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ECONOMETRIC MODELS OF INCREASING THE EFFICIENCY OF PROCESSES USING ALTERNATIVE ENERGY SOURCES

Qodirov Baxodir Tursunovich
Independent researcher of Andijan Institute of Economics and Construction
E-mail:qodirovbohodir0175@gmail.com

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Abstract:

In this article, the qualitative and quantitative indicators affecting the effectiveness of the use of alternative energy sources are studied, the criteria determining the economic potential are analyzed and their composition is compiled. Also, the processes of using alternative energy sources and the factors affecting it were analyzed and their quantitative effects were evaluated based on econometric models.

Keywords: renewable energy, alternative energy sources, econometric models, evaluation indicators, efficiency.

It is known that the field of economy is a humanitarian field. In recent times, there are many cases of uncertainty in economic events and processes. Because the organization, development, improvement, management and development of prospective strategies of economic processes are approached logically, rationally and objectively. This leads to increasing uncertainty in the field.

What should be done to reduce this uncertainty and the risks that are expected because of it. Today, it can be seen from the world experience that economic-mathematical and econometric models and methods are widely used in the quantitative assessment of the effects of uncertainty and factors affecting economic phenomena and processes.

It is known that efficiency is the achievement of a specific result at the lowest cost or the maximum possible output from a given amount of resources [6].

Economic efficiency is the high profitability of economic entities achieved as a result of economic activity, that is, it is expressed by obtaining high income (profit) by spending the least amount of resources or costs.

In other words, it is characterized by the ratio of the obtained economic effect to the consumption of production factors and resources, which led to the achievement of the highest production volume using resources of a certain value.

Economic efficiency is expressed as an economic indicator reflecting the profitability or profitability obtained in relation to the unit of resources and costs spent on production.

$$E_i^t = \frac{R_i^t}{C_i^t} \qquad (1)$$

here: E_i^t – economic efficiency (profitability) of *i*-network at time *t*, R_i^t – the income of network *i* at time *t*, C_i^t – resources and costs of network *i* at time *t*.

Of course, factors affecting the economic efficiency of economic entities can be divided into two groups. In particular, they include qualitative indicators: competition, innovative ideas, effective management, personnel competence, scientific developments, and quantitative indicators: fixed assets, labor resources, capital investments, resource costs, storage and transportation costs (Figure 1).

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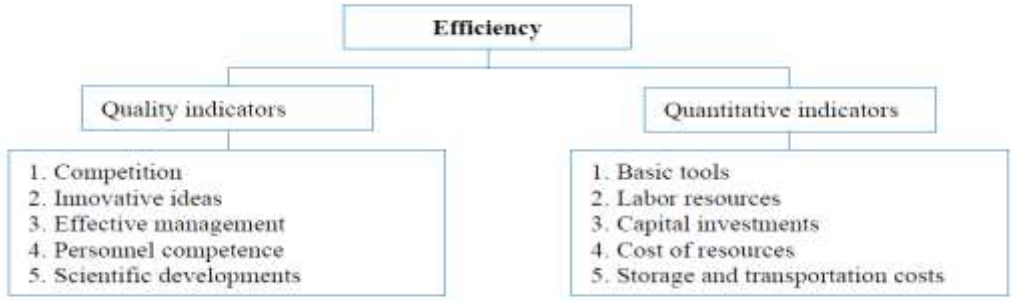

Figure 1. Grouping of factors affecting efficiency[1]

Quantitative indicators are often used in the study, analysis and evaluation of economic efficiency. Because quantitative indicators reflect the quantitative aspects of the studied process and are expressed in specific measurement units. This makes it possible to evaluate the quantitative relationship between the resulting and factor indicators on the basis of econometric models.

This, in turn, shows the economic potential of the studied economic object. That is, the economic potential depends on all the factors affecting it and participating in the process of production and sale [1].

In other words, the economic potential of the production process depends on the company's resources and their ability to turn into the necessary results to achieve specific goals in the production process [2].

In general, it can be seen that different methods and criteria are used in the evaluation of economic potential in economic literature and field studies. In particular, E.V. Nikolskaya [3] believes that the potential of each resource is related to other resources in the production system. He emphasized that the acceleration of production should reduce the material consumption of individual types of production units and increase the contribution of resources that help to increase its efficiency by organizing production accordingly.

