

## FORECASTING ANALYTIC MODEL OF CONSTRUCTION ENERGY CLUSTER DEVELOPMENT IN UKRAINE

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**Abstract:** The article proposes a scientific and methodological approach to solve the problems of the construction energy cluster forecasting development, which provides an opportunity to unite the known technology of constructing time series models with the technology of simultaneous systems equations. It was developed the quantification process of the forecasting economic and mathematical formation model of energy cluster development, which will allow to detail the stages of mathematical modeling in the context of the studied problems, taking into account the specificity of production and commercial activity of all integration formation participants. The conditions for carrying out forecasting and analytical procedures of construction energy cluster development have been identified, in particular by the specificity and type of cause and effect and dynamic relationships between the main economic indicators, the intensity factors development trends, the dynamics of regular factors, described by linear and nonlinear ones.

**Keywords:** energy cluster, forecasting development, investment.

### 1. Introduction

Crisis phenomena in the economy cause worsening of the production-commercial conditions activity and complication of the enterprises basic business processes implementation. The foregoing determines the need for rapid adaptation to modern trends in order to make operational and effective managerial decisions. There is a need to predict possible situations and to forecast the future state of the study objects. Henri Fayol, the famous founder of modern management actualized that to manage is to predict and to "predict" almost an act" (Fayol, 1992). In modern conditions, the production and commercial activity management and

the forecasting of possible situations, in particular, the negative ones, is an important part of the management process, in particular the construction energy cluster.

## 2. Literature review

According to the leading Ukrainian scientist B. Danylyshyn – without focusing on industrial and technological policy, it will be impossible to achieve the goals of truly strong economic growth, especially in the long term. At present, the Ukrainian economy has a character of a raw material, and it is clear that under such conditions it is impossible to talk about its sustainable quality development. Investments in Ukrainian manufacturing are insufficient, not only because of the high level credit rates or the crowding out effect.

From the point of entrepreneurs and investors view, in our country there are no companies that produce products to correspond the challenges of the third and fourth Industrial Revolutions.

Likewise, there are no companies whose products are in high demand in world markets. However, the scientist actualizes that the main thing is to create the conditions for the transition of the economy from, a state that is customary to the second technological stage, to an innovative high-tech economy in the paradigm of the third and fourth Industrial Revolutions (Danylyshyn, 2019).

Lilla Knop in article entitled 'Creative Clusters Against the Background of the Development of Clusters in Poland' presented the development of creative clusters in the context of the development of all clusters in Poland. In this comparison creative clusters were regarded in very good light and the common area are information and communication technologies, in particular digitization, multimedia, internet and mobile technologies. This technological area is the basis for the development of various areas of economy including cultural and creative industries and cultural heritage. It is also relevant that ICT has become a smart specialization for many regions of Poland, also constituting a national smart specialization, known as Smart creative technologies. Agata Mesjasz-Lech in her article, 'Factors Conducive to the Development of Business Cooperation in a Cluster Initiative -A Statistical Analysis', supported by statistical data about companies in Poland, analyzed what factors are conducive to cooperation between entrepreneurs. The study covered the years 2012-2014, which were characterized by strong economic growth, an increase in outlays for innovative activity as well as an increase in the number of clusters and innovative networks (Knop, 2013).

We are completely agreed with the opinion of famous scientists that focus on industrial and technological policy, on investments attraction, on innovative and high-tech economy creation. We actualize the problems that form new enterprise energy cluster models, as one of the instruments for achieving the above-mentioned objectives. In particular, there is a need to

research the economic and mathematical models of such integration structures forecast development, which will provide an opportunity to optimize resources, increase profitability, competitiveness and efficiency of the industrial and future commercial trends.

### **3. The goal of paper**

In the context of the research, to develop a scientific and methodological approach to solving the problems of forecasting the development of a building energy cluster, based on the synergy of technology of construction of time series models with technology of models of systems of simultaneous equations. Using linear and nonlinear trends to determine the conditions for carrying out forecasting and analytical procedures for the development of a building energy cluster according to the specificity and type of cause and effect and dynamic relationships between the main economic indicators, trends of the development of intensity factors, the dynamics of regular factors.

