The Model of Evaluation of the Renewable Energy Resources Development under Conditions of Efficient Energy Consumption

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Abstract

The methodical approach to the integrated evaluation of the renewable energy resources development has been improved based on synergy of scientific methods: multidimensional mean, matrix modelling, creating Fishbone Diagram, linguistic and cognitive concept. In order to form the development system of the energy market, the use of a generalized indicator of evaluation of the renewable energy resources development is substantiated. This is a set of group integral indicators of the appropriate means of influence: economic, environmental and social one. Calculation of this indicator and its graphical interpretation made it possible to determine the influence of group indicators and to establish functional relationships. According to results of the integrated evaluation of the renewable energy resources development for Ukraine for the period of 2007-2017, the measures for the revitalization of the energy market have been proposed. The article analyses the prospects for the development of the energy platform based on Smart Grid concept.

Keywords: Renewable energy resources (RER) development, Smart Grid concept, linguistic evaluation, energy independence, investments

Introduction

The irreversible exhaustion of world hydrocarbon reserves, rising energy prices, and the problems of environmental pollution make most developed countries shape their energy strategies aimed at the development of alternative energy. Ukraine is not an exception, and its economy is energy-dependent. Thus, there is a need for the development of theoretical foundations and practical recommendations for the formation of the management concept of energy-saving technologies, taking into account compliance with the conceptual foundations of sustainable development, namely, focusing on carbon-free energy production technologies. All this requires a radical reorganization of the methodological platform for managing energy-saving technologies, a set of functions in management (planning, organization, marketing, motivation, control, accounting, auditing, etc.) at all hierarchical levels of the Ukrainian economy.

Domestic and global energy markets are characterized by a steady tendency to increase demand for energy resources. At the same time, it is important to rationally coordinate and distribute energy flows within the energy system of enterprises, industrial associations, and the country. The problem of energy saving and the transition to technologies that involve the use of energy from alternative resources (solar energy, heat of the environment, etc.) give a chance partly or completely to move away from the use of gas and other fossil fuels, which is a priority trend in Ukraine today.

Today, Ukraine has set a course for European integration, including in the policy of efficient energy consumption. This requires a revision of the traditional approaches, principles and mechanisms of functioning of the electric power industry, the formation of a modern concept of its innovation development, which corresponds to the values of social development, and to the fullest extent takes into account the main tendencies and directions of scientific and technological progress in all areas, areas of life and activity of society. Experts believe that modernization of power grids will have a positive effect on the economic development of Ukraine and will allow expanding the price range of services for consumers, reducing or avoiding operating costs for the electricity grid, and increasing energy efficiency through better access of energy from renewable resources to the electricity grid.

Literature Survey

Today there are many theoretical studies in the field of renewable energy resources. But for the statistical study of this issue, scientific developments in the following areas are important: approaches to the classification of energy resources (Chang, R. D., Zuo, J., Zhao, Z. Y., Zillante, G., Gan, X. L., & Soebarto, V. (2017)), the feasibility of using different methods for the analysis and evaluation of the renewable energy resources development (Chen, H. H., Lee, A. H., & Kang, H. Y. (2017)), the identification and study of the main factors influencing the renewable energy resources development (Li, M. J., & Tao, W. Q. (2017)), the features of the application of modelling the renewable energy resources development (Liang, X. (2017)), etc. Let's consider the most promising and modern research.

In the stakeholder concept, when building a Stakeholder Panel in the field of environmental responsibility, the statistical indicators of RER development are calculated based on non-financial reporting of companies: energy intensity (G4-EN5 indicators), reduction of energy consumption (G4-EN6), reduction of energy demand of sold products or services (G4- EN7). Indicators G4 are taken from the Sustainability Reporting Guidelines. Indicators EN5-EN 7 are indicators of the GRI system (Karabegović, I., & Doleček, V. (2017)). The formation of the main indicators and the presentation of information on the environmental performance of the enterprise are emphasized (Marinakis, V., Doukas, H., Xidonas, P. & Zopounidis, C. (2017)), developing a list of indicators that are recommended to be taken into account when reporting from sustainable development. Sato, M., Kharrazi, A., Nakayama, H., Kraines, S. & Yarime, M. (2017), analyzing non-financial reporting, determine the place of environmental reporting in the non-financial indicators system. Indicators of RER development are components of environmental reporting.

One of the promising approaches to the analysis of dynamically developed systems, including the renewable energy resources development, is the analysis based on cognitive maps (Che, L., Zhang, X., Shahidehpour, M., Alabdulwahab, A., & Abusorrah, A (2017)). It is based on the concept of a cognitive map, which is a model of representations and knowledge of experts about the laws of development and the properties of the situation, which is analysed in the form of elementary semantic categories, which are in ratio. A cognitive map can be represented in the form of a directed graph.