Accordingly, the criteria for evaluating economic potential are divided into production components, material resources, personnel composition, technical and technological components, and information resources (Figure 2).

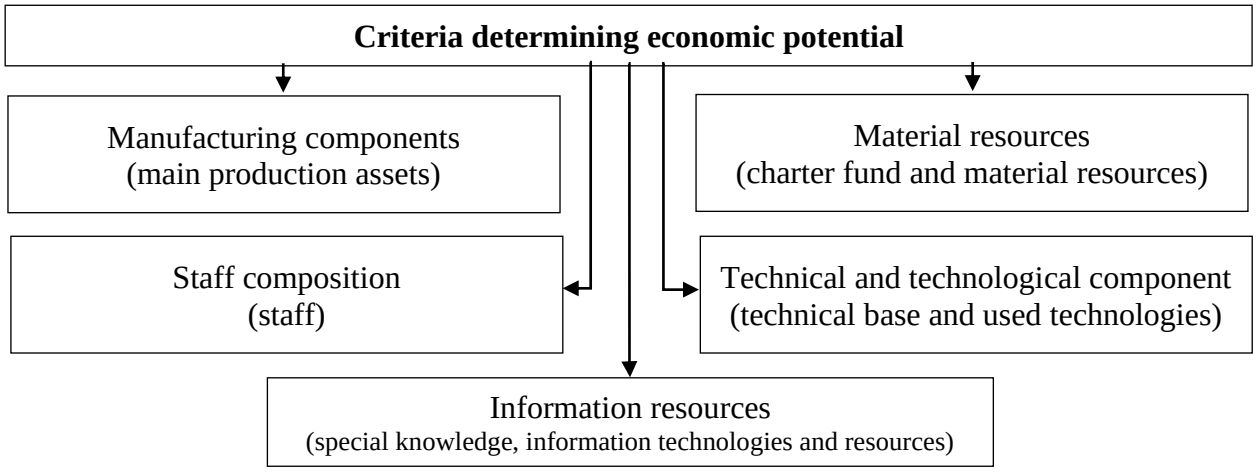

Figure 2. Criteria determining economic potential [4]

According to studies [5], the structure of economic potential does not only include the elements describing the financial and investment capabilities of the enterprise, but also depends on other factors participating in its production chain, as well as on management decisions.

Based on the above, the following can be cited as quantitative indicators affecting the efficiency of the use of renewable energy sources. In particular,

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renewable energy producing (converting) technologies, labor resources operating in the field, investments made to finance the field, and others are included. However, the main qualitative indicator affecting the efficiency of the use of renewable energy sources is the sustainability of existing natural renewable energy sources, and the main quantitative indicator is the renewable energy production (converting) technologies (Figure 3).

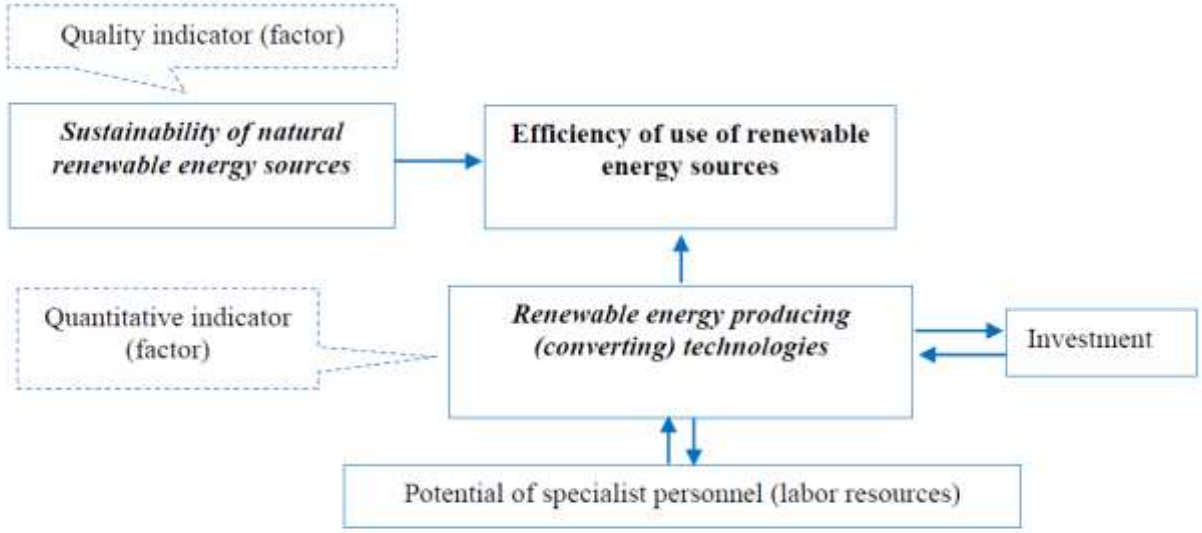

Figure 3. A model that determines the efficiency of using renewable energy sources[2]

