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MODELING THE DEVELOPMENT STRATEGY OF ALTERNATIVE ENERGY INDUSTRY ENTERPRISES IN CONDITIONS OF MARTIAL LAW AND POSTWAR

МОДЕЛЮВАННЯ СТРАТЕГІЇ РОЗВИТКУ ПІДПРИЄМСТВ В ГАЛУЗІ АЛЬТЕРНАТИВНОЇ ЕНЕРГЕТИКИ В УМОВАХ ВОЄННОГО ТА ПІСЛЯВОЄННОГО СТАНУ

The article highlights the results of the economic and mathematical modeling to determine the development strategy of the "green" energy industry enterprises in the conditions of martial law and postwar. Two models were considered. The first model assumes that the current value of capacity is depended not only on Feed-in-tariff and Cost, but also the installed capacity in previous period. The second model describes the main factors affecting energy production, including demand, monthly average purchase/sale price and installed capacity, and production in previous period. Then calculations were carried out with a scenario approach to determine the optimal development strategies for the enterprises. Based on these models, it was determined that for enterprises in the "green" energy industry, in the first "pessimistic" scenario, the generated energy should be sold on the international market, and in the second "optimistic" on the domestic one.

Keywords: *alternative energy, Feed-in-tariff, econometric modeling, autoregression models, method of instrumental variables, scenario modeling.*

У статті висвітлено результати проведеного економіко-математичного моделювання для визначення стратегії розвитку підприємств в галузі «зеленої» енергетики в умовах воєнного та післявоєнного стану, в залежності від ринку купівлі/продажу виробленої енергії. На підставі аналізу статистичних та аналітичних матеріалів, а також наукових здобутків як вітчизняних, так і зарубіжних науковців, доведено актуальність вивчення розвитку ринку альтернативної енергії в умовах переходу енергетичної системи України до європейської мережі, впливу ведення активних бойових дій на території локалізації значної кількості встановленої потужності та зменшення частки відновлювальних джерел енергії в загальному виробництві енергії в Україні. Під час дослідження було розглянуто дві моделі. Перша модель описує вплив держави на виробництво енергії з альтернативних джерел за допомогою економіко-математичного моделювання виробництва енергії на прикладі вітряних електростанцій. Для постановки моделі припускаємо, що на поточне значення залежної змінної (потужність) впливають не лише незалежні змінні («зелений» тариф та собівартість енергії), а також й кількість встановленої потужності у попередніх періодах, тобто лагова залежна змінна. Друга модель описує основні фактори, що впливають на виробництво енергії (залежна змінна), зокрема враховано попит, середньомісячну врівноважену ціну купівлі/продажу та кількість встановленої потужності, а також лагову змінну – виробництво у попередніх періодах. Для аналізу виділили два основних ринку збуту виробленої енергії – зовнішній (ринок експорту) та внутрішній (ринок «на добу наперед»), для кожного з яких побудували авторегресійні моделі. На основі знайдених моделей, провели розрахунок зі сценарним підходом для визначення оптимальних стратегій розвитку підприємств. За результатами економіко-математичного моделювання визначили, що для підприємств в галузі «зеленої» енергетики при першому «песимістичному» сценарії слід продавати вироблену енергію на зовнішній ринок, а при другому «оптимістичному» – на внутрішній.

Ключові слова: *альтернативна енергетика, «зелений» тариф, економетричне моделювання, авторегресійні моделі, метод інструментальних змінних, сценарне моделювання.*

Problem statement. Over the past decades, the energy issue has been one of the most pressing for humanity. Today, to solve this issue, a gradual transition to the use of alternative energy sources is being carried out, which makes it possible to overcome a number of world problems. They are climate change, energy security and country independence, cheaper energy prices, etc. Reducing Ukraine's energy dependence on traditional fuel resources is possible only through the development and use of its own alternative energy, using local resources such as bio-energy or ones that do not need fuel at all – solar power, wind power and small hydropower. In 2017, the energy sector of Ukraine started preparations for integration with the European energy system ENTSO-E. It was planned to join the system in 2023. Russia's full-scale invasion took place on the day of the first test period of the Ukrainian energy system's disconnection from the energy system of Russian Federation and Belarus. This led to an emergency synchronization with ENTSO-E on March 16, 2022. Despite the war has become an orientation to European development for the United Energy System of Ukraine, it has stopped development and caused destructive losses for enterprises in the "green" energy industry. Therefore, there is a question of defining the development strategy of enterprises producing energy from renewable sources in the conditions of martial law and postwar, depending on the market of energy production, demand, price and damage of installed capacity.

