FIXING PRICES FOR POWER DISTRIBUTION SERVICES SEPARATELY FROM ENERGY SUPPLY PRICES

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In the economic sense, an energy network company (ENC) acts within the power system as a self-supporting link, having its own interests and resources circulation.
The implementation of the economic self-sufficiency of ENCs makes it is necessary to develop a mechanism for their mutual relations with power generating companies and consumers. The problem of expanding the scope of self-sufficiency of ENCs has always been an extremely urgent one, because it signifies bigger possibilities for improving their principal activities and new incentives towards organizing alternative directions for this business development, which are due to the demands set by the energy and power transmission services market.

As far as the products life cycle is concerned, there exist the following kinds of products and services that are provided by electricity networks companies:

1. Power transmission devices and transformer equipment at the stage of operation servicing;
2. Services in the area of transmission and distribution of energy between consumers.

This means that the work efforts of the employees of network companies are focused on material products and their labor is of a productive character not only at the stage of actual product making (i.e., making energy) and providing energy supply services to consumers, but also at the stage of operating real capital. At this phase, the task of formulating a unified objective index comes up, an index, which should fully display the physical essence of the products referred to, and which are used as an object, the labor of the employees of a network company is applied to.

The major and basically constant element of a power network in terms of time and space, i.e., the main one that determines its throughput capacity, is its current-conductive part: i.e., its wires, cable conductors and transformer coils. All the other elements of an overhead transmission line (OTL) are designed to secure the reliable operation of its conductive elements only, either in the normal or in an emergency mode. It is that conductive part that contains a connecting link, which most fully and in an objective way characterizes both the physical scope of the power system as such and its throughput capacity, and at the same time it can serve as an object for labor application, as a measuring device to measure the dimension of the product generated by the power system company at the phase of its operation, and as the only objective indicator for fixing the prices for power distribution services separately from the prices of energy supply.
At the present moment, operation works volumes tend to be determined on the basis of conventional (topmost) measurement units, which are not substantiated either technically, or economically, and which do not characterize objectively what they are designed for. A different norm-setting index is required under the current market conditions.

The point is how one can define, i.e., measure and meter the product volume at the stage of operation servicing. Due to the fact that the major, basic element of the natural product at the stage of operation is the current-conductive part of an overhead transmission line (its wires, cables, transformer coils), it means that it is this part that should be used to determine the volume of any natural product.
On the basis of the results obtained from the theoretical investigations and generalizations that have been carried out, it is being proposed here to adopt as a measuring unit for the volume of natural products generated by a power system company at the stage of its operation one kilometer of a three-wire overhead transmission line, with the cross-section of one single aluminum wire equal to 300 mm^2. This sort of a line will be labeled here as *the normative electricity line* (NEL). The quantitative values of NEL across the entire range of rated wire and four-wire cable cross-sections are shown in Table 1. The said NEL is a new measuring tool to measure the natural product of electric network companies (their lines and networks) at the stage of their operation. NEL is also a measuring tool to measure the volume of transmission devices being serviced , a measuring tool designed to measure the physical volume of real owned capital. By using NEL, it is possible to assess the operation volume of a power network company. NEL is a really existing, and an invariable and stable unit of measurement, which has a clear physical content (300 $mm^2 \times 1$ km). This is a universal unit that can suit all electric power systems, any regions and countries and any periods of time.

It is recommended to use NELs instead of the conventional unit, and also to use them for fixing the price of services in the area of energy distribution separately from that for energy supply. NEL combines all the above-mentioned types of products as one single indicator.

Table 1

Cross-section, mm	Cable length of one NEL, km	No. of NELs per 1km of cable, units
3×10 +1x6	8.3333	0.12
3×16 + 1x10	5.1724	0.1933
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3×185 + 1x50	0.4959	2.0167
3×240 + 1x70	0.3797	2.6333

When the line voltage remains one and same, an overhead transmission line can let pass a strictly definite amount of electric energy. Due to this it has a direct functional connection to the potential capacity of power systems in a given line sector, in a given area and within an ENC to let pass through an amount of electric energy that is determined by its design and energy supply contracts. Any change of the quantitative value of NEL in a given line unequivocally means that the throughput capacity of that line has changed in the same direction. A NEL for some power line featuring different voltages can easily be reduced to the base voltage of a concrete utility, proceeding from the correlation between the throughput capacity of the specific overhead transmission line and the base OTL. It is worth using NELs in the capacity of a stable unit of measurement of natural products at the operation phase for forming up, planning and analysing the various technical/economic indexes related to the activities of a electric network company during any time intervals. Norms that are elaborated on the basis of the NEL idea are indeed technically and economically well grounded, because they have been elaborated on the basis of an invariable unit of measurement (both technically and economically). Table 2 gives an example of the calculated installed capacity N^{ENC}_{inst} on the basis of NEL for 0.4 – 35 – 330 kV power networks of the Electricity Grid of the Town of Kingisepp, which is part of the JSC "Lenenergo"

$$N^{ENC}_{const} = N^{ñ}_{ð} + N^{ñ}_{î},$$

where N^{c}_{p} is the operating capacity of power circuits, MVA;

N^{c}_{o} is the capacity of switched off elements of the circuit, MVA.

The said operating capacity of electric power networks represents a guaranteed ability of the power system to transmit electricity from the source of energy to consumers, regardless of the consumption mode.