Today, in order to study, analyze, and econometric modeling of the processes of increasing the efficiency of the use of renewable energy sources in our country, first of all, it is necessary to observe, collect, process, group and summarize statistical indicators of renewable energy sources.

According to statistics, in 2021, 30815.5 bln. soum equivalent of electricity was produced, of which 3103.1 bln. soums or 10.1 percent is the contribution of renewable energy. Observations showed that during the period 2015-2021, 9.5 percent of the total electricity, gas, steam supply and air conditioning products were accounted for by renewable energy. In this case, renewable energy is mainly produced in hydroelectric power stations.

Table 1

The volume of renewable energy production dynamics[1], billion soum

Indicator	**2015 y.**	**2016 y.**	**2017 y.**	**2018 y.**	**2019 y.**	**2020 y.**	**2021 y.**
Electricity, gas, steam supply and air conditioning	8 993,3	10 522,6	11 656,0	14 518,5	22 014,7	27 375,3	30 815,5
From this:							
Renewable energy	836,4	926,0	1 049,0	1 437,3	2 135,4	2 600,7	3 103,1

[1] Information of the State Statistics Committee of the Republic of Uzbekistan.

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Using the data in the table above, the quantitative relationship between electricity, gas, steam supply and air conditioning industry products (y) and renewable energy products (x) can be estimated based on correlation and regression analysis.

First of all, it is necessary to determine the presence of multicollinearity between the outcome and factor indicators based on correlation analysis. Eigen and pair correlation coefficients are calculated.

Table 2

According to the resulting and factor indicators pairwise correlation matrix[2]

	y	x
y	1	0,998017332
x	0,998017332	1

According to the results of the correlation analysis, the correlation coefficient $r_{yx} = 0{,}998017$ of the outcome and factor indicators was equal, which showed the presence of multicollinearity between them. That is, $|r| > 0{,}7$ satisfies the inequality, indicating the presence of autocorrelation or strong correlation between these indicators. This can also be seen in the output chart analysis (Figure 4).