Analysis of recent research and publications. The development of alternative energy sources has a lot of attention in scientific works of both foreign and domestic authors. The issues of modeling and forecasting of Ukraine's energy strategy were investigated by Diachuk O., Podolets R., Yukhymets R., Simonsen M. [1]. The issue of Ukraine's transition to renewable energy was studied by Chepeliev M., Trypolska H., Venher V [2]. By analyzing these materials, it is possible to note that the scenario forecasting approach is usually used to analyze the dynamics of the "green" industry development, taking any possible risks and threats into account. The diversity of the "green" energy sector in Ukraine allows to model different processes, but recent research and publications do not take the beginning of a full-scale aggression against Ukraine into account. It is possible to assume that there is no analysis based on mathematical modeling of the current state of the alternative energy market. There is a need to study this issue, because the industry is valuable, requires investments and constant support from the state.

Research objective. The purpose of the research is economic and mathematical modeling to define the development strategy of alternative energy industry enterprises, concerning sources of renewable energy and various markets of purchase/sale of produced energy, in conditions of martial law and postwar. To achieve the results, it is necessary to study the trends of the "green" energy market in Ukraine at the beginning of 2022, to identify the main factors influencing energy production in the "green" energy sector, to build a model of demand, average monthly purchase/sale price and generating capacity.

Research results. With the great potential of the alternative energy industry in Ukraine, the full-scale invasion of Russian Federation has stopped the rapid development of the "green" energy sector and has caused significant destruction and corresponding production decrease [3]. We have compared production by renewable energy sources in the first quarters of 2020 and 2022 [3]. From production dynamics in Fig. 1 and from the average growth rates of production in table 1, it is possible to see that production decreased twice in similar periods. The January decrease is due to the intensity of the power plants, but the indicators have decreased to the level of summer ones in February and March.

Table 1

The average growth rates of energy production in the first quarters of 2020 and 2022

	2020	2022
The average growth rates	-15,12%	-36,46%

Renewable energy has been at high risk of complete or partial destruction due to the war in Ukraine. 47% of the installed capacity of the power stations on renewable energy sources is available in the regions where active combat actions is currently taking place [4]. However, many of the stations are located in neighboring areas to ones where active fighting is taking place [4]. Thus, the vast majority of wind power plants in Ukraine are built in the southern regions of the country – Zaporizhzhia, Kherson, Mykolayiv, Odesa [4]. As it is shown at the Fig. 2 about 89% of the installed capacity of wind power plants is installed in the regions where of active combat actions are now in progress, another 9% are located in the neighboring areas to the regions with active combat actions. Such data indicate that almost all installed capacity of wind power stations has stopped its work. Among the installed capacity of solar power plants in the zones of active combat actions is about 37%; among the stations on biofuel is 48%. In the neighboring regions with high probability of deployment of combat actions, respectively, 34% and 42%. It should be noted that before the end of active combat actions on the territory of Ukraine and the liberation of occupied regions,