### **4. Quantification process of energy cluster development**

Scientists distinguish three stages of the integration structures development process, in particular, clusters: determinism, stochasticity and adaptability. These stages correspond to three types of information, namely certainty, uncertainty, ignorance.

Depending on the purpose of the study, time to conduct the forecasting procedures and access to information, analytics use different forecasting models. The complete certainty of the information provides the possibility to construct deterministic models in which all structural coefficients of equations are known, as well as exogenous (control) variables and perturbation effects. However, the assumptions which laid out in the construction of deterministic models, do not take into account many difficult conditions in the function of a real cluster. The structural relationships between the system elements are not constant in time, they are identified by different random changes, caused by external perturbation effects.

Therefore, it is advisable to construct models taking into account the probabilistic nature of external influences and structural equations. A stochastic approach, based on the fact that we know the statistical characteristics of random processes and functions, which affect the external influences on a simulated system and structural relationships between its elements. However, the probabilistic characteristics of the system for most tasks are not known beforehand, and their definition is often associated with certain difficulties.

The fragmentation of information provision, stipulates the application of adaptive approach to the solution of the optimal control problem, which is the implementation of the stochastic approximation method as a basis for the construction adaptive economic and mathematical models.

The feature of constructing adequate multi-factor forecasting model is that the functioning of the study object in retrospect should be well described by equations based on sufficient statistical information (Klebanova, 2011).

With the purpose of building the probability of the cluster development scenarios, the choice of the most optimal option, based on commercial goals of the integration formation participants and, accordingly, the planning of its activities on the prospect. We believe that an important instrument of modern management is forecasting the parameters of the cluster's economic potential.

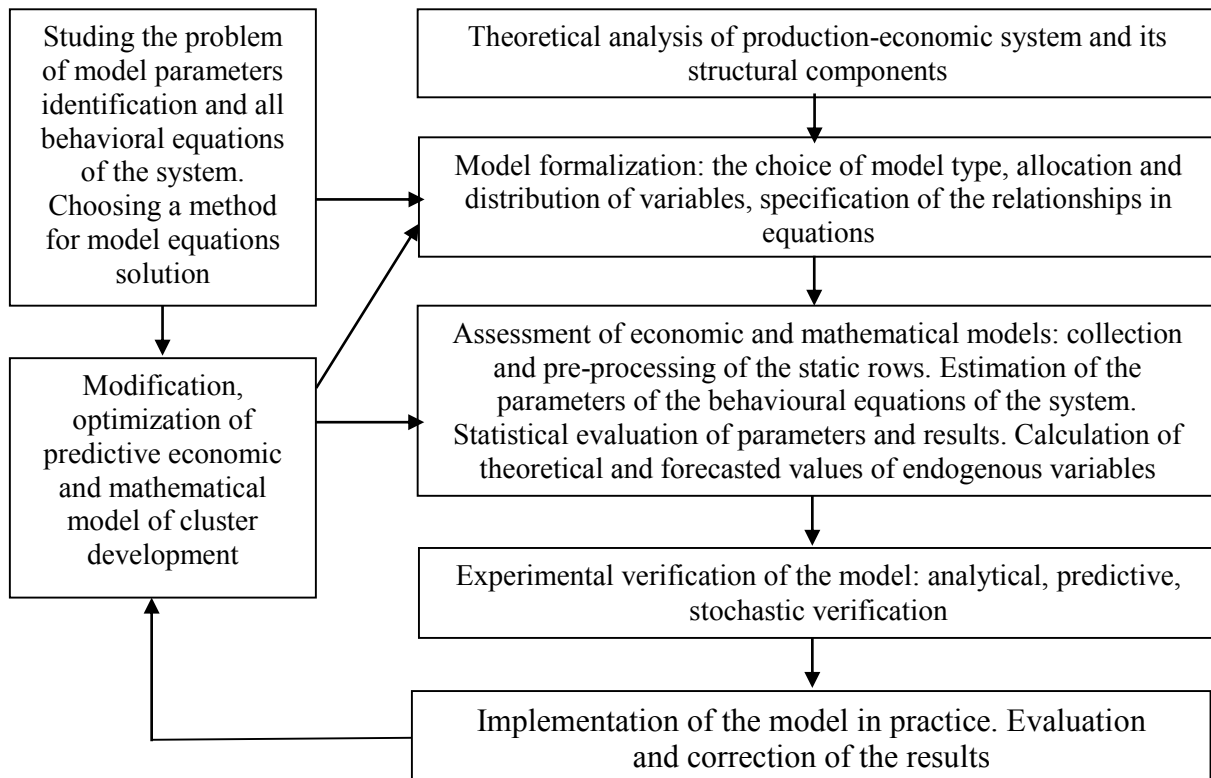
In the process of forecasting the most problematic issue is availability of sufficient and reliable information. Especially in the context of sampling for the forecasting previous period process, which is usually insufficient to establish a clear cause-and-effect connection and the adequate economic and mathematical models construction.

