш за все за рахунок падіння виробництва в обробній промисловості, продукція якої на ринках мала як низьку конкурентоспроможність, так і обмежені можливості реалізації на внутрішньому й в зовнішньому ринках. Паралельно поступово налагоджувалися процеси економічної діяльності, головними ознаками яких мало місце розширення, з одного боку, традиційних видів діяльності з порівняно низьким ступенем технологічної складності, а з другого – тих видів діяльності, які забезпечували функціонування економіки в умовах ринку, а також мала місце обмеженість у нагромадженні факторів економічного росту на основі інноваційних напрацювань, які зумовлювали б розвиток виробництв із порівняно високим ступенем доданої вартості. До складу таких видів діяльності входить, зокрема, ядерна енергетика, для функціонування і розвитку якої в умовах «нової реальності» необхідні нові потужності, що замінять ті, строк експлуатації яких закінчується, й нарощення генерації енергії в цілях забезпечення повоєнної реструктуризації економіки. Як показують результати дослідження, нині в ядерній енергетиці України існує можливість локалізації окремих видів діяльності за рахунок потужностей українського енергетичного машинобудування, що суттєво знизить вартість відповідних проєктів, а це надважливо в умовах обмеженості фінансових ресурсів і зростаючої вартості будівництва нових. У роботі на основі виокремлення особливостей «нової реальності» економічної діяльності екзогенного походження презентовано можливості й обґрунтовано доцільність розвитку й використання енергетичного машинобудування в інноваційних змінах характеру економічної діяльності.

***Ключові слова**: економічна діяльність, трансформаційний шок, єдиний ринок, ядерна енергетика, енергетична безпека, енергетичне машинобудування, інновації і локалізація.*

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