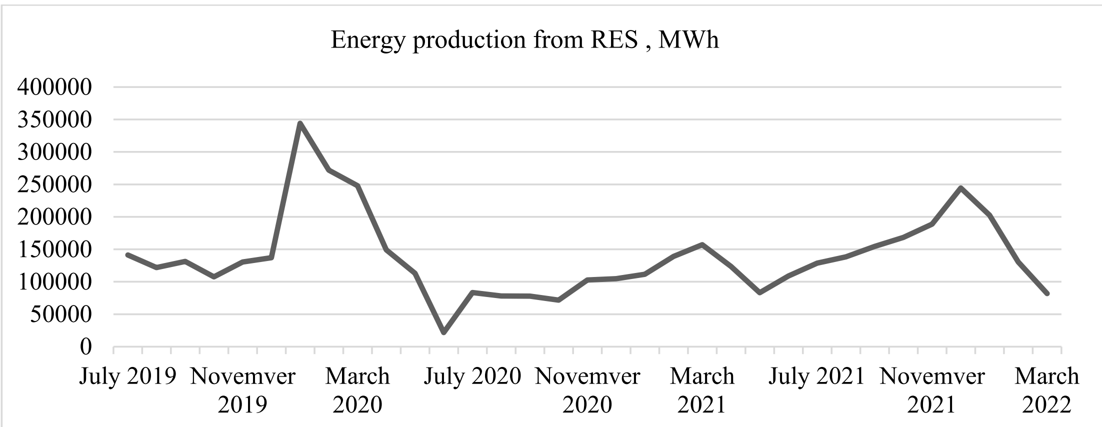

Fig. 1. Energy production from Renewable Energy Sources, July 2019 – March 2022

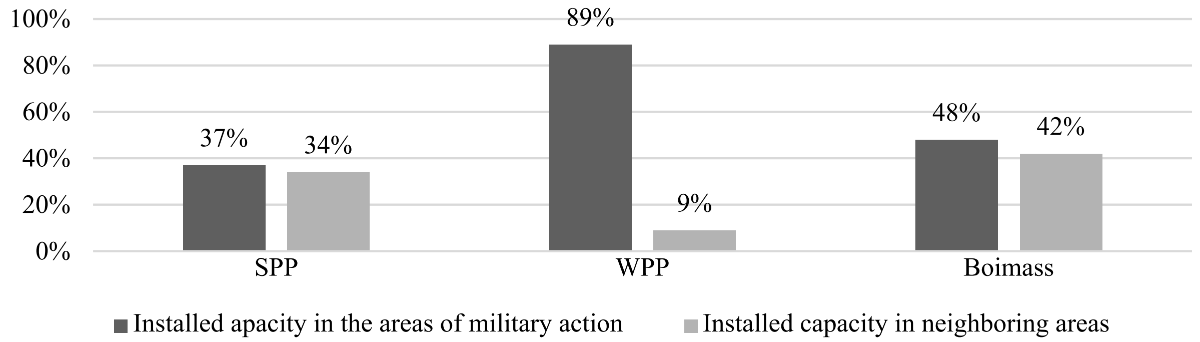

Fig. 2. The share of installed capacity in the areas of military actions and in neighboring regions

it is impossible to estimate the extent of losses of power equipment of stations, power lines, substations, etc.

In such a non-standard situation on the Ukraine's energy market, "green" energy enterprises need financial support. Since 2009, Ukraine has been using a system of Feed-in-tariff, when the state is obliged to buy all the produced electricity at the fixed rate [5]. Since 2020, the system of "green" auctions has also been launched, the winning entrepreneur receives a guarantee from Ukraine for long-term energy purchase at a fixed price [5]. However, the negative side of such state support is gradual reduction of the Feed-in-tariff, irregular payments, risk and impossibility of forecasting the results of auctions. Therefore, we will consider the influence of the state on alternative energy by means of economic and mathematical modeling of energy production on the example of wind power plants.

For model setting, we assume that the current value of the dependent variable (capacity) is influenced not only by independent variables (Feed-in-tariff and cost of energy), but also by the amount of installed capacity in the previous periods, i.e. the lag dependent variable. The autoregressive model looks like:

$$\begin{cases} Capacity_t = a_0 + a_1 Cost_t + a_2 FIT_t + a_3 Capacity_{t-\tau} + U_t, \\ \widehat{Capacity_t} = a_0 + a_1 Cost_t + a_2 FIT_t + a_3 Capacity_{t-\tau}, \end{cases} \quad (1)$$

where $Capacity_t$ – dependent variable, installed capacity in the period *t*, MW; $Cost_t$ – independent variable, cost of energy in the period *t*, cent/kWh; FIT_t – independent variable, Feed-in-tariff) in the period *t*, cent/kWh; $Capacity_{t-\tau}$ – independent variable, lag variable, installed capacity in the period $t-\tau$, МВт; U_t – residuals.

For this model were used data [3], [4] and [5] in 2018–2021 period. Based on p.175 at [6], for substantiation of the lag magnitude we used mutual correlation function. The highest value of the mutual coefficient of correlation with the lag of one month is 0,991, so $\tau = 1$ for the model (1).