The process of forecasting the parameters of the cluster economic potential should provide information about the future state of the forecasting object, based on the circumstances; recommendations regarding the impact of the conditions and factors with the aim of making effective management decisions to achieve the expected future target.

The energy cluster should create the conditions for basic, integrated development within the objective function aimed at activating its technological, scientific-technical, industrial-commercial and human resources, as well as prejudice, minimization of active and passive economic threats connected, for example, to fragmented state policy in the field of support of integration entities.

The development of a comprehensive economic and mathematical model is the process of consistent improvement and extension of the model based on static analysis and experimental verification of results. The stages of formation of a complex economic and mathematical model are presented in Fig. 1.

In particular, the theoretical economic analysis, the selection of variables and their relationships, and the pre-processing of static series must be performed before determining the model's numerical analyses. Equations and variables can be represented in several variations. Experimental verification of variants can lead to the study of new variables, equations and their verification. The next stage – the experimental analysis of the model in general can make adjustments and stipulate the expediency of additional inspections.



**Figure 1.** Quantification of the economic-mathematical predictive model formation process of energy cluster development.

## 5. Components of the forecasting analytic model of energy cluster development

The study of the modeling process demonstrated that the complex model construction should be started on the basis of the analysis of simple small models. As they provide a deeper understanding of economic processes and communications, therefore need to be comprehensive, that is to present the interrelationship of all production process phases.

A comprehensive economic-mathematical model is a set of equations describing the communication between some macroeconomic indicators. The communication between variables can represent stochastic and deterministic character. Stochastic communications are implemented with some probability and are described by means of regressive equations.

The deterministic ratios are expressed by the identity and does not contain any random values.

An example of deterministic communication can be the ratio between the gross of national income and gross profits of certain industries.

When determining the algebraic type of regression equations and identities the linear and logarithmic functions are used.

For large models with non-linear connections obtaining numerical ratings of parameters and research of their characteristics is quite a challenge. Therefore, in complex economic and mathematical models prefer linear equation. However, the linearity of some connections is not approximated by linear relations. The dynamics of economic relations is usually taken into account by the means of time indicators or by introducing into the model equations that characterize the trends. A linear regression equation can be presented in the form of (Mashunin, 2013):

$$Y_t = b_0 + b_1 x_{1t} + b_2 x_{2t} + \dots + b_m x_{mt} + u_t \quad (1)$$

$Y_t$  – dependent variable,

$x_{1t}, \dots, x_{mt}$  – independent variable,

$u_t$  – accidental deviation,

$b_0, b_1, \dots, b_m$  – parameters of the regression equation.