Integrated evaluation of the renewable energy resources development is used in evaluating energy security at macro, meso- and micro-levels. For example, Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017) for evaluating the energy security of enterprises consider threats that are characterized by indicators of energy efficiency of an industrial enterprise using statistical reporting. When evaluating the energy security of an enterprise, Radovanović, M., Filipović, S., & Pavlović, D. (2017) propose a certain set of indicators related to the possibility of obtaining information on the acceptability or unacceptability of the decentralization of energy supply for industrial enterprises, etc. Stativka, N., & Lialina, N. (2017) consider the evaluation of the energy security of an enterprise as part of its energy security strategy and the development of energy security indicators, based on of which it will be possible to formulate a strategy for ensuring the energy security of the enterprise. In the work of Ibidunni, A. S., Ogunnaike,

O. O., & Abiodun, A. J. (2017), they proposed methods for taking into account the factors of energy security in the form of linear constraints to the problem of linear programming, a production model of fuel economy of the country was built.

Methods

In forming evaluation system of the renewable energy resources development, expert analysis has been used, namely, brainstorming and the construction of the Fishbone Diagram. Ishikawa diagram is used as an analytical tool for reviewing the possible factors and identifying the most important causes, which give rise to specific consequences and are manageable. In order to more effectively identify and add possible causes to the composition of the major ones, as well as to more specifically elaborate the possible root causes of the "main bone" branches, one traditionally applies a method of motivating the generation of creative ideas, known as "brainstorming". A typical application of such a method is to execute a diagram drawing on the board by a team leader who first defines the main problems and asks for help from a team of employees in order to identify the main reasons that are schematically indicated on the main bone of the diagram and their details. The group makes offers until the full cause-and-effect diagram is eventually filled (Kumar, A., Sah, B., Singh, A. R., Deng, Y., He, X., Kumar, P., & Bansal, R. C. (2017)). At the end of the discussion, the decision is made what is the most probable root cause of the problem.

Also, when calculating the integral indicator of the evaluation of the renewable energy resources development, the normalization of indicators has been used based on the variation scale, while the calculation of the integral index itself has used the multidimensional mean and matrix modelling. A multidimensional mean is an integrated evaluation of an object in a multidimensional space. Because the parameters of the information space, based on which the multidimensional mean is calculated, are represented by different dimension units, the standardization procedure (or normalization) is used. Matrix modelling as a method of linguistic and cognitive research has been used in our research to determine the relationship between the quantitative values of the Harrington scale and the perception of the state of the renewable energy resources development. Also, elements of the linguistic and cognitive study have been used in concluding the effectiveness of management of the renewable energy resources development.

Results

Due to the analysis of the statistical information regarding the domestic energy market, it was determined that the alternative energy of Ukraine during the independence period has been developing at an extremely slow pace, and only when the "green" tariff was accepted, it received a new impetus for the renewable energy resources development. Wind energy and solar power (photovoltaics) are the leading areas of alternative energy development in Ukraine, as well as in the world market.

The evaluation needs to be made for the strategies of the renewable energy resources development. The developed algorithm for calculating the integral indicator of the renewable energy resources development allows us to evaluate the real state of the energy market and to formulate appropriate measures to reduce the country's energy dependence.

The formation of the evaluation system of the renewable energy resources development begins with the distribution of indicators by groups (Tetiana, H., Karpenko, L., Fedoruk, O., Shevchenko, I., & Drobyazko, S. (2018)). The structuring of indicators for evaluating the renewable energy resources development is made in three groups: economic, environmental and social one (Table 1).

Table 1: Indicators for evaluating the renewable energy resources development

Group integral indicators	Indicators	Indicator symbol	Unit
Economic (I_{econ})	Demolition of the main productive funds of the enterprises of the fuel and energy complex	k1	%
	Percentage of total investments in enterprises of fuel and energy complex and gross domestic product	k2	%
	Energy intensity of the gross domestic product	k3	ton of conventional fuel /USD
	Total investments in the renewable energy resources development	k4	USD
	Losses in transportation and distribution of renewable energy resources	k5	%
Environmental (I_{ecol})	Part of the carbon dioxide emissions and population	k6	kg of CO_2/person
	Part of the carbon dioxide emissions and the gross domestic product	k7	kg of CO_2/USD
	Gross domestic consumption of renewable energy	k8	MW
	Total technological power of renewable energy resources	k9	MW
	Percentage of carbon dioxide emissions and gross domestic product at parity purchasing power	k10	kg of CO_2/USD
Social (I_{soc})	Number of jobs at renewable energy enterprises	k11	units
	Life expectancy of the population of the country	k12	years
	The number of employees which work with harmful working conditions at enterprises in the energy industry	k13	people
	The number of employees entitled to benefits and compensations for work with harmful working conditions at enterprises	k14	people
	Employee accrued wages at enterprise in the energy industry	k15	USD

An expert analysis has been used when developing the evaluation system of the renewable energy resources development (D_{res}). Its result is the construction of the Fishbone Diagram system, which makes it possible to determine which indicators are incentives, and which ones are disincentives (Figure 1).