For estimation of model parameters, we applied the Wallis method, which is based on the Instrumental variables method and Aitken's Generalized least squares method, the method is described on p. 179 at [6]. The Instrumental variable model for autoregression model (1) is constructed in the form of a regression:

$$\widehat{Capacity_{t-1}} = z_0 + z_1 Cost_{t-1} + z_2 FIT_{t-1}, \quad (2)$$

where $Capacity_{t-\tau}$ – dependent instrumental variable, installed capacity in period $t-\tau$, MW; $Cost_{t-1}$ – ndependent instrumental variable, cost of energy in the period $t-\tau$, cent/kWh; FIT_{t-1} – independent instrumental variable, Feed-in-tariff in the period $t-\tau$, cent/kWh.

The instrumental variable model (2) has such a parameter estimation:

$$\widehat{Capacity_{t-1}} = -5175,24 - 644,9 Cost_{t-1} + 1268,65 FIT_{t-1}.$$

The accuracy of this model is 0.93. Based on the results of the regression analysis, we obtained the following estimate of the model (1) parameters:

$$\widehat{Capacity_t} = 52,11 - 8,73 Cost_t + 0,98 Capacity_{t-1}.$$

The accuracy of this model is 0.93.

The hypothesis of autocorrelation of residuals can be confirmed using the Durbin-Watson statistic, described on p. 182 at [6]. For this study, the lower critical value of the DW statistic is 1.08; the upper critical value is 1.34. The DW statistic is 0.76 and indicates the autocorrelation. After using Aitken's generalized least squares method, we get the following model (1) evaluation:

$$\widehat{Capacity_t} = -7,88 - 26,73 Cost_t + \\ + 29,02 FIT_t + 0,92 Capacity_{t-1}. \quad (3)$$

The capacity model's parameters estimates indicate that the cost increase by 1 eurocent/kWh decreases the capacity by 26.73 MW; the Feed-in-tariff increase by 1-euro cent/kWh increases the capacity by 29.02 MW. When assessing the adequacy of the model, it was determined that the coefficient of determination (0.998) indicates that 99.8% of the capacity variation in period *t* is determined by the variation of independent variables. The correlation coefficient (0.99) indicates a close relationship between the dependent and independent variables. Using Fisher's F-test (491), it was determined that the regression could be considered relevant.

We compare the results obtained from the built model for determining energy production from renewable sources with real statistical data for 2021. The cost price is determined by the levelized cost of electricity, data is available at [7]. The Feed-in-Tariff was changed in accordance with the provisions of the Law "On Alternative Energy Sources" [5]. To calculate the production with available capacities, we assume that the approximate monthly production of electricity can be calculated using the formula:

$$V = Capacity \times days \times h, \quad (4)$$

where *V* is energy production, MWh; *days* is the number of days of operation of the station per month, days;

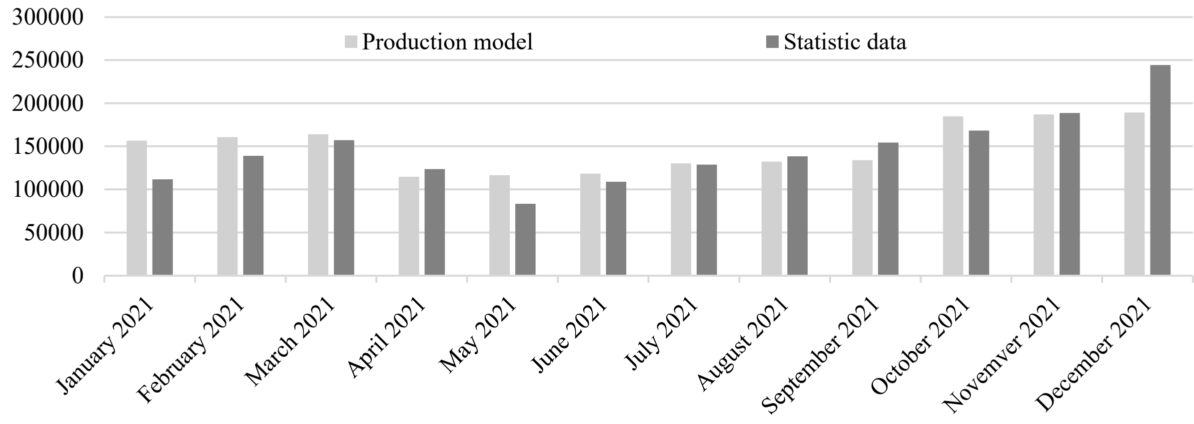

Fig. 3. Comparison of model and real data of wind energy production

hours – the number of hours of operation of the station per day, h.