The dependent variable  $Y_t$  in other equations may act as an independent variable. In this context, we divide all variables into endogenous and exogenous ones. Endogenous includes all indicators that can be determined from the system of equations. The number of these indicators cannot exceed the number of all equations and identities models, then the model can be represented as follows:

$$Y_{1t} = a_{11} Y_{1t} + \dots + a_{1k} Y_{kt} + b_{10} x_{0t} + \dots + b_{1m} x_{mt} + u_{1t} \quad (2)$$

$$Y_{2t} = a_{21} Y_{1t} + \dots + a_{2k} Y_{kt} + b_{20} x_{0t} + \dots + b_{2m} x_{mt} + u_{2t} \quad (3)$$

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$$Y_{kt} = a_{k1} Y_{1t} + \dots + a_{kk} Y_{kt} + b_{k0} x_{0t} + \dots + b_{km} x_{mt} + u_{kt} \quad (4)$$

In these equations  $x_{0t} = 1$ , and the individual coefficients,  $a_{11}, \dots, a_{kk}$  i  $b_{10}, \dots, b_{km}$  can be equal to zero if the corresponding variable is not included in the equation. May also be zero  $u_{it}$ ,  $i = 1, \dots, k$ , if this equation is deterministic and is described by the use of identities, the system can be represented in a matrix form:

$$y = Ay + Bx + u \quad (5)$$

$y = \begin{pmatrix} y_{1t} \\ y_{kt} \end{pmatrix}$  – vector of endogenous variables in measurement  $k$ ,

$x = \begin{pmatrix} x_{1t} \\ x_{mt} \end{pmatrix}$  – vector of endogenous variables in measurement  $m$ ,

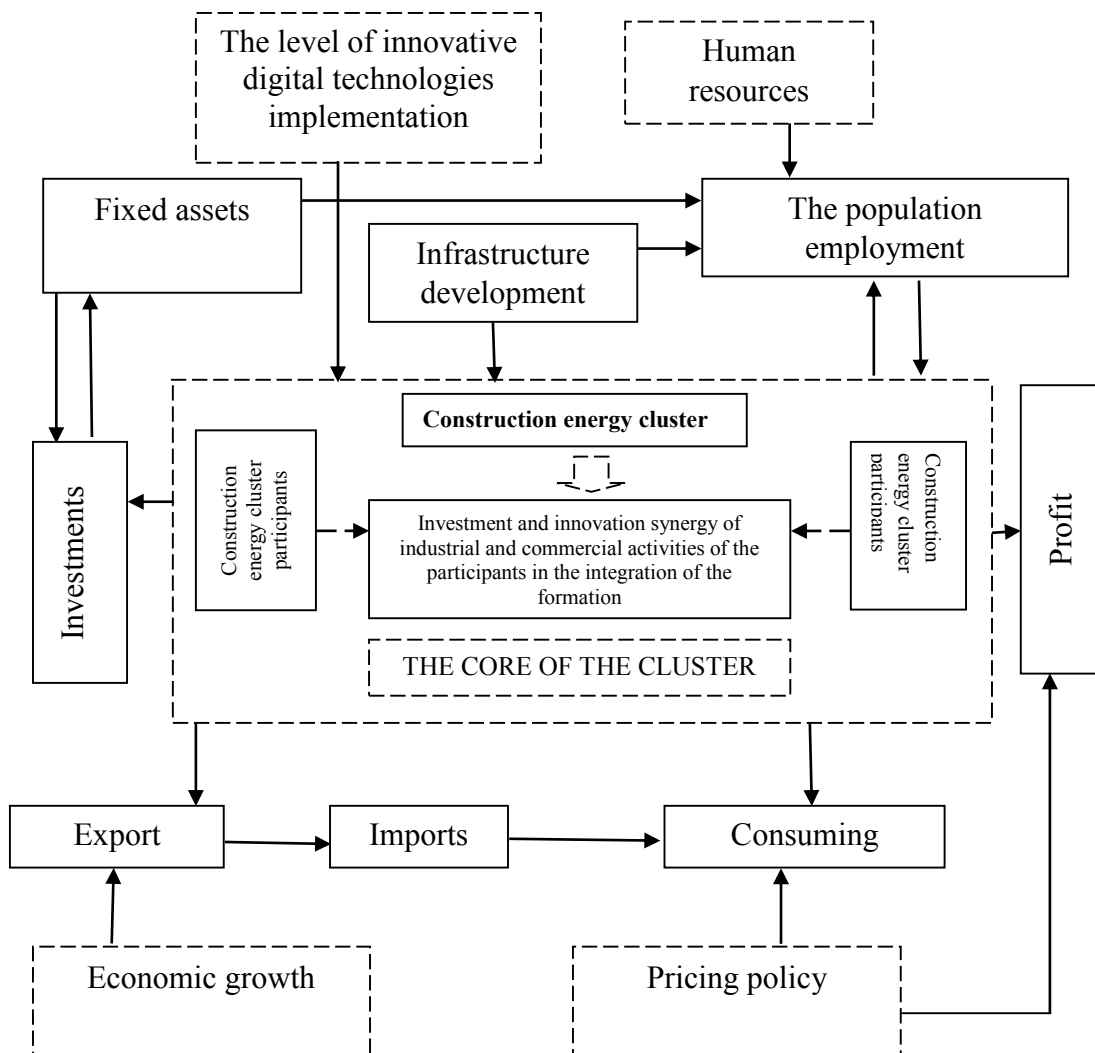
$u = \begin{pmatrix} u_{1t} \\ u_{kt} \end{pmatrix}$  vector of random deviations in measurement  $k$ ,

