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THE ENERGY STRATEGY: FORECASTS AND REALITY (REVIEW)

Introduction. *At the present stage of the development of Ukraine, in the face of challenges and risks, it is extremely important to formulate the national energy policy.*

Problem Statement. *The energy development strategy of Ukraine shall provide for the transition from the import of raw materials to the energy-efficient development of the fuel and energy complex using the results of fundamental and applied research in the field of natural and socio-economic sciences, the domestic innovative potential and R&D projects.*

Purpose. *To overview the conceptual approaches related to forecasting (predicting, foresight) the life of society as a whole, and the development of power engineering, in particular.*

Materials and Methods. *A literary review of authoritative sources on methods for forecasting the development of power engineering, including that in Ukraine, has been presented.*

Results. *The research presents a retrospective look at the status of Ukraine's power engineering until the 1990s and in the period of independence of the state. It was emphasized that the energy strategies of Ukraine as adopted in 1996, 2006, and in 2013 did not reach their purposes and indicators even in the medium-term prospects. In 2017, Ukraine adopted the fourth energy strategy, with the following main targets: safety, energy efficiency, and competitiveness. The last (fourth) energy strategy (ES-35) was developed in extreme conditions, under the influence of global changes in the world energy trends and numerous challenges for the domestic power engineering. Illustrative energy development schemes that characterize the complexity of energy forecasting and the need to take into account a number of key factors have been presented. The energy strategy of Ukraine and, in particular the ES-35, will depend on "the energy contours of the new world", i.e. the energy trends and scenarios, as well as the global and local risks. The expected key parameters and indicators of the energy strategy may not coincide with the implemented values.*

Conclusions. *The energy strategy of Ukraine (in particular, the ES-35) depends on "the energy contours of the new world," i.e. the energy trends and scenarios, as well as the global and local risks. The expected key parameters and indicators of the energy strategy may not coincide with the implemented values.*

Keywords: fuel and energy complex, energy strategy, forecasting, strategy implementation, management and monitoring, and roadmap.

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Ukrainian power engineering is the foundation of the national economy, one of the main preconditions for social stability and national security. In 2015, this sector of the economy generated about USD 133 billion tax payments to the national budget (25% of the total). Ukraine's integrated energy system is the sixth largest in Europe falling behind Germany, France, Italy, Spain, and the United Kingdom. 450,000 engineers and workers (3% of the employed population) are engaged in the Ukrainian energy sector. The domestic power engineering is a driver for the development of other industries. At the same time, there are several industries that affect the energy sector [1].

Ukraine's power engineering was a powerful component of the USSR's fuel and energy complex (FEC). Significant changes in the conditions and opportunities for power engineering development were associated with a significant increase in the cost of oil and gas production and transportation from the North, Western Siberia since the late 1970s and the enhancing role of FEC required a new long-term energy development program. In 1984, the Benchmarks of the Long-Term Energy Program of the USSR and the *Energocomplex* Republican (USSR) Comprehensive Target R&D Program were adopted. However, global political changes in the USSR and in the world (the perestroika, the collapse of the USSR and the entire social camp) have negated the goals and objectives of the programs. Having got independence, Ukraine was tasked with developing a national energy development strategy.

Until the 1990s, Ukraine had a well-developed fuel and energy complex with a high R&D potential as compared with foreign counterparts. In the next period, in the conditions of socio-political and economic shocks, only the accumulated potential, without any support of fundamental scholarly research, was used. Then, gradual underachievement with respect to foreign technological and technical innovations began, with imported equipment flowing into the domestic market. This was especially true for municipal power engineering, heat supply systems and equipment. Foreign producers got an opportunity to build up their production base at the expense of Ukrainian taxpayers. At some stage of economic development, in the period of reforms, it is possible or even necessary to purchase foreign equipment, to adopt foreign experience in the creation of innovative technologies (a good copy is as valuable as its original). For a while, this could be an impetus for searching domestic R&D solutions for the creation of energy efficient equipment and innovative technologies (with the necessary protection of intellectual property). However, it should be a temporary measure. At the same time, Ukraine needed to create its own energy strategy in the context of current trends of the development of R&D progress in the field of energy, in particular, given the fact that in Ukraine, raising energy efficiency still has not been fully utilized as energy resource.