Since energy production from renewable energy sources is seasonal, after analyzing existing statistics, quarterly seasonal production coefficients for wind turbines were used [8].

The results of using models (3) and (4) presented in Fig. 3. It indicates that the real values has the same tendency as the modeling ones at different moments of time. However, at the beginning of the year the real values are a bit lower, this phenomenon can be explained by the imperfect tariff policy in Ukraine in the "green" energy industry, as well as the introduction of a new "green" auction system, which is not yet fully understood by market participants.

Globally possible development strategies for the "green" energy industry enterprises are considered as two markets for the sale of energy from renewable sources – domestic and international. To simplify the model, the domestic market is represented by the day-ahead market [9], since it is a key platform for electricity trading and an indicator of the cost of electricity in the domestic market and the international is represented by the export market [10].

The current value of the energy production in MW can characterize the renewable energy involvement in the purchase/sale process. To build an autoregression model, we assume that the monthly average value of the dependent variable (production of "green" energy) is affected by demand, average monthly weighted price and capacity. Demand for the domestic market is defined as the share of RES in monthly energy consumption [9], for the international market – the share of RES in energy export [10]. We assume that the volume of production in the previous period, that is, the lagged dependent variable, also affects the change in the dependent variable. The autoregressive model looks like this (5), where $Production_t$ – independent variable, energy production from RES in the period *t*, MWh; $Demand_t$ – independent variable, demand of the energy from RES in the period *t*, MWh; $Cost_t$ – independent variable, average monthly price of purchase/sale in period *t*, UAH/MWh; $Capacity_t$ – independent variable, installed capacity in period *t*, MW; $Production_{t-\tau}$ – independent variable, lag variable, energy production from RES in the period $t-\tau$, MWh; U_t – residuals.

For this model were used data available at [3; 4; 8; 9] and [10] in 2018–2022 period. The highest coefficient of correlation for both the day-ahead market and the export market is 0.977, which indicates the lag of one month. The Wallis method was used to estimate the model parameters [6]. In general, the instrumental variable has the following representation:

$$Production_{t-\tau} = a_0 + a_1 Demand_{t-\tau} + a_2 Cost_{t-\tau} + a_3 Capacity_{t-\tau}\ , \quad (6)$$

where $Production_{t-\tau}$ – independent instrumental variable, energy production from RES in the period $t-\tau$, MWh; $Demand_{t-\tau}$ – independent instrumental variable, demand of the energy from RES in the period $t-\tau$, MWh; $Cost_{t-\tau}$ – independent instrumental variable, average monthly price of purchase/sale in period $t-\tau$, UAH/MWh; $Capacity_{t-\tau}$ – independent variable, installed capacity in period $t-\tau$, MW. The results of using models (5) and (6) for the day-ahead market and the export market presented in Table 2.

The results of using Aitken's method for the day-ahead market model indicate that the demand increase by 1 MWh increases the production by 0.5 MWh; the average monthly price increase by 1 UAH/MWh increases the production by 0.09 MWh; the capacity increase by 1 MW increases the production by 0.42 MWh; the production increase by 1 MWh the month before increases the production by 0.96 MWh. Assessing the adequacy of the model, the coefficient of determination (0.993) indicates that 99.3% of the variation in production in period *t* is determined by the variation of independent variables. The correlation coefficient (0.977) indicates a close relationship between the dependent and independent variables. The Fisher's F-test (1504.55) determined that the regression could be considered significant. According to the Student's t-test (Table 3), all criteria are significant.

The results of using Aitken's method for the day-ahead market model indicate that the demand increase by 1 MWh decreases the production by 0.04 MWh; the

$$\begin{cases} Production_t = a_0 + a_1 Demand_t + a_2 Cost_t + a_3 Capacity_t + a_4 Production_{t-\tau} + U_t\,, \\ \widehat{Production_t} = a_0 + a_1 Demand_t + a_2 Cost_t + a_3 Capacity_t + a_4 Production_{t-t,} \end{cases} . \quad (5)$$