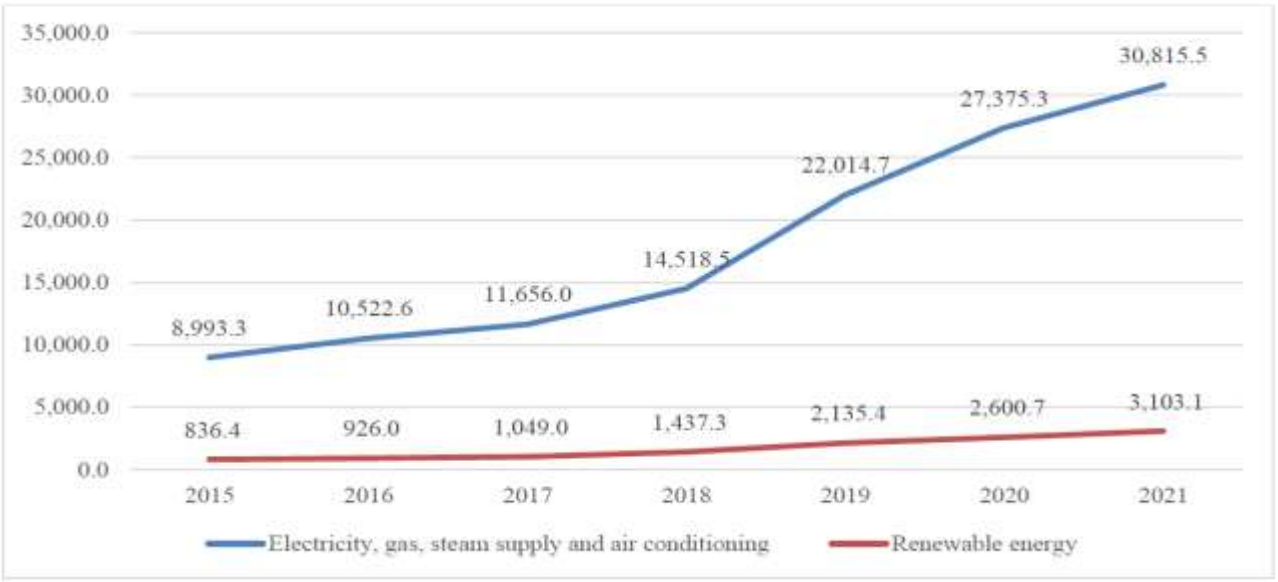

Figure 4. Dynamics of electricity, gas, steam supply and air conditioning industry products and renewable energy product volumes[3], billion soum

[2] Author's calculations.
[3] Compiled by the author.

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It should be noted that until recent years in our country, things have been slow in fully meeting the demand for electricity of the population and economic entities. Naturally, the use of renewable energy sources, which require a large initial investment, was indifferent to the establishment. For example, the establishment and popularization of solar photoelectric power stations and biogas power stations are among them.

The increasing demand for electricity in the country and the increase in environmental damage caused by traditional power plants, as well as the limitation of the natural resources used in this, are drawing attention at the government level to the use of renewable energy sources, which are the most important natural clean product in our country.

Today, hydroelectric power stations are leading in the production of alternative energy in the republic.

According to the analysis, the volume of renewable energy in 2021 will be 3103.1 billion. was 3.7 times compared to 2015, 3.4 times compared to 2016, 3.0 times compared to 2017, 2.2 times compared to 2018, 1.5 times compared to 2019 and 2020 increased by 1.2 times.

In addition, in 2021, among the factors that determine the efficiency of the use of renewable energy sources, the volume of the main funds used in the sector is 2007.3 billion. soums and the average annual number of employed employees was 1751 people, this indicator compared to 2015, the volume of basic funds increased by almost 10.1 times, while the average annual number of employees decreased by 0.9 times (Table 3).

Table 3
Key indicators of the renewable energy sector[4]

Years	The volume of renewable energy, billion soum	The size of the main funds, billion soum	Average annual number of employees, person
2015	836,4	198,2	1,9
2016	926,0	257,6	1,9
2017	1 049,0	221,2	1,7
2018	1 437,3	260,7	1,6
2019	2 135,4	182,0	1,7
2020	2 600,7	3,0	1,7
2021	3 103,1	2 007,3	1,8

In order to econometrically analyze the influence of the factors influencing the trend of the volume of renewable energy (y), in particular, the volume of Basic funds (x_1) and the average annual number of employees in the field (x_2), it is first necessary to determine the presence of multicollinearity between these factors based on correlation analysis (Table 4).

[4] Information of the State Statistics Committee of the Republic of Uzbekistan / Author's calculations.

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Table 4
Pairwise correlation matrix for renewable energy volume, fixed assets volume, and average annual number of employees in the industry[5]

	y	x1	x2
y	1	0,692996164	-0,303675851
x1	0,692996164	1	0,041824791
x2	-0,303675851	0,041824791	1

According to the results of the correlation analysis, the correlation coefficients of the outcome and factor indicators $r(y:x_1)$ and $r(x_1:x_2)$ showed a weak direct relationship between them, while $r(y:x_2)$ showed a weak inverse relationship.

It can also be checked by the autocorrelation coefficient.

$$r_{ei} = \frac{\overline{\in_i \in_{i-1}} - \overline{\in_i} \cdot \overline{\in_{i-1}}}{S_{ei} \cdot S_{e_{i-1}}} \quad (2)$$

If $r_{ei} < 0,5$, it indicates no autocorrelation. $r_{ei} = 0,328$, so there is no autocorrelation.