At the present stage, the main goal of new energy development strategy should be the transition from imported raw materials to energy-oriented development of fuel and energy using the results of fundamental and applied research in the field of natural and socio-economic sciences and the development of domestic innovative R&D potential. All this should be based on new conceptual approaches, in the context of key internal and external risks and challenges of the development of fuel and energy complex, in close connection between the components of energy-economy-ecology triangle and a high pace of scientific knowledge growth [2].

Since 1996, Ukraine has had four energy strategies [3—6]. The first three ones (1996, 2006, 2013) failed to reach the projected targets and indicators. Their impracticability was evident as early as at intermediate intervals, with the subsequent strategies adopted before the expiration of the previous one.

In 2017, a new Energy Strategy of Ukraine for the period up to 2035 (ES-35) [6] was adopted as a symbiosis of the draft Energy Strategy of Ukraine for the period up to 2035 (developed by the

National Institute for Strategic Studies, NISS) and the *New Energy Strategy of Ukraine until 2020: Security, Energy Efficiency, and Competition* (designed by the Razumkov Center in cooperation with the Friedrich Naumann Foundation (Germany) in Ukraine). The proposals received for the EC-35 were elaborated using *Psychea Expertus* program (PSYCHEA R&D Center).

The ultimate goal of the ES-35 is to maximize the contribution of the energy sector to the growth of the national gross domestic product with a significant increase in its energy efficiency index (oil ton equivalent per USD 1000) and to ensure energy security at minimum costs for implementing the ES-35 measures. This goal is also reflected in the title *ES-35: Security, Energy Efficiency, and Competitiveness*. For the first time in the documents of such kind, energy efficiency has been identified as a key priority.

It is too early to talk about any trends in the implementation of the latest *Energy Strategy of Ukraine for the period up to 2035: Security, Energy Efficiency, and Competitiveness* (ES-35) [6]. We hope the ES-35 will achieve its ambitious goals. The Energy Strategies of Russia ES-10, ES-20, and ES-30 were also unsuccessful, with the last one transformed into ES-35, in 2014. The targets as determined by international agreements (the Kyoto Protocol) were not reached and the indicators of well-known ES *20-20-20 Program* were revised. Some countries that signed the Paris Agreement in 2015 have been tending to change their position. Proceeding from the above, the targets and indicators of these agreements may also be questionable.

One hundred and twenty-five countries joining the Paris Agreement have undertaken to reduce their greenhouse gas emissions by 2025 as compared with 2005, in order to prevent a more than 2 °C increase in the global temperature. The Agreement comes into effect upon its ratification in, at least, 55% of the countries producing, at least, 55% of the world greenhouse gas.

What are the reasons for such poor results of implementation of strategies? Are they caused by improper forecasting methods and tools, mismanagement of paths and mechanisms of implementation, socio-economic and geopolitical turbulence, or by the global financial and economic crisis? Or is it generally impossible to know the future over a rather long term?

Below, there is an overview of conceptual approaches related to forecasting (predicting, precognizing) the society, in general, and the energy development, in particular. The approaches to the problem of predicting the future have been analyzed in [7]. Many eminent philosophers and economic theorists insisted on the unpredictability of future knowledge as fundamental thesis. Joseph Schumpeter, a prominent economist, believed, "*Any prediction is extrascientific prophecy that attempts to do more than to diagnose observable tendencies and to state what results would be if these tendencies should work themselves out according to their logic*" [7]. F.A. Hayek, another outstanding economist and Nobel Prize winner, noted that *the events of the present were so different from the historical past that nobody could know where they would lead to. Looking back, one could understand the events of the past by tracking and evaluating their effects. However, the present events are not history. They are directed into the unknown and one can hardly ever say what to expect* [8]. Ilya Prigogine, Nobel Prize winner, physicist and chemist, commented the unpredictability of the future, "*We can, of course, extrapolate existing knowledge beyond our vision and make assumptions about the mechanism governing the dynamics of the universe. However, we should not forget that, although in principle we can know the initial conditions at an infinite number of points, the future, however, remains fundamentally unpredictable*" [9]. Philosopher of the 20th century Karl Popper, through a logical chain (syllogism), claimed that since the growth of human *knowledge* could not be predicted, the future course of human (state or region) history was not foreseeable [10]. Indeed, defense and leading industries have a dramatic impact on the history of any state, but they depend on disruptive innovations and groundbreaking technologies based on new scientific knowledge the growth of which is unpredictable.

Even two or three decades ago, it was impossible to predict the sixth technological wave. It is based on interdisciplinary scientific approaches, in particular, on the self-organization theory, synergetics, as well as on socio-, cognito-, bio-, info-, and nanotechnology (SCBIN) [11].