Table 2

Results of modeling strategies of alternative energy industry enterprises

The day-ahead market	Model of instrumental variables (6), the significance of the model	$\widehat{Production_{t-1}} = 103295,31 + 1,01 Demand_{t-1} - 2,26 Cost_{t-1} + 1,15 Capacity_{t-1}$, F > 0,05 is significant
	Estimation of the parameters of the autoregression model (5), the significance of the model	$\widehat{Production_t} = -20758,2 - 0,17 Demand_t + 0,2 Capacity_t + 1,18 Production_{t-1}$, F > 0,05 is significant
	Value of the Durbin Watson statistic , upper/ lower critical values	DW = 0,25 Upper value – 1,31; lower value – 0,971
	Estimation of autoregressive model (5) parameters after applying Aitken's method	$\widehat{Production_t} = 73,5 + 0,05 Demand_t + 0,09 Cost_t + 0,42 Capacity_t + 0,96 Production_{t-1}$
The export market	Model of instrumental variables (6), the significance of the model	$\widehat{Production_{t-1}} = 28958,95 + 4,41 Demand_{t-1} + 0,01 Cost_{t-1} + 0,23 Capacity_{t-1}$, F > 0,05 is significant
	Estimation of the parameters of the autoregression model (5), the significance of the model	$\widehat{Production_t} = 57,73 - 0,043 Cost_t - 0,04 Capacity_t + 0,99 Production_{t-1}$, F > 0,05 is significant
	Value of the Durbin Watson statistic, upper/ lower critical values	DW = 0,48 Upper value – 1,31; lower value – 0,971
	Estimation of autoregressive model (5) parameters after applying Aitken's method	$\widehat{Production_t} = 8,06 - 0,04 Demand_t + 0,07 Cost_t - 0,03 Capacity_t + 1,09 Production_{t-1}$

average monthly price increase by 1 UAH/MWh increases production by 0.07 MWh; the capacity increase by 1 MW decreases the production by 0.03 MWh; the production increase by 1 MWh the month before decreases the production by 1.99 MWh. Assessing the adequacy of the model, the coefficient of determination (0.999) indicates that 99.9% of the variation in production in period *t* is determined by the variation of independent variables. The correlation coefficient (0.99) indicates a close relationship between the dependent and independent variables. The Fisher's F-test (278818.34) determined that the regression could be considered significant. According to the Student's t-test (Table 3), all criteria are significant.

In order to choose a development strategy for the enterprise, it is necessary to assume how the industry will develop further. This issue is quite risky in conditions of martial law, because the situation is changing unconventionally, and it is difficult to track the changes. In this study, we assume two possible scenarios – pessimistic and optimistic. We believe that the first scenario is "capacity reduction" (related to the continuation of hostilities on the territory of the installed capacity, destruction, and cessation of activity). The second scenario is "capacity increase" (related to the installation of new capacity in relative safe places, restoration of work, repair of damage).

To predict the average monthly purchase/sale price, seasonality and risks related to inflation must be taken into account. Special indicators called seasonality indexes are used to detect and measure seasonal fluctuations (Table 4). In the study, we have monthly data for three years, to find the indices we use the ratio of the average value of the indicator for the i-th month to the average for all years [11].

In general, the model of the average monthly energy purchase/sale price looks like this:

$$Cost_t = \left(b_0 + b_1 Infl_t\right) Season_t, \qquad (7)$$

where $Cost_t$ – dependent variable, average monthly price of purchase/sale in period *t*, UAH/MWh; $Infl_t$ – independent variable, inflation index in period *t*, %; $Season_t$ – seasonality index in period *t*.

For the day-ahead market, the average monthly purchase/sale price model (7):

$$Cost_t = \left(-1091,9 + 1198,8 Infl_t\right) Season_t.$$

The Fisher's F-test = 3.02 indicates the significance of the model (> 0,05). For the export market, the average monthly purchase/sale price model (7):

$$Cost_t = \left(-1858,9 + 1994,4 Infl_t\right) Season_t.$$

The Fisher's F-test = 0,89 indicates the significance of the model (> 0,05).