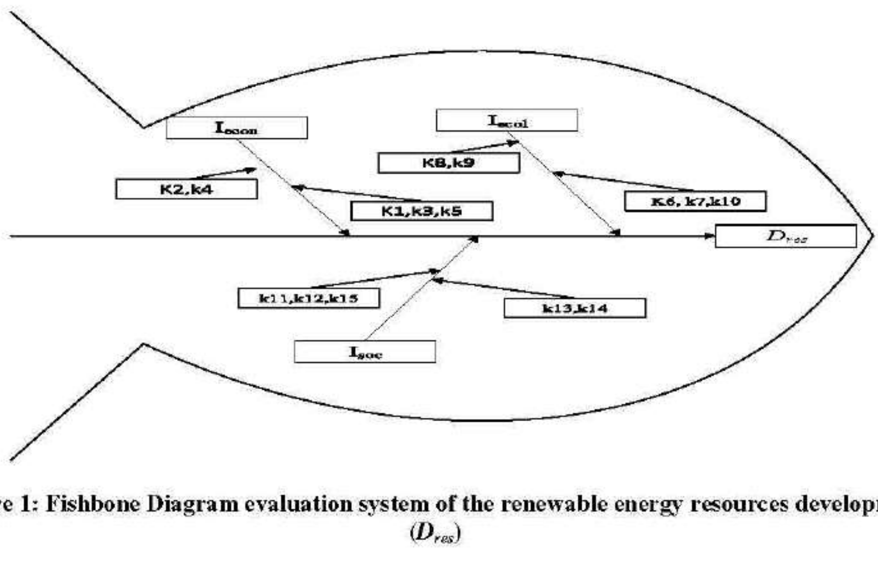

Figure 1: Fishbone Diagram evaluation system of the renewable energy resources development (D_{res})

According to the created Fishbone Diagram evaluation system of the renewable energy resources development, (D_{res}) designates 7 incentives factors (k2,k4,k8,k11,k12,k15) and 8 disincentives factors (k1,k3,k5,k6,k7,k10,k13,k14). As we can see, each indicator has the same weight. This approach is acceptable and makes it possible to avoid the problem of subjectivity of expert evaluation in the evaluations of the integral indicator.

In the course of the research, indicators of the renewable energy resources development in Ukraine for 2007-2017 have been analysed. The task of bringing partial indicators to a single scale of measurement, namely, their normalization, has been accomplished.

There are several ways of normalization. The first option is to use a deviation of the partial indicator from the maximum:

$$\Delta A_i = A_{\max\ i} - A_i \tag{1}$$

where: ΔA_i is a deviation of the partial indicator from the maximum; $A_{\max\ i}$ – maximum value of the indicator; A_i is the partial indicator.
But this option of normalization of indicators does not allow avoiding the discrepancy of scale deviations.

The second option is the use of dimensionless value ($\overline{A_i}$):

$$\overline{A_i} = \frac{A_{\max\ i} - A_i}{A_i}, \tag{2}$$

$$\overline{A_i} = \frac{A_i}{A_{\max\ i}}. \tag{3}$$

Formula (2) is used when the reduction of A_i leads to an increase (improvement) in the value of the additive form of the criterion. Formula (2) is used when the increase in the value of the additive formula of the criterion leads to an increase of A_i.
Normalization of data makes it possible to calculate a generic integral indicator of the evaluation of the renewable energy resources development through its components with the corresponding weighting factors.
Normalized indicators for the renewable energy resources development in Ukraine are presented in the Table 2.

Table 2: Normalized indicators for the renewable energy resources development in Ukraine for 2007-2017

Conventional symbols	Years										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
k1	0.666	0.686	0.740	0.753	0.734	0.690	0.707	0.749	0.743	1	0.751
k2	1	0.476	0.532	0.429	0.448	0.485	0.850	0.934	0.700	0.523	0.476
k3	1	0.960	0.907	0.867	0.911	0.884	0.849	0.809	0.765	0.703	0.699
k4	0.372	0.524	0.587	0.593	0.790	0.908	0.833	0.770	0.902	1	0.822
k5	0.864	0.837	0.762	0.816	0.735	0.767	0.754	0.767	0.856	0.989	1
k6	0.980	1	0.969	0.824	0.882	0.929	0.914	0.885	0.789	0.639	0.654
k7	1	0.940	0.884	0.880	0.903	0.898	0.875	0.847	0.806	0.718	0.691
k8	0.609	0.752	0.846	0.813	0.861	0.860	0.835	1	0.882	0.852	0.851
k9	0.769	0.770	0.770	0.764	0.769	0.813	0.851	0.937	0.971	0.980	1
k10	1	0.940	0.880	0.880	0.904	0.892	0.869	0.845	0.797	0.714	0.690
k11	0.980	1	0.969	0.824	0.882	0.929	0.914	0.885	0.789	0.639	0.654
k12	1	0.940	0.884	0.880	0.903	0.898	0.875	0.847	0.806	0.718	0.691
k13	0.609	0.752	0.846	0.813	0.861	0.860	0.835	1	0.882	0.852	0.851
k14	0.769	0.770	0.770	0.7643	0.769	0.813	0.851	0.937	0.971	0.980	1
k15	1	0.940	0.880	0.880	0.904	0.892	0.869	0.845	0.797	0.7142	0.690