Therefore, the quantitative relationship between the volume of renewable energy and the influencing factors: the volume of fixed assets and the average annual number of employees in the field can be estimated based on a multifactor regression model. In this case, the multifactor regression model can be expressed as follows.

$$y = a_0 + a_1 x_1 - a_2 x_2 + \varepsilon \quad (3)$$

Based on the data in Table 3, a multifactor regression model is constructed using the method of least squares.

$$y = 6744,316 + 1,0061 x_1 - 3136,0336 x_2$$

The obtained regression equation should be statistically analyzed. First of all, the approximation error of the constructed models is determined by the following formula.

$$A = \frac{\sum |\in : Y|}{n} \cdot 100\% \quad (4)$$

$$A = \frac{1,847}{7} \cdot 100\% = 26,38\,\%$$

Approximation error allows you to check the significance of the equation and its coefficients, estimate absolute and relative approximation errors. Also, the standard error of (y) is determined. $S_y = 662,401$

Evaluation of the overall significance of the multivariate regression equation is done through the coefficient of determination and Fisher's criterion.

$$R^2 = 1 - \frac{s_e^2}{\sum (y_i - \bar{y})^2} \quad (5)$$

$$F = \frac{R^2}{1 - R^2} \cdot \frac{n - m - 1}{m} \quad (6)$$

$R^2 = 0,6345$; $F = 3,472$ ($F_{\text{Table}} = 6,94$)

The significance of the parameters of the regression equation is checked by the t-statistics criterion.

$$t_i = \frac{b_i}{S_{b_i}} \quad (7)$$

$t_{a_0} = 1,597$; $t_{a_1} = 2,464$; $t_{a_2} = 1,299$ ($t_{\text{Table}} = 3,495$)

Durbin-Watson test is used to analyze the correlation of deviations.

$$DW = \frac{\sum (e_i - e_{i-1})^2}{\sum e_i^2} \quad (8)$$

$$DW = 1,33$$

According to the Durbin-Watson criterion, the error deviation $1,5 < DW < 2,5$ should be in the interval. Otherwise, it means that there is autocorrelation.

In short, according to the multifactor regression model created as a result of calculations, an increase in the volume of fixed assets (x_1) by 1 unit leads to an increase in the volume of renewable energy (y) by 1.006 units, while an increase in the average annual number of employees (x_2) by 1 unit

[5] Author's calculations.

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of renewable energy causes the size of (y) to decrease to 3136,034 units. Therefore, it can be concluded that (x_1) is the factor that has the greatest influence on the resulting factor.

However, according to the model evaluation results, it was found that the model was not statistically significant according to Fisher and t-statistics criteria.

This model can be expressed on a standard scale. The regression model on the standard scale assumes that all the values of the studied properties are converted to standards (standardized values) according to the formulas, and this is defined as follows.

$$t_j = \frac{xj_i - \overline{xj}}{S(x_j)} \quad (9)$$

here: x_{ji} - i -the value of the variable in the observation.

$$t_y = \frac{y_i - \overline{xj}}{S(y)} \quad (10)$$

Thus, the origin of each standardized variable is combined with its mean value and its standard deviation is obtained as a unit of variation.

If the relationship between variables in a natural scale is linear, then changing the origin and the unit of measurement does not violate this property, so standardized variables are associated with a linear relationship.

$$t_y = \sum \beta_j t_{xj} \quad (11)$$

To estimate the unknown parameters, we use the method of least squares and create a system of normal equations.

This system of linear equations is solved by the Gaussian method and the standardized form of the regression equation is constructed.

$$t_y = 0{,}754\, x_1 - 0{,}397\, x_2$$

In addition, it is appropriate to consider the above econometric analysis based on other types of models. For example, in the form of the Kobba-Douglas model, the relationship between the indicators of the volume of renewable energy (y), the volume of fixed assets (x_1) and the average annual number of employees in the field (x_2) can be expressed as follows

$$y = a_0 x_1^{\alpha} x_2^{\beta} \quad (12)$$

here: a_0, α, β - unknown parameters of the model.

To find the unknown parameters of this model, the model is transformed into a small equation by logarithmization,

$$\ln(y) = \ln(a_0) + \alpha \ln(x_1) + \beta \ln(x_2)$$

and the parameters are found by the method of least squares.

$$y = 7{,}3748\, x_1^{0{,}4111} x_2^{-4.3434}$$

In short, an increase in the volume of fixed assets used in the production of renewable energy by 1 unit can lead to an increase in the volume of renewable energy by 0.4 units, an increase in the number of employees working in the production of renewable energy by 1 unit can lead to a decrease in the volume of renewable energy by 4.3 units .

It is worth noting that the factors affecting the adoption of renewable energy are trust, distributive justice, location and socio-demographic factors. Of all these four factors, trust has the most significant impact on the development of renewable energy.

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