Table 3

The results of the Student's t-test for the variables of the day-ahead market model and the export market model

	The day-ahead market				The export market		
t1 (Demand) =	157,95	>	2,04		138,17	>	2,04
t2 (Cost)=	5,47	>	2,04		8,26	>	2,04
t3 (Capacity) =	69,24	>	2,04		24,06	>	2,04
t4 (Production the month before) =	3295,25	>	2,04		13643,04	>	2,04

Table 4

Seasonality indexes

Seasonality index for Cost (the day-ahead market)	Seasonality index for Cost (the export market)	Seasonality index for Demand (the day-ahead market)	Seasonality index for Demand (the export market)
0,085	0,115	0,115	0,095
0,086	0,092	0,116	0,088
0,083	0,061	0,104	0,110
0,081	0,145	0,089	0,081
0,064	0,078	0,066	0,078
0,079	0,082	0,067	0,062
0,086	0,062	0,072	0,063
0,089	0,076	0,076	0,063
0,093	0,066	0,078	0,083
0,087	0,079	0,064	0,089
0,086	0,075	0,074	0,096
0,081	0,068	0,078	0,091

For the demand prediction, we believe that it depends on the average monthly purchase/sale price. In order to determine the type of dependence, during the study, we use linear dependence:

$$(Demand_t = (c_0 + c_1 Cost_t) Season_t) , \qquad (8)$$

and exponential dependence:

$$(Demand_t = (c_0 EXP(c_1 Cost_t)) Season_t). \qquad (9)$$

The results of determine the type of dependence, using models (8) and (9), were compared at table 5.

For the day-ahead market, since the value of Fisher's F-test (2.24) is greater than the table value (2.07), the exponential dependence is statistically more significant. For the export market, this is a linear dependence.

We evaluate the prediction of installed capacity changes expertly, taking the specifics of each scenario and changes in the inflation index into account. The inflation index data in 2019–2022 period is available at [12]. The results are presented at the Table 6.

The general model, including (5), (7), (9) for calculating the annual energy production for the day-ahead market (10).

The general model, including (5), (7), (8) for calculating the annual energy production for the export market (11).

The economic and mathematical modeling results are presented in the form of a histogram for various scenarios, based on models (10) and (11), data of table 6, and data available at [3; 4; 8]. [9; 10; 12] in 2019–2022 period. The first "pessimistic" scenario predicts the inflation index increase and the capacity decrease (Fig.4).

The second "optimistic" scenario foresees the inflation index decrease and the capacity level restoration (Fig. 5). The results are based on models (10) and (11), data of table 6, and data available at [3; 4; 8]. [9; 10; 12] in 2019–2022 period.

Conclusions. During the study, trends in the development of the "green" energy industry in Ukraine were revealed. There are imperfect state regulation of the alternative energy sector and the production decrease

$$\begin{cases} \widehat{Production_t} = 73,5 + 0,05 Demand_t + 0,09 Cost_t + 0,42 Capacity_t + 0,96 Production_{t-1}, \\ Demand_t = (5 EXP(0,0005 Cost_t)) Season_t , \\ Cost_t = (-1091,9 + 1198,8 Infl_t) Season_t . \end{cases} \qquad (10)$$

$$\begin{cases} \widehat{Production_t} = 8,06 - 0,04 Demand_t + 0,07 Cost_t - 0,03 Capacity_t + 1,09 Production_{t-1} , \\ Demand_t = (2896,8 - 0,24 Cost_t) Season_t , \\ Cost_t = (-1858,9 + 1994,4 Infl_t) Season_t . \end{cases} \qquad (11)$$

Table 5

Comparison of linear and exponential dependence for the demand model

		The day-ahead market	The export market
Linear (8)	Dependence	$Demand_t = (152,8 + 0,14Cost_t)Season_t$	$Demand_t = (2896,8 - 0,24Cost_t)Season_t$
	Indicators of significance	Fisher's F-test = 0,913	Fisher's F-test = 2,09
Exponential (9)	Dependence	$Demand_t = (5EXP(0,0005Cost_t))Season_t$	$Demand_t = (7,9EXP(-0,0007Cost_t))Season_t$
	Indicators of significance	Fisher's F-test = 2,24	Fisher's F-test = 1,2

Table 6

Forecasting of installed capacity and inflation index using expert evaluation

Scenario 1		Scenario 2	
Inflation index, %	Capacity, MW	Inflation index, %	Capacity, MW
1,031	4932,89	1,031	5238,02
1,027	4424,35	1,027	5746,57
1,031	3915,80	1,031	6255,11
1,033	3407,26	1,029	6763,66
1,034	3356,40	1,028	6814,51
1,036	3152,98	1,026	7017,93
1,037	3051,28	1,025	7119,64
1,039	2898,71	1,023	7272,21
1,041	2390,17	1,021	7780,75
1,042	2491,87	1,020	7679,04
1,044	2441,02	1,018	7729,90
1,045	2339,31	1,017	7831,61