The information base is the data of statistical reporting of enterprises, the State Statistics Service of Ukraine, statistical collections of committees and departments of state power, the International Renewable Energy Agency (IRENA) for the period of 2007-2017.
The generalized integral indicator of the evaluation of the renewable energy resources development D_{res} is defined as the total value of group integral indicators by the formula:

$$D_{res} = \sum_{i=1}^{3} \beta_i \times D_{res_i} \quad (4)$$

where β_i is an influence coefficient on the value of the group integral indicators of the evaluation of the renewable energy resources development;
D_{res_i} are the group integral indicators of the renewable energy resources development.

Based on the established system of indicators presented in the table, the calculation of the integral indicator of the renewable energy resources development by the formula:

$$D_{res} = \sum_{i=1}^{3} (\beta_{econ} \times I_{econ} + \beta_{ecol} \times I_{ecol} + \beta_{Soc} \times I_{Soc}) = \\ = \sum_{i=1}^{3} (\beta_{econ} \times (\sum_{j=1}^{5} k_{1-5}) + \beta_{ecol} \times (\sum_{e=1}^{5} k_{6-10} + \beta_{Soc} \times (\sum_{o=1}^{5} k_{11-15}) \quad (5)$$

where D_{res} is the generalized integral indicator of the evaluation of the renewable energy resources development; I_{Ec}, I_{Ek}, I_{Soc} are group integral indicators of the evaluation; $\beta_{Ec}, \beta_{Ek}, \beta_{Soc}$ are the influence coefficients on the value of the group integral indicators of the evaluation of the renewable energy resources development of corresponding way of influence (economic, environmental and social one); k_n are the indicators of the evaluation of the renewable energy resources development; i is a number of indicators of the evaluation of the renewable energy resources development; j is a number of influence coefficients of economic dimension; e is a number of influence coefficients of environmental dimension; o is a number of influence coefficients of social dimension.

The limits of measuring the integral indicator of the evaluation of the renewable energy resources development D_{res} are in the range [0; 1].

Here is an example of the calculation of the group integral indicator of the renewable energy resources development according to the proposed methodology.
The formal view of the matrix of the economic dimension (I_{econ}) is:

$$I_{econ} := \begin{pmatrix} corr(k1,k1) & corr(k1,k2) & corr(k1,k3) & corr(k1,k4) & corr(k1,k5) \\ corr(k2,k1) & corr(k2,k2) & corr(k2,k3) & corr(k2,k4) & corr(k2,k5) \\ corr(k3,k1) & corr(k3,k2) & corr(k3,k3) & corr(k3,k4) & corr(k3,k5) \\ corr(k4,k1) & corr(k4,k2) & corr(k4,k3) & corr(k4,k4) & corr(k4,k5) \\ corr(k5,k1), & corr(k5,k2) & corr(k5,k3) & corr(k5,k4) & corr(k5,k5) \end{pmatrix} \quad (6)$$

Let us calculate the matrix of the economic dimension (I_{econ}) using 'Data Analysis' MS Excel package:

$$I_{econ} = \begin{pmatrix} 1 & -0{,}25 & -0{,}68 & 0{,}554 & 0{,}56 \\ -0{,}25 & 1 & 0{,}164 & -0{,}226 & -0{,}153 \\ -0{,}68 & 0{,}164 & 1 & -0{,}78 & -0{,}611 \\ 0{,}554 & -0{,}226 & -0{,}78 & 1 & 0{,}19 \\ 0{,}56 & -0{,}153 & -0{,}611 & 0{,}19 & 1 \end{pmatrix}$$

According to the results of calculation of the matrix of the economic dimension (I_{Ec}) we may conclude: the most direct functional relationship exists between the indicators "Total investments in the renewable energy resources development" (k4) and "Losses in transportation and distribution of renewable energy resources" (k5), the most inverse functional relationship exists between the

indicators "Energy intensity of the gross domestic product" (k3) and "Losses in transportation and distribution of renewable energy resources" (k5).
The formal view of the matrix of the environmental dimension (I_{ecol}) is:

$$I_{ecol} := \begin{pmatrix} corr\ (k6,k6) & corr\ (k6,k7) & corr\ (k6,k8) & corr\ (k6,k9) & corr\ (k6,k10) \\ corr\ (k7,k6) & corr\ (k7,k7) & corr\ (k7,k8) & corr\ (k7,k9) & corr\ (k7,k10) \\ corr\ (k8,k6) & corr\ (k8,k7) & corr\ (k8,k8) & corr\ (k8,k9) & corr\ (k8,k10) \\ corr\ (k9,k6) & corr\ (k9,k7) & corr\ (k9,k8) & corr\ (k9,k9) & corr\ (k9,k10) \\ corr\ (k10,k6) & corr\ (k10,k7) & corr\ (k10,k8) & corr\ (k10,k9) & corr\ (k10,k10) \end{pmatrix} \quad (7)$$