Future disruptive technologies are also unpredictable. Speaking about the scientific discoveries of the future, Petr Kapitsa claimed that new phenomenon of the nature was a physical phenomenon that could be neither foreseen nor explained based on already existing theoretical concepts. In his opinion, *the most valuable thing in science on which great science is based is unplannable, because it is achieved by a creative process, the success of which depends on the genius of the scientist* [12]. Vadym Loktev, Full member of the NAS of Ukraine says, "... *any discovery is unforeseen by definition and, therefore, is unpredictable in terms of both time and place. It is rather believed, a breakthrough is more expectable in a highly skilled environment, the sole purpose of which is fundamental research without any reference to anything specific*" [13].

To summarize the above, we cite T.I. Oizerman who has formulated the two sociological laws, namely: 1) *significant, increasingly multiplied over time part of consequences of human activity, both in a particular country and on the entire Earth is unpredictable (unknowable);* 2) *the future scientific knowledge is unpredictable (unknowable), therefore various social consequences are inevitable* [7].

The above opinions on unpredictability of the future can lead to mistrust of forecasting as such. There are limits beyond which any forecasts become fantasy. This is true for long-term horizons. At relatively short time intervals, in the absence of force majeure shocks, forecasts are undoubtedly necessary since they can describe the immediate future, albeit with some inaccuracies. *Unless there is forecasting, neither successful development of social production, nor implementation of social programs nor more or less controllable social processes are possible* [7].

The risk of unpredictable development concerns power engineering like many other economic industries. Proceeding from the above, the problem of forecasting (in the form of a formalized energy strategy, as a regulatory document) shall be studied. At the same time, the power engineering complex shall be analyzed not only as a physical and technical production system, but also as a basic industry of national economy, in the context of the energy-economy-ecology triangle, with different factors, direct links, and feedbacks inside the triangle taken into consideration.

Assessing the prospects for the development of any economic sector and, in particular, power engineering, is a complex process that requires in-depth knowledge of technology, forecasting tools, analytical experience, opinions, and hypotheses

R&D Expenditure on the Development of Key Power Engineering Technologies *

Key Power Engineering Technologies **	Expenditure, USD trillion
Electric power generation:	3.2—3.8
nuclear power plants	0.6—0.75
wind power plants	0.6—0.7
coal installations with supercritical steam parameters	0.35—0.4
coal-fired power plants	0.35—0.4
cogeneration plants with biomass gasification	0.1—0.13
solar energy-to-biomass converters	0.2—0.24
solar energy concentrators	0.3—0.35
O_2 capture and disposal at thermal power plants	0.7—0.8
Buildings and structures (thermal power engineering, ultimate consumption):	0.32—0.42
energy efficient buildings and appliances	No data available
heat pumps	0.07—0.12
solar heating systems and water heating	0.25—0.3

* the data is given for 2007; based on [18]; ** the data are given for the case of reducing greenhouse gas emissions in 2050 down to the level of 2005 (28 million tons of CO_2 equivalent).

