

Analysis of applicability of conventional units in power grid companies in the Russian Federation

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Abstract. Value formation for energy transmission services in the Russian Federation is carried out under strict state control, basing on the widespread practice of benchmarking or "best practice" methods. The basis for calculating some of the best indicators is the concept of "unit credit". (c.u.). Over the past few years, the issue of the "unjustified" application of the CU and the need to review it has been raised several times. The analysis of the current normative documentation has shown that use of different documents allows changing the results of calculation of the basic items of the expenses using c.u. as the basic indicator, for example, the expenses for maintenance service and repair (MRO) regarding a labor payment. This situation arises in the process of transferring the actual labor intensity of maintenance and repair works in c.u. The value of deviation of labor inputs determined by the difference in periodicity and labor intensity leads to significant distortion of result when forming costing and defining the optimum or the most effective values. Thus, these differences can become a tool for manipulation by energy companies when costing making use of benchmarking.

1. Introduction

The concept of "conventional unit" (c.u.) of equipment is used to calculate a large number of grid companies' performance indicators. Appearance of this indicator is due to the necessity to calculate the number of personnel, expenses for maintenance of grid equipment, and it was impossible to use as a basis the capacity or length of power lines due to significant differences in the structure of equipment of individual enterprises of power grids [1-10]. The modern pricing system also relies on this concept in terms of calculations. However, the majority of the regulatory and legal framework defining the use of conventional units became obsolete now or has the status of "inactive documents". This leads to the possibility of changing the calculated values in accordance with the company's goals.

2. Materials and Methods

A conventional unit is estimating certain labor intensity by a dimensionless coefficient (unit). The first documents defining the concept of conditional unit are attributed to 1960. For 1 c.u. were taken labor costs for the operation of 1 km of single-circuit 110 - 154 kV overhead line on metal and reinforced concrete supports. The structure of service volumes in conditional units for power grid facilities (pow-



er lines and substations) corresponded to the structure of operating personnel, and the number of conditional units per 1 person of production personnel (specific load for power grids of all voltage classes) was approximately the same [1, 3].

In course of time, the standards have been repeatedly corrected due to the regular analysis of the actual number of staff in the electricity grid. After having restructured the industry, such an analysis was practically discontinued, and the companies gained partial independence to determine the structure of personnel, and all these aspects resulted by appearance of "gaps" between the actual labor intensity of maintenance of electrical equipment of the networks and the standard number.

This problem is mentioned in the article by F.L. Golberg, where it is proposed to adopt the "bulk forming units" developed by ORGRES as an alternative to the existing conventional units [10]. In 2008, the FSK Company accepts these units for calculation by the Order No. 162. However, other power grid companies continue to work with conventional units.

Currently, the Russian Federation does not have a legal document that would enshrine this concept. The following definitions can be found in the literature:

- the number of conditional units per 1 person of production personnel is a specific load on the objects of electric networks of all voltage classes 1 c.u. = 40 h-hour [10];
- the number of conventional units determines the labor costs for one repair of this type on the accepted meter [1];
- the number of conventional units is an indicator characterizing the cost of live labor, expressed in working time spent for producing products (services) [3].

In terms of application of C.O.U. today use is made of various legal acts, as follows:

- The order of the State Building Committee of the Russian Federation from 03-04-2000 № 68, defining calculation of number of the personnel for repair and maintenance service;
- Order of the Federal Tariff Service of August 6, 2004 № 20-e/2;
- Regulatory document RD 39-0148311-601-88;
- Methodical guidelines for developing process charts and projects for maintenance and repair of overhead power lines, STO 56947007-29.240.55.168-2014.

Due to the transition of the pricing system to a new procedure of forming the gross revenue required (GRR) basing on the Methodology for comprehensive determination of the technical and economic condition of power facilities, including the indicators of physical wear and tear and energy efficiency of power grid facilities (approved by Resolution of the Government of the Russian Federation No. 1401 of December 19, 2016), grid companies are forced to use the benchmarking system or the "best practice method".

To realize this approach, the Ministry of Energy initiated data collection since 2016. The list of these indicators is quite extensive, and some of them are calculated considering the number of c.u. at the power grid facility, and some of them take into account this number indirectly. The indicators calculated on the basis of the number of conventional units include, first of all, maintenance and repair costs, which are the most significant expenses of any grid company. Fig. 1 shows the rating of power grid companies by specific maintenance and repair costs.

