Assessment of the Importance of Energy Facilities Reconstruction Factors

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Abstract. In modern conditions, the necessity to integrate the complex of managerial, technological and climatic factors in choosing solutions at all stages of the planning and management of construction production requires a re-evaluation of the existing approaches to reconstruction process. In this article the author considered the question of estimating the importance of factors influence on the total duration of the reconstruction of energy facilities. The purpose and objectives of the study were formed, based on the analysis of codes and standards in the construction sphere, as well as data about the objects of reconstruction. The studies of national and foreign scientists and specialists of the construction sphere, process simulation program and programs of federal and regional energy development were used for the methodological basis of the research. The study provides a multifactor analysis of the impact of labor efficiency depending on the work type on the duration of the reconstruction of objects. The quality of the model was checked with three formal criteria. The conclusions and results of the study allow us to conclude about the importance of certain factors in the total model and build the most qualitative model.

1. Introduction

Nowadays, electric power industry is the basic branch of the Russian economy, which provides electricity and heat for the national needs of the country, as well as export of electricity to the foreign countries. Sustainable development and reliable functioning of the industry largely determine the energy security of the country and are the important factors for its successful economic development.

At the same time, the reliable functioning of the industry can be carried out only with the development of science and technology, the formation of a system of codes and standards, formation of optimal organizational and technological models of construction objects with provision for features of design and construction in modern conditions.
On this basis, there was developed the Strategy of the development of the power grid complex of the Russian Federation during the period up to 2030, based on the decree of the President of the Russian Federation dated November 22, 2012 No. 1567. The most important component in the development of modern Russian power engineering is the reconstruction and modernization of power transmission lines and electric power substations. The lack of investment into the electricity grid in the 1990s has led to significant physical wear of existing electrical networks. As a result, the share of expired electric distribution networks is 50%, while the wear indicators of electric networks being operated by Federal Grid Company of Unified Energy System JSC is over 50%. At the same time, in foreign countries, the wear indicators of electric networks vary in the range of 27 – 44% [1, 2].

In recent years, the power grid complex, incl. "Rosseti" PJSC, is aimed at the introduction of new technologies in construction, reconstruction of facilities, as well as modernization of existing systems. At the same time, a significant influence on the efficiency of construction production is provided by various groups of factors, incl. natural-climatic (conditions in mountains, wetlands, soil subsidence, etc.).

At the same time, the important subject is the assessment of the influence of various factors on the overall duration of construction process, as well as reconstruction of the facility, since the interrelation of all stages of work determines the overall efficiency of construction production organization in any region [3-6].

2. Methods
The theoretical and methodological basis of the study was the work of native and foreign scientists and specialists in the field of construction management, organizational and technological modeling. The research methods are based on the theory of mathematical modeling, probability theory and statistical methods [4-22].

In modern conditions, multiple-factor regression analysis is widely used in statistics, econometrics, technical sciences, where the comprehensive assessment of the factor significance is provided.

We consider the multiple-factor analysis of labor efficiency degree depending on the work type on the duration of reconstruction of transmission line section in the region of Krasnodar Krai.

Selection begins with a pithy analysis namely on the basis of knowledge about the research subject to determine that specific factors such as $x_1, x_2 \ldots x_k$ can be affected on the result $Y$ index. For example:

$y$ - time of restoration of the network site work (days);

$x_1$ - labor intensity of dismantling an existing wire (man-hour);

$x_2$ - labor intensity of dismantling existing supporting structures (man-hour);

$x_3$ - labor intensity of dismantling existing foundations (man-hour);

$x_4$ - labor intensity of excavation work (man-hour);

$x_5$ - labor intensity of foundation work (man-hour);

$x_6$ - labor intensity of mounting supporting structures (man-hour);

$x_7$ - labor intensity of wire installation (man-hour);

$x_8$ - labor intensity of improvement work (man-hour);

At first sight, all these factors are important, and therefore it is advisable to apply a methodology of evaluating factors based on multiple regression analysis.

The above mentioned factors correspond to the inclusion in the general model, since all of them are quantitatively measurable.
In the study, the author considered the power equation. For a given type of equation, the logarithmic values are the initial data. Such a model will be linear with respect to the logarithms of the initial benchmarks.