Let us calculate the matrix of the environmental dimension (I_{ecol}) using 'Data Analysis' MS Excel package:

$$I_{ecol} = \begin{pmatrix} 1 & 0,93 & -0,346 & -0,801 & 0,924 \\ 0,93 & 1 & -0,535 & -0,872 & 0.999 \\ -0.346 & -0,535 & 1 & 0,512 & -0,543 \\ -0,801 & -0,872 & 0,512 & 1 & -0,88 \\ 0,924 & 0,999 & -0,543 & -0,88 & 1 \end{pmatrix}$$

According to the results of calculation of the matrix of the environmental dimension (I_{ecol}) we may conclude: the most direct functional relationship exists between the indicators "Part of the carbon dioxide emissions and the gross domestic product" (k7) and "Percentage of carbon dioxide emissions and gross domestic product at parity purchasing power" (k10), the most inverse functional relationship exists between the indicators "Total technological power of renewable energy resources" (k9) and "Percentage of carbon dioxide emissions and gross domestic product at parity purchasing power" (k10).
The formal view of the matrix of the social dimension (I_{soc}) is:

$$I_{soc} = \begin{pmatrix} corr\ (k11,k11) & corr\ (k11,k12) & corr\ (k11,k13) & corr\ (k11,k14) & corr\ (k11,k15) \\ corr\ (k12,k11) & corr\ (k12,k12) & corr\ (k12,k13) & corr\ (k12,k14) & corr\ (k12,k15) \\ corr\ (k13,k11) & corr\ (k13,k12) & corr\ (k13,k13) & corr\ (k13,k14) & corr\ (k13,k15) \\ corr\ (k14,k11) & corr\ (k14,k12) & corr\ (k14,k13) & corr\ (k14,k14) & corr\ (k14,k15) \\ corr\ (k15,k11), & corr\ (k15,k12) & corr\ (k15,k13) & corr\ (k15,k14) & corr\ (k15,k15) \end{pmatrix} \quad (8)$$

Let us calculate the matrix of the social dimension (I_{soc}) using 'Data Analysis' MS Excel package:

$$I_{soc} = \begin{pmatrix} 1 & 0,968 & -0,912 & -0,915 & 0,995 \\ 0,968 & 1 & -0,828 & -0,84 & 0,96 \\ -0,912 & -0,828 & 1 & 0,998 & -0,928 \\ -0,915 & -0,84 & 0,998 & 1 & -0,93 \\ 0,995 & 0,96 & -0,928 & -0,93 & 1 \end{pmatrix}$$

According to the results of calculation of the matrix of the social dimension (I_{soc}) we may conclude: the most direct functional relationship exists between the indicators "Life expectancy of the population of the country" (k12) and "Employee accrued wages at enterprise in the energy industry" (k15), the most inverse functional relationship exists between the indicators "The number of employees entitled to benefits and compensations for work with harmful working conditions at enterprises" (k14) and "Employee accrued wages at enterprise in the energy industry" (k15).

Graphical interpretation of the integral indicator of the renewable energy resources development in Ukraine is presented in Figure 2.

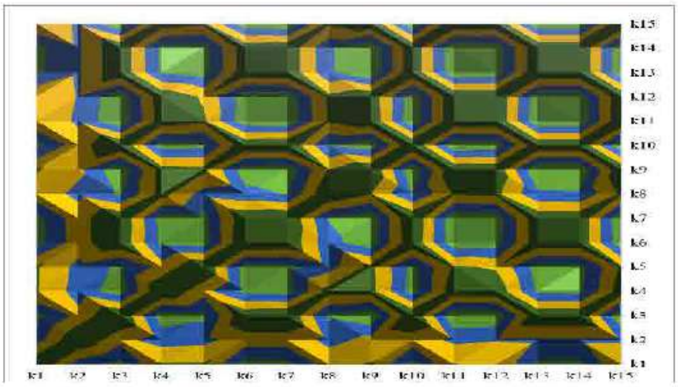

Figure 2: Graphical interpretation of the integral indicator of the evaluation of the renewable energy resources development in Ukraine for the period of 2007-2017

Integral indicator of the evaluation of the renewable energy resources development makes it possible to determine the influence of the group indicators (economic, social and environmental one) on the integral indicator, establishes functional relations between the indicators. The level of functional relation between the indicators can be differentiated into ranges of values: high inverse relation $\in$ [-1;-0,5], medium inverse relation $\in$ (-0,5;0), relation is absent – 0, medium direct relation $\in$ (0;0,5], high direct relation $\in$ (0,5;1] (Tetiana, H., Chorna M., Karpenko L., Milyavskiy M. & Drobyazko S. (2018)). Graphically, the level of functional relation between the indicators of evaluation of the renewable energy resources development in 3D can be traced from the height (high direct relation) to the depth (high inverse relation) (Hilorme, T., Nazarenko Inna, Okulicz-Kozaryn, W., Getman, O. & Drobyazko, S. (2018)).