Effective companies are highlighted in gray, and ineffective companies are highlighted in black. The middle line shows the value that will be set as the target for all companies. However, the issue of calculating maintenance and repair costs remains methodologically undeveloped.

3. Results

3.1. Credibility analysis of c.u. indicators

To assess the reliability of the calculation of key performance indicators of power grid companies, we compare different values used to calculate the labor intensity of some types of electrical equipment. The basis for calculating the labor intensity in accordance with the current normative and technical documentation is the technical documents developed within the organization that define the conditions and content of work on maintenance of electrical equipment.

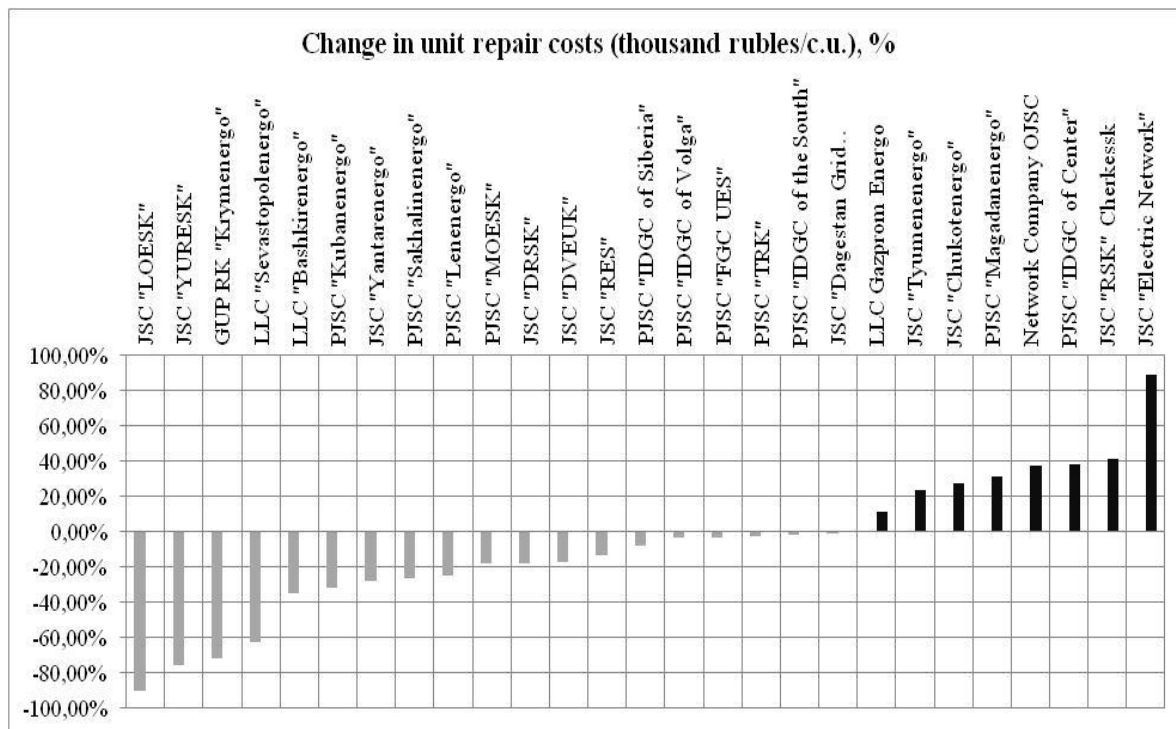


Figure 1. Rating of grid companies by unit maintenance costs in 2018 (according to the Ministry of Energy).

In accordance with the "Rules of Organization of Maintenance and Repair of Electric Power Facilities" approved under the Order of the Ministry of Energy of the Russian Federation dated 25.10.2017 No. 1013 for the purpose of increasing reliability in the operation of electric power facilities, as well as for the purpose of increasing the duration of overhaul periods and ensuring the quality of maintenance and repair work, electric power industry entities develop and approve the Standards for Maintenance and Repair of Electric Power Facilities or pieces of equipment of electric power industry. It is envisaged to carry out both planned preventive maintenance and technical repair. The standard is developed in strict accordance with current legislation, technical requirements of regulatory documents, and local acts of the organization. The main form of technical documentation reflecting the entire process of maintenance or repair of an electric power industry facility is the technological chart for maintenance and repair. Technical standards and requirements, methods and recommendations (taken into account in the process of drawing up the technological charts) should reflect the main provisions of the technical policy of the organization, long-term experience of maintenance and repairs, both in its organization and in other organizations, to take into account the features of the operating equipment, service life, technical condition and the remaining life of the equipment, as well as individual elements and units, the requirements of the design documentation of manufacturers, as well as occupational health and safety requirements.