$A$  – square matrix of order  $k$ ,

$B$  – rectangular order matrix  $k \times m$ .

If the matrix  $A$  is triangular, then the system is called recursive.

The main blocks of variables and their relationship in a complex economic and mathematical model are presented in Fig. 2.



**Figure 2.** Scheme of endogenous and exogenous components of a complex economic and mathematical model of energy cluster development.

The economic-mathematical model in the form (2) directly reflects the connection between the variables and therefore called the structural form of the model. For example, if the system (2) can be solved relatively, then we get a system of equations:

$$y_{1t} = r_{10}x_{0t} + r_{11}x_{1t} + \dots + r_{1m}x_{mt} + v_{1t} \quad (6)$$

$$y_{2t} = r_{20}x_{0t} + r_{21}x_{1t} + \dots + r_{2m}x_{mt} + v_{2t} \quad (7)$$

$$\dots$$

$$y_{kt} = r_{k0}x_{0t} + r_{k1}x_{1t} + \dots + r_{km}x_{mt} + v_{kt} \quad (8)$$

In matrix form, the system of these equations can be represented by:

$$y = Rx + v \quad (9)$$

The random deviation vector  $v_{1t}, \dots, v_{kt}$  is a linear combination  $u_{1t}, \dots, u_{kt}$  of structural shape. The coefficients  $r_{ij}, i = j = 1, \dots, k$ , associated with the matrix of structure coefficients are as follows:

$$R = (I - A)^{-1}B$$

where  $I$  – is a unit square matrix of order  $k$ .

The above model form of equations (6) is called the derived form.

The perspectives of numerical calculation parameters in structural form and the possibility of its transformations in derived form are connected with a concept of model identification.

The model is called identified if the regression equation of the structural form helps to reflect economic connections. Each equation in the identified system reflects to a specific connection of variables that cannot be duplicated and replaced with another combination of equations. That is, the identified model if no linear combination of structural equations form can lead to equations containing the same variables as some structural equations form.

When calculating the prognostic values of endogenous variables, it is advisable to insert the expected values of exogenous factors into the given form of the system. Usually explore several predictive options. In this case, the original option involves the trends extrapolation of exogenous variables. Other options take into account possible deviations from the trends of exogenous variables. When distinguishing trends, different methods are used: linear, exponential, logarithmic, and trend parameters can be estimated using the least squares method. The closeness of selected trend degree to the original trend is checked by using standard regression characteristics. The covariance parameter matrix is used to calculate parameter boundaries that provide the maximum and minimum variants of forecasts.

Trend selection is most often based on one of two principles or a combination of these. The first is related to the presentation of trends as an analytic function over time. The second defines the law of motion process in the autoregressive scheme form where the current indicators depend on the values of this indicator of past period time. Suppose we have  $n$  values of some metric over a certain period of time.