Based on the calculation of the integral indicator of the evaluation of the renewable energy resources development (D_{res}), the construction of a generalized Harrington desirability function has been proposed, which was originally used for the analysis of technical means. The basis of its construction is the idea of transforming the natural values of certain indicators (parameters) into the scale of desirability.

The scale of desirability is a psychophysical scale, its purpose is to establish a correspondence between physical and psychological parameters, and under physical parameters, one understands the possible indicators that characterize a certain state of the object of optimization, and under the psychological parameters, one understands the subjective importance of such indicators for the functioning of the system as a whole, which is usually set up expertly based on experience and a retrospective analysis of the functioning of the system.

In order to construct the scale of desirability, one uses a table of correspondence of desirability function (d_i) between the relations of desirability in the empirical and quantitative system, in our case, table 3, which presents the values corresponding to certain points of the intersection of the curve given:

$$d = \exp[-\exp(-y)] \quad (9)$$

Table 3: Interrelation between the quantitative values of the Harrington scale and the perception of the state of renewable energy resources development

Desirability (linguistic scale)	Values according to Harrington scale
high (H)	1,00-0,80
good (G)	0,79-0,63
satisfactory (S)	0,62-0,37
bad (B)	0,36-0,20
unsatisfactory (U)	0,19-0,00

The value of the partial response, given to the values on the scale of desirability, is defined as $d_i\ (i = 1,2,...,n)$ and is called partial desirability (from the French "desirable" – desirable). If the value is $d_i = 0$, it corresponds to a completely unsatisfactory state of renewable energy resources development; instead if the value is $d_i = 1$, it corresponds to the best possible state. If the value is $d_i = 0{,}37$, it corresponds to the limit of the acceptable values.
The results of calculations for the evaluation of the renewable energy resources development for Ukraine for the period 2007-2017 are presented in the table 4.

Table 4: The results of complex evaluation of the renewable energy resources development for Ukraine for the period 2007-2017

Years	The value of the integral indicator of evaluation of the renewable energy resources development, part	The conclusion on the effectiveness of management of the renewable energy resources development	The direction of changing the effectiveness of management of the renewable energy sources development*
2007	0,52	satisfactory	X
2008	0,58	satisfactory	—
2009	0,60	satisfactory	—
2010	0,75	good	↑
2011	0,61	satisfactory	↓
2012	0,59	satisfactory	—
2013	0,64	good	↑
2014	0,61	satisfactory	↓
2015	0,66	good	|
2016	0,68	good	|
2017	0,70	good	|

* — – *the state of the system is stably negative;* | – *the state of the system is stably positive;*
↑ – *the state of the system gets better;* ↓ – *the state of the system gets worse.*

The conclusion on the effectiveness of the management of the renewable energy resources development is formed in accordance with the table 3. Thus, from the conducted research one may conclude that there is a positive status of the evaluation of the renewable energy resources development for Ukraine for the period of 2007-2017, and its positive dynamics is also well seen.
At the present stage of renewable energy resources development in Ukraine, there are negative external and internal factors. External factors are: economic factors – the intervention of foreign capital; political factors; social factors – the impoverishment of the population, the labour outflows of the population in the energy sector. The negative factors influencing the stagnation of the renewable energy resources development are: exchange rate volatility, lack of transparency of alternative energy market, low capitalization, institutional structure imbalances, lack of reliable information for making informed decisions on the need for renewable energy resources.

But the revival of the situation on the renewable energy resources development in Ukraine since 2015 is connected with the implementation of the Smart Grid concept, it is a world-view of the future power industry, based on energy conservation and built on a methodological platform that consists of: principles of construction, key requirements (values), functional properties (attributes), as well as elements of the basis for their implementation.

Pending this, the effects of the implementation of the Smart Grid concept will depend on the group of stakeholders: energy companies (wholesalers of electricity, energy service sales retailers, electricity transmission companies, distribution network companies), end-users (industrial users, commercial users, population), regulatory authorities (state regulatory authorities, wholesale electricity market operators, security regulators), the state and society as a whole.

Discussion

Thus, end-users may expect the following effects from the implementation of this concept: the ability to control electricity consumption, increase the overall level of service, increase the reliability of energy supply, access to information on energy supply in real-time, the ability to participate in demand management, to optimize the interrelation of generation distribution etc.

While for energy companies, the expected effects are as follows: reduction of electricity losses, transparent accounting and billing system, optimization of asset management, maintenance and monitoring in real time, etc. In addition, the Smart Grid technology protects against unauthorized selection of electricity and promotes longer-term operation of the equipment due to the reasonable organization of the electricity grid.