The flow chart contains the following sections:

- measures and conditions of safe work performance (hazardous production factors are reflected at the workplace, fire safety measures are listed, and environmental requirements to work performance are specified);
- work organization (the name and quantity of protective equipment and clothes, tools and devices, materials and spare parts, mechanisms of necessary mechanisms are listed, as well as the composition of the team with indication of position, electric safety group, number of people and their qualification features);

- work technology (the procedure of work performance is given, which includes both organizational (beginning and end of work) and technological operations (inspections, checks, main maintenance or repair works, tests and measurements) with indication of the performer, electric safety group, number of people, norm of time for an individual operation in h·h).

Thus, a flow chart is drawn up for each item of grid equipment, both for maintenance and repair. Labor intensity of the works performed under the technological map is an integral indicator and is determined by the list of operations performed within the framework of maintenance and repair.

Table 1 presents the norms of labor intensity (h·h) for repair of power transformer for voltage class 6(10) kV with capacity of 1000 kV·A with oil cooling of TM-1000/6(10) type, taken from technological charts of different electric grid companies.

Table 1. Labor input rates for the ongoing repair of the power transformer in different power grid companies.

Power grid company number	1	2	3	4
Transformer TM-1000/6(10), h·h	19,7	42	24	17

Significant differences are associated with the use of different normative and technical documentation as guidance ones for developing technological charts. As an example, Table 2 shows the labor intensity norms on maintenance and repair for different types of equipment according to several methodical documents. Table 3 shows the frequency of repair impacts on the same units of equipment indicating the source of these indicators. Table 4 shows the results of comparison of labor costs on maintenance and repair and their recalculation in conventional units.

Table 2. Norms of labor intensity of maintenance and repair according to various methodical documents for current repair.

Type of electrical equipment	In accordance with STO 56947007-29.240.55.168-2014, h·h	According to the Handbook [10], h·h	According to RD-39-0148311-601-88, h·h
Air lines up to 1000 V on metal and reinforced concrete supports	6	8	6
Cable lines up to 10 kV	23	21	23
Three-phase double-winding oil transformers up to 10 kV	18	-	5.2
Oil switch 35-110 kV	7	-	7.2

Table 3. Maintenance and Repair Frequency Rates according to various methodical documents for repair.

Type of electrical equipment	In accordance with STO 56947007-29.240.55.168-2014, month.	According to the Handbook [10], month	According to RD -39-0148311-601-88, month
Air lines up to 1000 V on metal and reinforced concrete supports	36	36	72
Cable lines up to 10 kV	24	12	72
Three-phase double-winding oil transformers up to 10 kV	36	-	24
Oil switch 35-110 kV	12	-	24

Table 4. Labor intensity standards of maintenance and repair according to different methodical documents in c.u. and h·h.

Type of electrical equipment	Recalculation in c.u. in accordance with the order of the Federal Tariff Service No. 20-e/2, c.u.	Full labor intensity of maintenance and repair in accordance with STO 56947007-29.240.55.168-2014, h·h	Complete labor-intensive maintenance and repair in accordance with RD-39-0148311-601-88, h·h	Maximum difference, h·h
Air lines up to 1000 V on metal and reinforced concrete supports	200	216	432	232
Cable lines up to 10 kV	350	529	1656	1306
Three-phase double-winding oil transformers up to 10 kV	-	648	124,8	523.2
Oil switch 35-110 kV	23	84	172,8	149.8

3.2. Modeling calculation of efficiency indicators using various methodical documents.

To illustrate possible distortion of the calculation results key indicators through the use of various methods for determining the cost of maintenance and repair, calculations were made for the real section of the power grid. Table 5 shows the list of electric equipment of the real section of electric grids and defines annual labor costs both in h·h and in c.u.