We determine them by  $x_t$ , and the values of the trend component by  $\hat{x}_t$ , and describe the trend with the following functions:



Linear (gradual increase):

$$\hat{x}_t = a + bt \quad (10)$$

Exponential (progressive increase):

$$\hat{x}_t = e^a + bt \quad (11)$$

Logarithmic (slow increase):

$$\hat{x}_t = \ln(a + bt) \quad (12)$$

The parameters  $a$  and  $b$  in all three functions can be estimated using the ordinary least squares method by linearizing the functions above. The deviation of the actual indicator from the trend is estimated by the formula:

$$u_t = x_t - \hat{x}_t \quad (13)$$

The standard error of the equation is determined by the relation:

$$\overline{S_u} = \sqrt{\frac{1}{n-m} \sum_{t=1}^n u_t^2} \quad (14)$$

Where  $m$  is the number of estimated parameters of the trend function.

We will assume that of the three given functions best describes the trends and the function for which the magnitude  $\overline{S_u}$  is the least significant.

The autoregressive trend looks like:

$$\hat{x}_t = c_0 + c_1 \hat{x}_{t-1} + c_2 \hat{x}_{t-2} + \dots + c_k \hat{x}_{t-k} \quad (15)$$

The combination of time and auto regression trends usually yields the best results. Suppose that in the first stage we have selected one of the three functions as a trend and estimated its parameters. Calculate the autocorrelation of residuals:

$$c = \frac{\sum_{t=2}^n u_t u_{t-1}}{\sum_{t=2}^n u_t^2} \quad (16)$$

You can go to the next step:

$$\hat{x}_t - c \hat{x}_{t-1} = a + bt \quad (17)$$

Let us estimate the least squares parameters  $\hat{a}$  and  $\hat{b}$ . The trend value will be obtained from the relation:

$$\hat{x}_t = \hat{a} + \hat{b}t + c \hat{x}_{t-1} \quad (18)$$

The extrapolation values of the indicators are calculated by  $t$  substituting instead of the numbers,  $n+1, \dots, n+p$ , and  $\hat{x}_{t-1}$  instead the values trend obtained in the previous stage. At the starting point  $\hat{x}_{t-1}$ , we define the index  $t=n$ . The lower and upper bounds of  $\hat{a}$  and  $\hat{b}$  parameters allow to estimate the minimum and maximum extrapolation values.

Parameters of the regression equations are estimated on the basis of the temporary ranks taken in a definite time. The numerical estimates made show the correlation between economic indicators over a given time interval. However, these links may change in the future. A number of macroeconomic indicators are developing at different rates. As a result, the relationships and proportions between indicators are changed, as reflected in changes in model parameters. Thus, when using a model for forecasting, it is sometimes advisable to make adjustments to the system coefficients. Such adjustments are required in the medium-term and long-term forecast.

## 6. Prospects for the energy cluster development in Ukraine

### 6.1. Materials and Methods

In our article a comprehensive systematic model of spatial and dynamic assessment of the energy saving potential of construction enterprises is developed (Klymchuk, 2018).

**Table 1.**

*Grouping of construction enterprises by clusters*

Cluster no.	Construction enterprise
1	JSC "SBK"
2	PJSC "TPK", LLC "Pantek", LLC "Izolit",
3	LLC "Inteco construction", LLC "Latest Concrete Technologies", LLC "Aerok", LLC "CARROT BM", PJSC "Keramperlit", LLC " Armotex »
4	Saint-Goben Construction Products Ukraine LLC, Techno-Alliance LLC,
5	PBKG "Kovalska", PJSC "Heidelberg Cement Ukraine", LLC "Valkyrie", PJSC "Dickergoff Cement Ukraine", LLC "Wienerberger"

The study was conducted in 2016-2017 by the leading construction companies in the Kiev region.

### 6.2. Results and Discussion

In our opinion, in order to increase the level of energy saving potential, it is advisable to maximize the profitability of the enterprise, which is the main factor for its growth. Therefore, the level of profitability of assets is an integral indicator for assessing the efficiency of the production and commercial activity of the enterprise and the quality of its work, but not for

managing the process of increasing the economic potential as a whole. The results of the calculations are presented in Table 2.