Particularly urgent issues in Ukraine are the renewable energy resources development. Smart Grid technologies can provide the optimal distribution of power flows of the electricity grid, reduce losses in it, quickly coordinate the response in the event of accidents, the possibility of merging into a single grid both large power plants and modern renewable energy resources.

The model of the Smart Grid concept should be based on: technological basis (scientific and technological progress in the areas of energy saving), normative basis (development of systematic and methodological provision of this concept at the national level), information basis (information relations turn into a systemic factor that provides a transition from the energy to the energy information system based on information and communication and computer technologies) and management basis (management as separate elements of the energy information system and the entire system in general).

But with any managerial decision, it is necessary to evaluate the effect of its implementation. At the same time, in our opinion, it is possible to conduct an economic evaluation of the effects of the implementation of the Smart Grid concept in the following directions:

1. Environmental effects – it gives a chance to reduce carbon emissions.
2. The effects of reducing the operating and exploitation costs of power companies – it gives a chance to reduce losses in electricity distribution by optimizing power plants and the balance of the grid.
3. Reduced costs for industrial consumers.
4. Effects of improving the quality of service for business customers based on interactive communication with consumers.
5. Improved efficiency and quality of power supply.
6. The effects of increasing the part of the renewable energy resources use and distributed generation.

All of these factors influence the formation of a group of key values in the system of energy management, in which there are two approaches to the creation of values. Thus, the Smart Grid concept of Departament of Energy (DOE) USA has such key values («Grids 2030». A National Vision for Electricity's Second 100 years. Office of Electric Transmission and Distribution of USA Department of Energy, 2003): accessibility, reliability, economic feasibility, efficiency, organic interaction with the environment, security – prevention of situations in the power industry, dangerous to people and the environment.

In the European Union, the key values in the system of energy management include (European Commission Directorate-General for Research Information and Communication Unit European Communities: «European Technology Platform Smart Grids, Vision and Strategy for Europe's Electricity Networks of the future», European Communities, 2006): flexibility in terms of response to changing consumer needs and emerging power supply problems; availability of electricity for consumers, in particular renewable energy resources and highly efficient local generation with zero or low losses; reliability of electricity supply and the quality of electricity in providing protection against dangers and uncertainty; profitability through the implementation of innovation, effective management, rational combination of competition and regulation.

Conclusion

The consequences of the global energy crisis, which covered all sectors of the country not only in Ukraine, require the implementation of progressive measures to manage energy-saving technologies for both the government and the entire energy conversion chain: generation, consumption, transportation, redistribution, etc.
Systemic implementation of innovative principles of energy management is an integral part of the European vector of integration of the Ukrainian economy.

The implementation of Smart Grid technology will significantly increase the reliability and cost-effectiveness of the functioning and development of Ukraine's grid and improve the quality of customer service. Today, a large number of green energy projects have been launched and operated in Ukraine, and "intelligent" systems for managing the creation, generation, transmission and consumption of energy are being implemented. Despite the risks involved in implementing energy-saving projects, the current regulatory framework provides investors with sufficient incentives and mechanisms to ensure the successful implementation and development of Green Grid projects, Smart Grid in Ukraine. Therefore, the issue of "green taxation", providing privileges to both legal entities and individuals, and the implementation of "intelligent" energy monitoring systems with the use of Internet technologies is particularly acute. The normative legal framework itself for the renewable energy resources development in Ukraine is a key issue for motivating agents from power generating, distributing and consuming groups.

Despite the risks and problems of implementing projects of power supply systems based on the use of alternative energy sources, the current regulatory framework provides investors with sufficient incentives and mechanisms to ensure the successful implementation and development of green energy projects in Ukraine. World practice shows that the state is the main initiator of the development of alternative energy, which, on the one hand, establishes the rules for the operation of alternative energy, on the other hand, provides the necessary legal and resource support, including financing and preferential taxation. It is government support for the development of alternative energy in Ukraine that should become one of the main factors in overcoming the energy crisis and improving the mechanism of tax privileges.

Progress in the direction of sustainable development and enhancement of energy security of the state prompts improvement of regulatory framework in the field of renewable energy resources and energy efficiency at the national, regional and local levels. An important component in this is the harmonization of Ukrainian legislation in this area in accordance with European and international norms.

The prospects for further formation are: the development of strategies based on the results of the calculated integral indicator of the evaluation of the renewable energy resources development; the formation of an effective mechanism at all levels of the economy, with the help of which these strategies are implemented (economic, legal, informational, organizational one); etc.