Table 5. Labor intensity of maintenance by type of equipment for the power grid section.

Type of electrical equipment	U, kV	Quantity, pcs. (unit)	Labor costs per year in accordance with STO 56947007-29.240.55.168-2014, h·h	Labor costs per year in accordance with FTS Order No. 20-e/2, c.u.
Complete transformer substation (2 transformer substation)	110/35/6	3	72	9
Complete transformer substation (2 transformer substation)	35/6	19	380	57
Complete transformer substation	35/6	5	80	15
Air switches	35	50	460	550
Air switches	6(10)	555	2608.5	3052.5
Oil switches	35	47	352.5	300.8
Oil switches	6(10)	254	2997.2	787.4
Power oil transformer	110/35/6	6	376.8	46.8
Power oil transformer	35/6(10)	43	1982.3	90.3
Power oil transformer	6(10)/0.4	685	15549.5	658
Separator with short-circuit breaker	110	10	177	47
Separator with short-circuit breaker	35	68	1067.6	646
IN TOTAL		1745	26103.4	6259.8

Calculations showed that the recalculation of the total labor intensity of one unit of equipment varies from 1 h-hour to 11 h-hour. The range of deviations is shown in Figure 2.

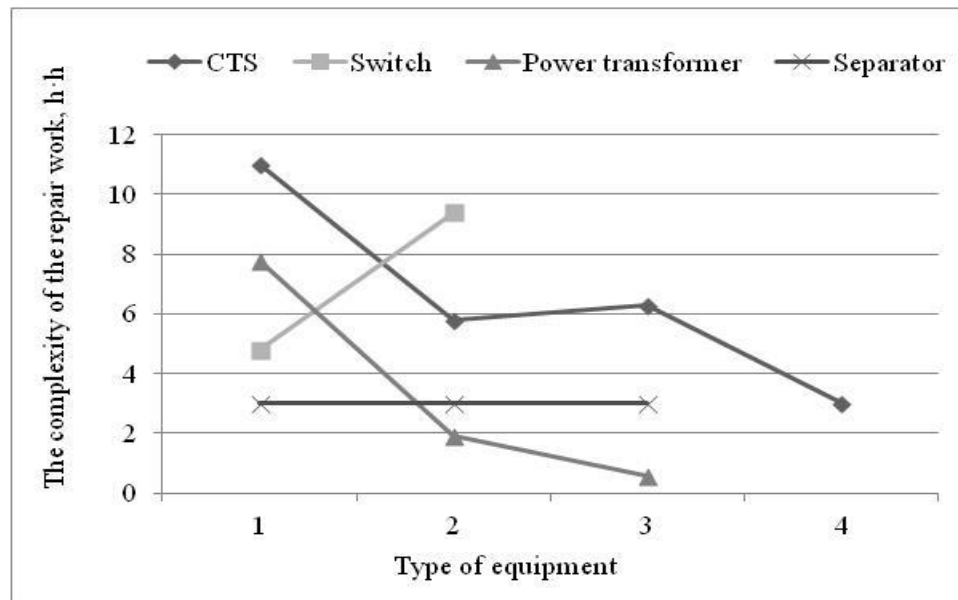


Figure 2. Calculation of h·h in 1 c.u. by groups of electrical equipment.

4. Discussion

Application of various methodical approaches for calculating maintenance and repair costs and estimation of unit costs in c.u. differs significantly depending on the type of the document used. This allows the energy company (in accordance with its objectives) to manipulate the calculations, overestimate or underestimate the absolute value of costs and ROE, and influence the place of companies in the efficiency rating. Benchmarking can be used only in case of availability of accurate and uniform guidelines, and if they are not available, KPI comparisons are not reliable [11-15].

Currently, power grid companies, especially those that can use industry guidelines (energy service companies of the oil and gas industry) can use internal industry guidelines or guidelines of the Ministry of Energy when calculating maintenance and repair costs. Differences in calculations can reach 10 times the value, which will eventually lead to an increase/decrease in RET, and eventually the tariff for energy transmission services.

It is necessary to develop new normative-methodical documents to determine the labor intensity and frequency of maintenance and repair. Using the existing regulatory framework does not allow performing reliable implementation of benchmarking when assessing the performance of power grid companies.

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