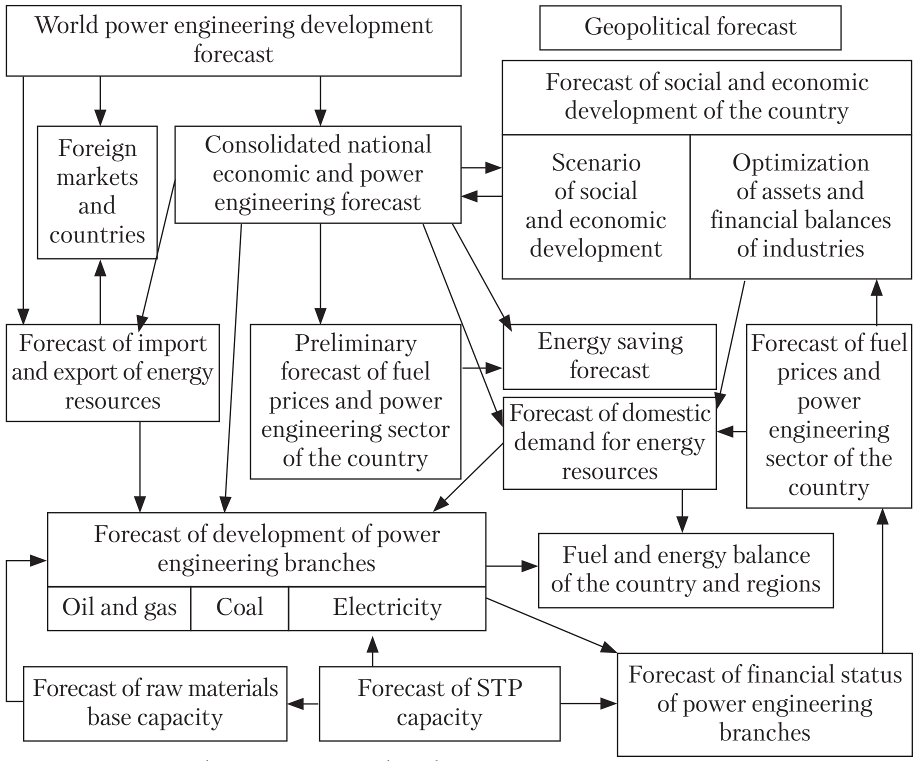

Fig. 1. Energy Market Forecasting Flowchart [16]

of experts in the field of energy and cross-sector problems.

Forecasting is a scientifically justified assumption about possible conditions of the system in the future and / or about alternative ways and terms of reaching the target condition [14]. With regard to the FEC development strategy, the forecast, in our opinion, is a scientifically justified identification of goals, priorities, tasks, directions and mechanisms of their realization proceeding from the existing state of the economy, R&D progress (or innovative development of science and technology), the legal framework and other factors that determine the development of power engineering. The forecast of energy development is a symbiosis of two components of forecast development: the research and the regulatory approaches [15].

The term classification of forecasts is relative and depends on the nature of the object and the purpose of forecast. The socio-economic forecasts are divided into the real-time, for a period up to one month; the short-term, for up to one year; the medium-term, for several years; the long-term, for a period over five years, up to about 15—20 years; and the strategic forecasts for a period beyond the long-term horizon [15].

A multilevel flowchart of power engineering development is presented in Fig. 1 [16]. Each block of this chart (for instance, the forecast of internal energy consumption) has its own inter-branch connections (Fig. 2) [17].

The charts shown in Figs. 1 and 2, with some adaptation, characterize the complexity of interrelations within the FEC of Ukraine. The R&D components of thermal power engineering sector are shown in Fig. 3 [18]. Table shows the main forecasting methods in the field of electric and thermal power engineering, as well as estimate of investments in power engineering for the period up to 2050.

The Figures and Table show the complexity of the energy forecasting. It is necessary to make

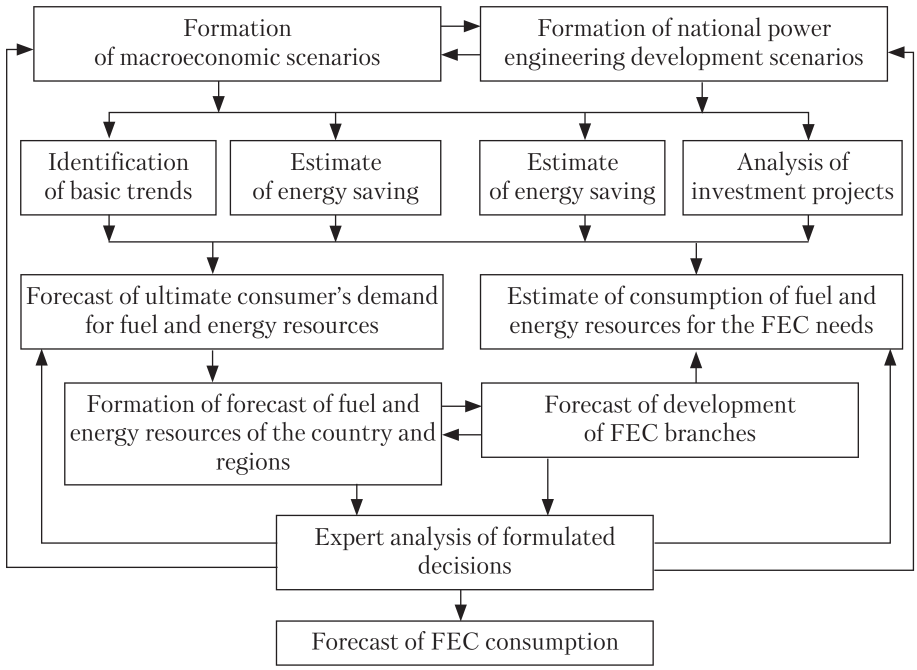

Fig. 2. Flowchart of Forecasting of Energy Consumption at the National and the Regional Levels [17]