References

«Grids 2030». A National Vision for Electricity's Second 100 years. Office of Electric Transmission and Distribution of USA Department of Energy, 2003. URL: https://www.energy.gov/oe/downloads/grid-2030-national-vision-electricity-s-second-100-years

Chang, R. D., Zuo, J., Zhao, Z. Y., Zillante, G., Gan, X. L., & Soebarto, V. (2017). Evolving theories of sustainability and firms: History, future directions and implications for renewable energy research. *Renewable and Sustainable Energy Reviews*, *72*, 48-56. URL: https://www.sciencedirect.com/science/article/pii/S1364032117300333

Che, L., Zhang, X., Shahidehpour, M., Alabdulwahab, A., & Abusorrah, A. (2017). Optimal interconnection planning of community microgrids with renewable energy sources. *IEEE*

Transactions on Smart Grid, 8(3), 1054-1063. URL: https://ieeexplore.ieee.org/abstract/document/7185424

Chen, H. H., Lee, A. H., & Kang, H. Y. (2017). The fuzzy conceptual model for selecting energy sources. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(4), 297-304. URL: https://www.tandfonline.com/doi/abs/10.1080/15567249.2011.652339

Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017). Sustainable supply chain management: framework and further research directions. *Journal of Cleaner Production*, *142*, 1119-1130. URL: https://www.sciencedirect.com/science/article/pii/S0959652616301883

European Commission Directorate-General for Research Information and Communication Unit European Communities: «European Technology Platform Smart Grids, Vision and Strategy for Europe's Electricity Networks of the future», European Communities, 2006. URL: https://www.edsoforsmartgrids.eu/policy/eu-steering-initiatives/smart-grids-european-technology-platform/

Hilorme, T., Nazarenko Inna, Okulicz-Kozaryn, W., Getman, O. & Drobyazko, S. (2018). Innovative model of economic behavior of agents in the sphere of energy conservation. *Academy of Entrepreneurship Journal, Volume 24, Issue 3, 2018.* URL: https://www.abacademies.org/journals/month-september-year-2018-vol-24-issue-3-journal-aej-past-issue.html

Ibidunni, A. S., Ogunnaike, O. O., & Abiodun, A. J. (2017). Extending the knowledge strategy concept: linking organizational knowledge with strategic orientations. *Academy of Strategic Management Journal*, *16*(3). URL: http://eprints.covenantuniversity.edu.ng/11867/
Karabegović, I., & Doleček, V. (2017). Development and Implementation of Renewable Energy Sources in the World and European Union. *CONTEMPORARY MATERIALS*, *2*(6), 130-148. URL: http://doisrpska.nub.rs/index.php/conterporarymaterials3-1/article/view/4070

Kumar, A., Sah, B., Singh, A. R., Deng, Y., He, X., Kumar, P., & Bansal, R. C. (2017). A review of multi criteria decision making (MCDM) towards sustainable renewable energy development. *Renewable and Sustainable Energy Reviews*, *69*, 596-609. URL: https://www.sciencedirect.com/science/article/pii/S1364032116309479

Li, M. J., & Tao, W. Q. (2017). Review of methodologies and polices for evaluation of energy efficiency in high energy-consuming industry. *Applied Energy*, *187*, 203-215. URL: https://www.sciencedirect.com/science/article/pii/S0306261916316245

Liang, X. (2017). Emerging power quality challenges due to integration of renewable energy sources. *IEEE Transactions on Industry Applications*, *53*(2), 855-866. URL: https://ieeexplore.ieee.org/abstract/document/7738432

Marinakis, V., Doukas, H., Xidonas, P., & Zopounidis, C. (2017). Multicriteria decision support in local energy planning: an evaluation of alternative scenarios for the sustainable energy action plan. *Omega*, *69*, 1-16. URL: https://www.sciencedirect.com/science/article/pii/S0305048316304492

Radovanović, M., Filipović, S., & Pavlović, D. (2017). Energy security measurement–A sustainable approach. *Renewable and Sustainable Energy Reviews*, *68*, 1020-1032. URL: https://www.sciencedirect.com/science/article/pii/S1364032116002185

Sato, M., Kharrazi, A., Nakayama, H., Kraines, S., & Yarime, M. (2017). Quantifying the supplier-portfolio diversity of embodied energy: Strategic implications for strengthening energy resilience. *Energy Policy*, *105*, 41-52. URL: https://www.sciencedirect.com/science/article/pii/S030142151730099X

Stativka, N., & Lialina, N. (2017). Formation of the organizational-economic mechanism of agricultural enterprises energy efficiency. *Agricultural and Resource Economics International Scientific E-Journal*, *3*(2), 56-64. URL: http://are-journal.com/are/article/view/104

Tetiana, H., Chorna M., Karpenko L., Milyavskiy M. & Drobyazko S. (2018). Innovative model of enterprises personnel incentives evaluation. *Academy of Strategic Management Journal. Volume 17, Issue 3, 2018* URL: https://www.abacademies.org/journals/month-june-year-2018-vol-17-issue-3-journal-asmj-past-issue.html

Tetiana, H., Karpenko, L., Fedoruk, O., Shevchenko, I., & Drobyazko, S. (2018). Innovative methods of performance evaluation of energy efficiency project. Academy of Strategic Management Journal, 17(2), 112-110. URL: https://www.abacademies.org/articles/innovative-methods-of-performance-evaluation-of-energy-efficiency-projects-7067.html