3. Results
To analyze the correlation coefficients between factors, we used the packet tools of "Data Analysis" CORRELATION (Microsoft Excel). As a result, for the groups of objects in the region of Krasnodar Krai, the author obtained the results in accordance with table 1.

|     | y   | x1  | x2  | x3  | x4  | x5  | x6  | x7  | x8  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| y   | 1.00|     |     |     |     |     |     |     |     |
| x1  | 0.40| 1.00|     |     |     |     |     |     |     |
| x2  | 0.11| -0.07| 1.00|     |     |     |     |     |     |
| x3  | 0.06| 0.69| 0.01| 1.00|     |     |     |     |     |
| x4  | 0.46| -0.11| -0.24| 0.19| 1.00|     |     |     |     |
| x5  | 0.83| 0.29| 0.26| 0.06| 0.48| 1.00|     |     |     |
| x6  | -0.63| 0.17| -0.14| 0.42| -0.39| -0.61| 1.00|     |     |
| x7  | 0.55| 0.89| -0.25| 0.68| 0.19| 0.29| -0.03| 1.00|     |
| x8  | 0.56| -0.02| 0.21| 0.18| 0.79| 0.77| -0.37| 0.04| 1.00|

Analysis of the data in table 1 shows y has the closest correlation with factors \( x_4, x_5, x_6, x_7, x_8 \) and the weak correlation with factors \( x_1, x_2, x_3 \). Accordingly, factors \( x_1, x_2, x_3 \) are excluded from the general model.

Factors \( x_1 \) and \( x_7 \) show a strong functional connection with the coefficient of pair correlation of 0.89. This means that when composing a new model and including the factors, only one of them should be present.

As a result, 4 combinations with one or another set of factors were considered in accordance with table 2.

Thus, the analysis of the data in table 2 (the determination coefficient, the Fisher's criterion, and the Student's distribution) shows that the best model can be constructed basing on the third option.

As a result of the regression analysis, we obtain the corresponding values of the multiple determination coefficient \( R=0.91 \) and the values of the coefficients \( \beta_1 1.66, \beta_5 0.30, \beta_7 0.09 \).

On this ground, the power-law model can be represented in the following form of an equation (1):

\[
y = e^{1.66} x_5^{310.7} x_6^{5.102} x_7^{9.102}
\]
**Table 2.** Results of multifactor analysis (power law).

| Option No. | Factors                      | Fisher's criterion | Coefficient of determination | Student's distribution |
|------------|------------------------------|--------------------|-------------------------------|------------------------|
| 1          | $x_4, x_5, x_6, x_7, x_8$   | 5.27               | 0.84                          | $y$ 1.15               |
|            |                              |                    |                               | $x_4$ 0.20             |
|            |                              |                    |                               | $x_5$ 0.70             |
|            |                              |                    |                               | $x_6$ -1.15            |
|            |                              |                    |                               | $x_7$ 1.66             |
|            |                              |                    |                               | $x_8$ 0.31             |
| 2          | $x_5, x_6, x_7, x_8$         | 7.82               | 0.84                          | $y$ 1.73               |
|            |                              |                    |                               | $x_5$ 1.35             |
|            |                              |                    |                               | $x_6$ -1.42            |
|            |                              |                    |                               | $x_7$ 2.14             |
|            |                              |                    |                               | $x_8$ 0.28             |
| 3          | $x_5, x_6, x_7$              | 11.98              | 0.84                          | $y$ 1.89               |
|            |                              |                    |                               | $x_5$ 2.63             |
|            |                              |                    |                               | $x_6$ -1.50            |
|            |                              |                    |                               | $x_7$ 2.34             |
| 4          | $x_4, x_5, x_6, x_7$         | 7.73               | 0.84                          | $y$ 1.65               |
|            |                              |                    |                               | $x_4$ 0.13             |
|            |                              |                    |                               | $x_5$ 2.30             |
|            |                              |                    |                               | $x_6$ -1.35            |
|            |                              |                    |                               | $x_7$ 2.15             |

**4. Discussions**

As a result, the significant factors were: $x_5$ (labor intensity of foundation work), $x_6$ (labor intensity of mounting supporting structures) and $x_7$ (labor intensity of wire installations).

The obtained results of the factor significance can be justified by the combined effect of the natural-climatic and territorial conditions of the reconstruction site.

The increase in the labor intensity of excavation works is explained with cramped, mountainous conditions on the reconstruction site.

The presence of seismic activity (up to 9 points), landslide zones justifies the labor intensity of the erection of complex foundation constructions, capable of stand not only static, but also dynamic loads.

The importance of the factors $x_6$ and $x_7$ (labor intensity of mounting supporting structures and labor intensity of wire installations) can be justified by the presence of mountain conditions, transitions through the ravines and rivers, which in turn increase the laboriousness of the work.
5. Conclusions

Thus, in the course of the study:

• the specifics of the reconstruction of power transmission lines has been studied;
• a multifactor analysis was performed, on the basis of which combinations of significant factors were considered and the most qualitative equation was constructed;
• the results were obtained on the example of the reconstruction of the transmission line section of the region of Krasnodar Krai, where labor-intensive work at the foundation construction, mounting supporting structures and suspension of wires were the most significant factors;
• the results of the importance of the factors are due to the impact of the natural-climatic and territorial conditions of the reconstruction site.

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