cross-sectoral coordination of forecasts of economic and energy development, world economy development, possible trends in national and geopolitical events, based on the results of fundamental research in numerous directions. However, it is impossible to take into account the large number of key factors with a high uncertainty, as well as the risks and challenges of different nature ("activated environment impact"). *Forecasting has nothing to do with trying to take a guess on details of the future; it proceeds from the dialectical determination of the phenomena of the future, from the fact that necessity paves the way through chance. With respect to the phenomena of the future, we need a probabilistic approach taking into consideration a wide range of possible options. Forecast solutions are region of acceptable out of many possible ones* [15].

Unlike physical and engineering systems, such complex systems as power engineering do not have the most important property for modeling, which is the invariability of their basic parameters in the observed retrospective in the forecast period [16]. *Any tool for forecasting the production systems can give acceptable for practical purposes ranges of key (but far from all) parameters of the system dynamics rather than reliable trajectories of their development. In fact, it is intended to facilitate and to accelerate the human cognition and the prediction of behavior of such systems that are always incomplete and infinite, using means* of *procedures, models, and information* [16]. It is difficult to make long-term forecasts because their key indicators vary constantly depending on the number of unforeseen circumstances, both in the current and in the forecasted period. *Assessing the prospects for system development is a great challenge because of growing uncertainties that exist in any dynamic process. The further the prospect, the greater the impact of the incompleteness of knowledge. Accordingly, the forecast time management is limited. This limitation stems from the fact that there is a nonlinear increase in uncertainty as we move into the future* [15].

Under conditions of geopolitical turbulence and radical changes in the socio-economic structure,

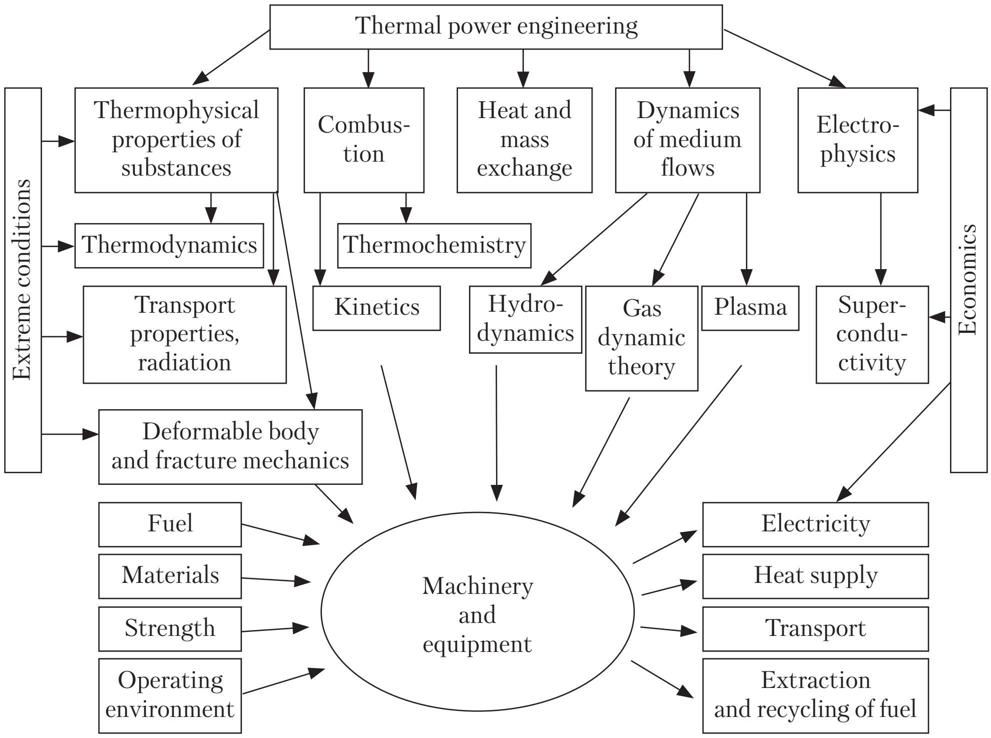

Fig. 3. R&D Aspects of Power Engineering [18]

which are accompanied by a downturn in the economy and, in particular, in power generation, bifurcation points may appear at any time stage of the implementation of the energy strategy. At these bifurcation points, small fluctuations of external influence can get sharply intensified, and forecast indicators for specific time intervals may become hardly reachable. Consequently, the FEC development scenarios may need to be revised accordingly. For some indicators there may be a good match, the others may be in an acceptable agreement, while for some indicators the forecast may fail. The main thing is to determine the range of values of key indicators and trends in the development of power engineering and its individual branches.