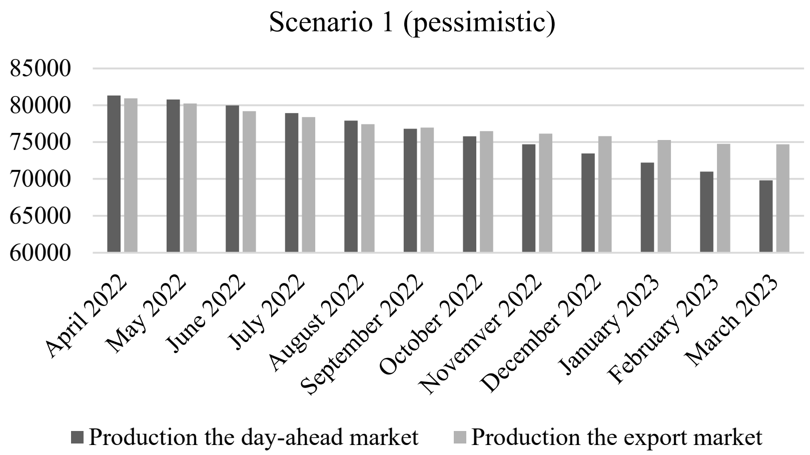

Fig. 4. The first pessimistic scenario

due to the war on the territory of Ukraine among the main problems. To analyze the first question, based on statistical data on wind power plants in Ukraine, an autoregression model of the dependence of capacity on the levelized cost of electricity, the Feed-in-tariff and the installed capacity in the previous period was built. Comparing this model with real data confirms the existence of imperfect tariff policy in Ukraine problem. An autoregressive model of dependence of energy production on demand, average monthly purchase/sale price, capacity and production in the previous period was built to study the current situation. As a strategy, we considered two markets – domestic, represented by the day-ahead market, and international, represented by the export market. For the annual prediction, we selected two scenarios – pessimistic and optimistic. According to the results of economic and mathematical modeling, it was determined that for the "green" energy industry

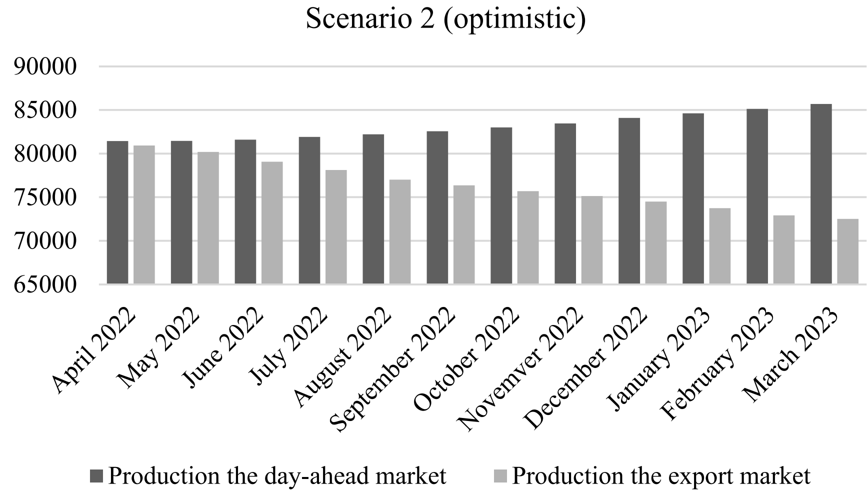

Fig. 5. The second optimistic scenario

enterprises, due to the first "pessimistic" scenario, the produced energy should be sold on the international market, and due to the second "optimistic" one – on the domestic market. The first scenario involves the capacity reduction, so the production for the export market will attract more cash inflows. The second scenario involves the capacity increase, so, in this case, the production of energy from alternative sources for the domestic market receive a priority in order to increase the share of RES in the fuel and energy structure of Ukraine, for energy independence and efficiency. This study can be used for further in-depth economic and mathematical modeling and study of the issue of development strategies of enterprises in the field of "green" energy.

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