**Table 2.**

*Graduation of construction enterprises clusters by the integral indicator of energy resource saving potential and profitability*

Cluster no.	I <sub>pne</sub>	Profitability, %
1	3,38	28
5	2,01	7,1
4	1,97	3,2
2	1,78	2,8
3	1,03	2,6

The correlation between the integral indicator and the average for each cluster is the level of assets profitability which is 91.6%, that indicates a high correlation of indicators.

The presented data in the Table 2 give an opportunity to emphasize that the enterprises with the highest level of energy saving potential (= 3.38) are included in cluster 1 (JSC "SBK"). Cluster #5 became the second largest energy saving potential (= 2.01) (PBKG "Kovalska", PJSC "Heidelberg Cement Ukraine", LLC "Valkyrie", PJSC "Dickergoff Cement Ukraine", LLC "Wienerberger"). The lowest level (= 1.03) was shown by the enterprises that were part of cluster #3 (LLC "Inteco construction", LLC "Latest Concrete Technologies", LLC "Aerok", LLC "CARROT BM", PJSC "Keramperlit", LLC " Armotex »).

Based on the application of the proposed economic and mathematical model, methods of retrospective analysis, multivariate regression analysis, expert evaluations, the forecasting and analytical procedures of determining the prospects for the development of the construction energy cluster were conducted and the change of the integral index of the energy saving potential and profitability was calculated.

**Table 3.**

*Forecast of integral index of energy saving potential values and energy clusters profitability for 2020-2023*

Cluster no.	2020		2021		2022		2023	
	I <sub>pne</sub>	Profitability, %	I <sub>pne</sub>	Profitability, %	I <sub>pne</sub>	Profitability, %	I <sub>pne</sub>	Profitability, %
1	3,38	28	4,01	30	4,67	32	4,75	35
5	2,01	7,1	2,37	7,8	2,45	8,23	2,86	8,91
4	1,97	3,2	2,05	3,5	2,78	3,9	2,95	4,01
2	1,78	2,8	1,96	2,9	2,07	3,01	2,54	3,4
3	1,03	2,6	1,44	2,9	1,67	2,97	1,93	3,03

## 7. Summary and conclusions

Based on the study, we can conclude that the value of the main variants of the forecast is fully determined by the following conditions:

- Specifics of cause-effect and dynamic relations between the main economic indicators defined on the basis of regression analysis of time or structural series;
- Type of balance and indirect relations. Indirect relationships include inverse relationships between variables and evaluated using certain methods.
- Trends of intensity factors development (labor productivity, indicators of the use of fixed assets, etc.), which are evaluated on the basis of extrapolation parameters of the regression equation.
- Dynamics of regular factors development, which is described on using linear and nonlinear trends, as well as autoregressive variables.

Extrapolation of regular factors, usually considered in three main ways.

The initial economic energy cluster state. This condition is described by the values of endogenous variables in the last base year.

The proposed scientific and methodological approach solving problems of forecasting of energy cluster development, provides an opportunity to combine the known technology of time series constructing models with the technology of simultaneous equations system constructing models. Thus, the presented model of energy cluster development covers a complex of basic business processes, implemented in the energy cluster and provides the opportunity to harmonize the application of all the above approaches, thus providing a gradual transition to a socially oriented concept of development.

In particular, it allows to assess the consequences of priority projects implementations in a cluster, structural integral indicator changes, as a result, to form mechanisms of an energy cluster development that provides its competitiveness, the progressiveness, also at the regional level it will promote growth of employment population and its vocational guidance taking into account strategic problems of the territorial industry development and also to define the markets, the special institutional conditions for competition development demanding formation

The quantification process of predictive economic formation and mathematical model of the energy cluster development has been developed, which will provide the opportunity to detail the stages of mathematical modeling in the context of the investigated problems, taking into account the specificity of production and commercial activity of all integration formation participants.

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