As already mentioned, since 1996, Ukraine's energy strategies have been superseding each other before the expiration of each previous one. It was impossible to track the implementation of each strategy's indicator. At provisional stages, the benchmarks, in most cases, were not in line with those forecasted. The reforms of the FEC of Ukraine (in particular, the reasons for their failure), the current challenges for the Ukrainian power engineering sector, the priorities of the FEC development, the short-term tasks, and the mechanisms of energy policy have been sufficiently analyzed in [19].

The latest (fourth) energy strategy (ES-35) was developed under extraordinary conditions of global changes in the world energy trends and influenced by a number of challenges for the domestic power engineering. The ES-35 draft as published on the website of the Ministry of Power Engineering and Coal Industry on December 19, 2016, was analyzed by Ukrainian and European experts and worked out. On June 1, 2017, the revised draft was published, and on August 17, 2017, it was approved by the decision of the Ministry.

Keeping in mind the results of the forecasts of the preceding energy strategies, the expert community has come up with proposals for practical support of the ES-35 [19]. "*In the future, in the case of a change of government, we do not need to reject the current strategy and to develop a new one. It is necessary to monitor the implementation, to understand and to take into account the (world and European) trends, and then to modify it, if necessary*" (S. Golikova, Director of *Transenerhoconsulting*). "*The energy strategy shall set goals for individual sectors of the power engineering industry. However, the tasks and mechanisms (algorithms) of achieving these goals are not the subject of the strategy. They shall be formulated and specified in short-term plans of the government of Ukraine, the competent authorities, and the energy companies for targeting the development goals as defined by the Energy Strategy*" (V. Riabtsev, advisor of the Group for Coordination of the Program for the Energy Sector Reform and Development under the Ministry of Power Engineering and Coal Industry of Ukraine). It has been also proposed to establish an expert working group for monitoring the implementation of energy strategies for specific periods of time. "*It is important that the term for summarizing the results of the Strategy implementation does not raise doubts about this implementation. A specific program should be developed to implement the Strategy in real time. ... It is not necessary to establish a five-year period again! The maximum term of 2 years would be nice*" [20].

Undoubtedly, Ukraine's energy policy and, in particular, the ES-35 will depend on the "new world power circuits", i.e. on energy trends and scenarios, global and local risks. "*In the international arena, it is time for new alliances and interest groups that have already begun to shape new power circuits and to set fresh trends. It is increasingly important to understand the essence of new geopolitical energy processes that will form the basis of the future for the next three to five years. Further, it is extremely difficult to predict*" [21].

The foregoing and other proposals are reduced to the development and adoption of a roadmap [18, 22], "*a meaningful aspect of which shall contain specific mechanisms for implementing realistic benchmarks and be based on appropriate financial sources, resources, and potential needs*" [22].

Thus, in the situation with many uncertain factors, in addition to the developed strategy (in particular, ES-35), in order to eliminate (minimize) the discrepancy between the expected forecast indicators and the real ones, it would be advisable, in the case of variable conditions, changes in the trends, emergence and exacerbation of new risks and challenges, to review/amend/modify the long-term forecast of the power engineering industry development, to monitor its realization using current (short-term) plans at relatively short intervals (three to five years) during which, according to expert estimates, there will be no radical changes or transformations in the national power engineering complex ("the controllable object"). This means the realization of ongoing forecasting every time as new information is received. In this case, the energy strategy becomes a flexible document, an action guide instead of being a mere declaration. General trends in energy development may change as goals and objectives of the national economy are modified.

Supporting the energy strategy with "current plans and forecasts" will reduce the severity of discussions between those who stand for different energy development trends. For example, the advocates of nuclear energy do not share, in the long run, an optimistic enthusiasm of the proponents of renewable energy. The latter have their reasons against the use of nuclear energy and hope for almost complete transition of Ukraine to renewable energy by 2050 [23].

As mentioned above, the forecasted indicators of the previously adopted three energy strategies of Ukraine and the two strategies of Russia did not coincide with the real ones as early as at intermediate time intervals. "*In essence, forecasting is a probabilistic experiment in which different events can occur under the same conditions, i.e. the experiment is a function defined on many events*" [24]. The problem of energy forecast quality has not been well developed, as there have been no established criteria to evaluate objectively the advantages and disadvantages of a given forecasting system [24].