Table 2

Line Nos.	Line desig-nation	Gage, OTL min. cross-section , mm^2	OTL length, km	Installed c-ty MVA ($mm^2 \cdot km \cdot 1O^{-3}$) (NEL)
35 kV				
1	3g-1	AS-70	9	1.89
2	3g-2	AS-70	9	1.89
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– – – – – –				
Total				9.813
Total				1100.0
Total for the company				1796.22

The index of the working capacity of the power system of some economic unit (i.e., of a company, a network area company, a line section) is determined by the operating capacity of its basic elements:
- its transformer substations 6(10) kV and more;
- its power transmission lines with voltages of 0.4; 6; 10; 35 kV and more:

$$N^{c}_{p} = N^{mn}_{p} + N^{l}_{p}, \text{ MB·A}$$

The operating capacity of transformer substations is determined, using the following formula:

$$N^{mn}_{p} = \sum_{i=1}^{n} N^{mn}_{yi} - \sum_{j=1}^{m} N^{m.n}_{oj} \cdot \frac{t_j}{T_i}, \text{ MVA},$$

where $N^{m.n}_{yi}$ is the capacity (according to the certificate-based data) of the i_{th} transformer that is installed in the TSST, MVA;

$i = 1,\ldots, n$ is the number of transformers in the TSST of the system, pcs;

Ti is the scheduled time of the i_{th} transformer, hrs;

N^{mn}_{oj} is the capacity of the switched off j_{th} transformer (according to the schedule, out of schedule, in emergencies), MVA;

t_j is the time of the j_{th} switching off of the i_{th} transformer, hrs.

The operating capacity of overhead and cable transmission lines is determined, proceeding from the following formula:

$$N^{n}_{p} = \sum_{i=1}^{k} N^{л}_{yi} - \sum_{j=0}^{l} N^{л}_{oj} \cdot \frac{t_j}{T_i}, \text{ MVA},$$

where N_{yi} is the installed capacity of the power transmission line determined by the following formula: $N^{л}_{yi} = F_{yi} \cdot l_{yi} \cdot v \cdot 10^{-3}$, MVA,

F_{yi} is the minimum wire or cable conductor cross-section (mm^2);

l_{yi} is the length of wires (HV×3 phases) of the cable, km;

v is a unity norming multiplier member, which considers also the economic current density in A/mm^2 and the economic voltage distribution, kV/km;

$N^{л}_{oj}$ is the capacities of the j_{th} switching over in the i_{th} line, MVA;

t_j is the time of the j_{th} switching off of the i_{th} line, hrs;

$T^{л}_i$ is the time of scheduled work of the i_{th} line, hrs;

10^{-3} is the transformation factor of transforming kVA into MVA

The scheduled duration of making scheduled repairs is calculated on the basis of time rates for major and current repairs. Any reduction in the actual value of the operating capacity is determined, considering emergency shut-downs and unplanned switchings off of power lines and transformers. Monthly and quarterly reports on fulfilling assignments concerning the operating capacity must be worked out as part of the ongoing statistics reporting.

The working capacity index of a network serves as a guiding element for the operating activities of personnel members, directing them towards the provision of a reliable functioning of power system equipment and devices and securing a sustained energy supply of consumers, i.e., towards the fulfilment by the circuit employees of their basic duties.

The use of this given normative indicator makes it possible to stimulate the execution of organizational and technical arrangements aimed at reducing the number and duration of scheduled and emergency switchings off, at the introduction of advanced technologies in the field of repairs and technical maintenance, including repairs with a voltage being present, elimination of bottlenecks, an increase of the throughput capacity, extension of the time when power networks remain in their working condition, which fact can secure a reduction of the electric power consumption levels while transmitting the latter and during its transformation, speeding up the introduction of new power system installations, improving also the quality of energy supply for consumers.

An economic appraisal of the results achieved by an Electric Network Company can be carried out on the basis of service prices in the process of energy distribution, separately from the prices of energy supply, which are fixed per unit of the operating capacity of the system.

Under the conditions of an open, regulated electric energy market the prices of services in the area of electric energy distribution are fixed for a period under examination, separately from the energy supply prices and on the basis of the methodology elaborated by the author of this article, and also software, based on the operational mathematical demand function, developed for the first time ever.

$$N^c_D = \frac{(N^c_{ycm} + N^c_o)\,p_{nocm}}{p_{nocm} + p} - N^c_o ,$$

where N^c_D is the function demand for the network capacity;

N^c_{ycm} (*Ninst.*) is the installed capacity of an ENC, MVA;

N^c_o is the capacity of switched off electric network elements of an ENC;

p_{nocm} (P_{const}.) is the conventionally constant part of the price, Rbls.;

p is the invariable addition to the price $p_{\text{const.}}$, Rbls.

The dimension of the income is calculated by means of the function of demand for services in the area of energy supply

$TR^c = pN_o$.

The aggregate costs for the period being examined are calculated by the following formula:

$$TC^c = A + \sum_{i=1}^{n} \Delta W^c_i \cdot p'_{W_c} ,$$

where A is the conditionally constant costs, covering also taxation amounts, Rbls.;

ΔW^c_i is the volume of the i_{th} electric power losses;

p'_{W_c} is the price of the i_{th} electric power losses.