The history of systematic forecasting in power engineering has counted about 40 years. It is possible to compare the forecasted and the real indicators over many years and to assess the quality of forecasting based on the statistical data. The problems related to assessing the quality of the forecasting systems have been discussed in [24].

The leading forecasting centers (such as the International Energy Agency (IEA) and the US Department of Energy (DOE) are limited to fragmentary assessment of the accuracy of their forecasts. This assessment is usually reduced to tables of relative errors determined from the available forecasted and real values over years. They give only an intuitive estimate of the forecast quality based on the assumption that 1% relative error is good and 10% is bad.

Having generalized the results of the analysis of long-term forecasts of the world energy market, a research program has been proposed as part of creating a methodology for assessing the quality of forecasting systems and analyzing the prospects for the development of energy markets [24].

Despite the lack of objective criteria for assessing the quality of forecasting tools [16, 24], systematic forecasting of power engineering as an integral part of the energy-economy-ecology triangle has been widely recognized and used in leading energy countries.

Are long-term forecasts of the development of power engineering and carbon dioxide (the greenhouse gas that has the largest share in atmospheric contamination resulting from anthropogenic activity) emissions possible? The experts from leading national and international institutions have different views on this issue. Some of them, based on the results of unjustified forecasts, are prone to a negative answer. Others, having developed the method of the so-called genetic forecast of the world energy, consider it a very reliable tool for forecasting scenarios of energy development and future changes in the environment and climate [25]. This allows them to formulate fundamental conclusions on the development of energy in the coming decades [25] as follows:

1) the stabilization of national specific energy consumption per capita at a certain level is mainly determined by climatic and geographical factors;

2) a steady and practically linear decrease in the amount of carbon dioxide per unit of energy consumption, as a result of changes in the structure of the fuel and energy balance, has been observed for more than one hundred years (the transition from coal to oil, gas and, recently, to renewable energy).

In the world, several energy forecasting systems have been proposed by the IEA, the US DOE, the International Institute for Applied Analysis, several research centers of the European Commission and the United Nations. In Russia, it is the Model-Information System for the Study of Prospects of the Energy Industry (MISPEI); in Ukraine, it is the *Foresight* program created by the Institute for System Analysis of Igor Sikorsky Kyiv Polytechnic Institute National Technical University of Ukraine, *TIMES-Ukraine* macroeconomic model of energy development strategy, intertemporal equilibrium model of the Institute for Economics and Forecasting of the NAS of Ukraine, and *Psychea Expertus*-model. There are also other models, including LEAP (Long-Range Energy Alternatives) model, Holt-Winters model, MARKAL/TIMES, etc.

It is hoped that the policy of Ukraine's FEC development will be implemented taking into consideration the results of enhanced transdisciplinarity in science and energy-related technologies. In the last decade, there has been a trend to intellectualization in computer science and computer technology. The strategic European framework program *Horizon 2020* has opened an era of intensive development of the so-called smart technologies. All smart systems are result of transdisciplinary collaboration. To support this endeavor, the European Joint Technology Initiative (JTI) and the Electronic Components and Systems for European Leadership (ECSEL), powerful European leadership association, have been created.

Every year, ECSEL publishes a strategic plan for the implementation of research and innovation in the electronic components of systems and technologies that ensure the development of functional domains of modern digital society, such as energy, transport, manufacture, ecology, and others [26]. The word “smart” means not only having or showing a quick-witted intelligence, it is also an acronym, with each character denoting the criteria for setting the goal to achieve: **s**pecific, **m**easurable, **a**ttainable, **r**elevant, and **t**ime-bounded [26]. Research in this direction is being carried out at the Glushkov Institute of Cybernetics of the NAS of Ukraine.

The problem of modeling the new electricity market in Ukraine gets more and more relevant. The Law of Ukraine on the Electricity Market of Ukraine ratified in 2017 establishes the principles of operation of new domestic electricity market. Today, in Ukraine, there is a complicated process of implementation of the relevant European legislation, including the “third energy package”. A prerequisite for making good decisions about changing the market regulation mechanisms is to use mathematical models that enable assessing the consequences of implemented decisions and determining which ones are effective and which are wrong. That is why the problem of mathematical modeling of competitive equilibrium in the electricity market becomes so important. The simulation of the state of competitive equilibrium is associated with searching such prices for electricity in power units and such amount of generation, supply, and consumption of electricity, at which each participant (agent) reaches its own goals: to maximize its own well-being; for the consumer, to maximize the supply of electricity to consumers, for the supplier; to maximize its own profit, for the generating company; and to maximize assistance to market participants in fulfilling their obligations, for the operator of the electricity transmission system. This issue has been studied by the Pukhov Institute of Modelling Problems in Power Engineering of the NAS of Ukraine [27].

The realities of the modern world are such as the forecasting of strategic prospects for energy development shall inevitably pass through bifurcation points, the exit from which may change the scenarios of the development of power engineering as industry (for example, the abrupt changes in the world oil prices, in 2000—2018). The expected key indicators may not match the real values. As noted in [16, 24], the modern science has not yet had any methods for predicting confidently the development of power engineering for a long period, but the experience of forecast models gives grounds for restrained optimism about building consistent scenarios, albeit without assessing their completeness and probability of realization. Supporting the energy strategy with “current forecast plans” (road maps) adds optimism about the implementation of such a regulatory document. To this end, it is necessary to solve the problem of organizing the implementation of the ES-35 with a clear definition of the mechanisms of implementation of tasks for the executive and legislative authorities with constant monitoring of the implementation of the ES-35 at intermediate stages. Alternatively, it has been proposed to create a specialized structure, a sort of energy strategy institute, with the involvement of independent experts to prepare roadmaps for power engineering foresights [28]. It seems, establishing such an institute is too much, but a committee (task force) of experts and decision makers in the field of power engineering, economics, and ecology would be appropriate. This committee shall include all originators of the ES-35: NISS, the Razumkov Center, PSYCHEA, the Ministry of Power Engineering and Coal Industry, the relevant branches of the NAS of Ukraine [2, 23, 29, 30], in particular, the Department for Physical and Technical Problems of Power Engineering, and the Department of Economics, which are involved in energy policy-making studies for the future.

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ЕНЕРГЕТИЧНА СТРАТЕГІЯ: ПРОГНОЗИ І РЕАЛІЇ (ОГЛЯД)

Вступ. На сучасному етапі розвитку України в умовах викликів і ризиків вкрай важливо сформувати енергетичну політику країни.

Проблематика. Стратегія розвитку енергетики України повинна передбачати перехід від імпортно-сировинного до енергоефективно-орієнтованого розвитку ПЕК з використанням результатів фундаментальних і прикладних досліджень в галузі природничих і соціально-економічних наук, вітчизняного інноваційного потенціалу з його науково-технічними та науково-технологічними розробками.

Мета. Виконати огляд концептуальних підходів, пов'язаних з прогнозуванням (пророкуванням, передбаченням) життя суспільства загалом, і прогнозуванням розвитку енергетики, зокрема.

Матеріали й методи. Огляд авторитетних джерел літератури щодо методів прогнозування розвитку енергетики, зокрема й, розвитку енергетики України.

Результати. Наведено ретроспективний погляд на стан енергетики України до 90-их рр. XX ст. і у період незалежності держави. Підкреслено, що прийняті енергетичні стратегії України в 1996, 2006 і 2013 роках не досягали своїх прогнозованих цілей та індикативних показників вже на проміжних часових інтервалах. Четверта енергетична стратегія (ЕС–35) головними цільовими орієнтирами має безпеку, енергоефективність і конкурентоспроможність. Вона розроблялася в надзвичайних умовах — при глобальних змінах трендів світової енергетики та під впливом низки викликів для вітчизняної енергетики. Наведено ілюстративні схеми розвитку енергетики, які характеризують всю складність прогнозування енергетики, необхідність урахування ряду ключових чинників. Енергетична стратегія України, й зокрема ЕС–35, буде залежати від «енергетичних контурів нового світу» — енергетичних трендів і сценаріїв, глобальних і локальних ризиків. Очікувані ключові параметри та показники енергетичної стратегії можуть не збігатися з реалізованими значеннями.

Висновки. Запропоновано супроводжувати енергетичну стратегію «поточними планами-прогнозами» (дорожніми картами) з чітким визначенням механізмів імплементації завдань для виконавчої та законодавчої влади з постійним моніторингом ходу реалізації ЕС–35 за тимчасовими інтервалами.

Ключові слова: паливно-енергетичний комплекс, енергетична стратегія, прогнозування, реалізація стратегії, управління і моніторинг, дорожня карта.