ELECTRICITY WASTAGE IN ELECTRICAL NETWORKS

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Abstract. This paper examines the phenomenon of electricity wastage in electrical networks, including overhead and cable lines, as well as power transformers. It explores both active and reactive power losses that occur during electricity transmission and distribution. The study provides formulas and methodologies for calculating these losses in three-phase alternating current systems and highlights the impact of various factors, such as load variations and compensation equipment. The paper also presents empirical data on power transformer losses and offers a detailed example of loss calculation for a specific transformer type. Effective monitoring and optimization strategies are emphasized as key approaches to improving network efficiency.

Keywords: electricity wastage, power loss, active power, reactive power, electrical networks, transmission lines, power transformers, compensation equipment, Uzbekistan power system, energy efficiency.

Loss of electricity in electrical networks, air and cable lines, and transformers.Types of wastage.

Electricity loss in electrical networks, overhead and cable lines and transformers. Types of losses. Active losses. Reactive losses. Waste of electrical energy in electrical networks, air and cable lines, transformers. Types of waste.

Active and reactive capacities are required for normal electricity consumption. Reactive power is used to generate a magnetic field, and its production does not require the use of a primary energy resource. However, transmission via lines is associated with a certain active waste in network elements. Losses on the line when installing the compensating equipment

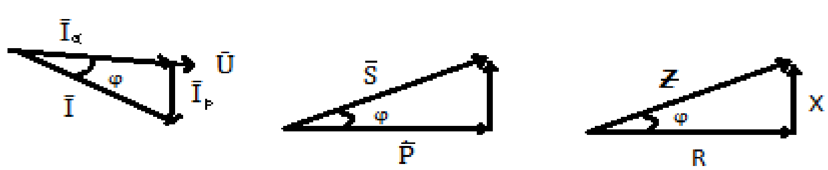
$\triangle P = \frac{P^2+Q^2}{U^2}R$ and $\triangle Q = \frac{P^2+Q^2}{U^2}x$ of value (1)

$\triangle P = \frac{P^2+(Q-Q_{ku})^2}{U^2}R$ and $\triangle Q = \frac{P^2+(Q-Q_{ku})^2}{U^2}x$ value decreases. (2)

Loss of active and reactive capacities in three-phase alternating current lines, if we do not take into account the line conductivity (B = 0, G = 0):

$\triangle P = 3I^2*R = 3*(I_a^2+I_p^2)*R$ $\triangle Q = 3I^2*X = 3*(I_a^2+I_p^2)*X$ (3,4)

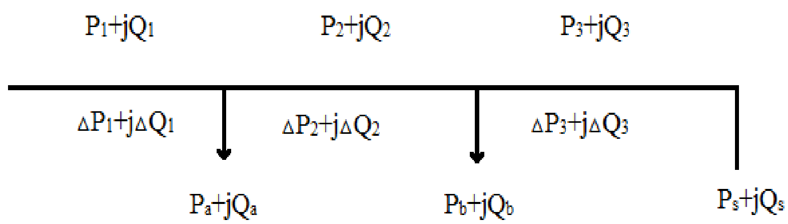
where R and X are the values of active and reactive constituents of line I and Ip with full and inductive resistance of line I.



a) b) c)

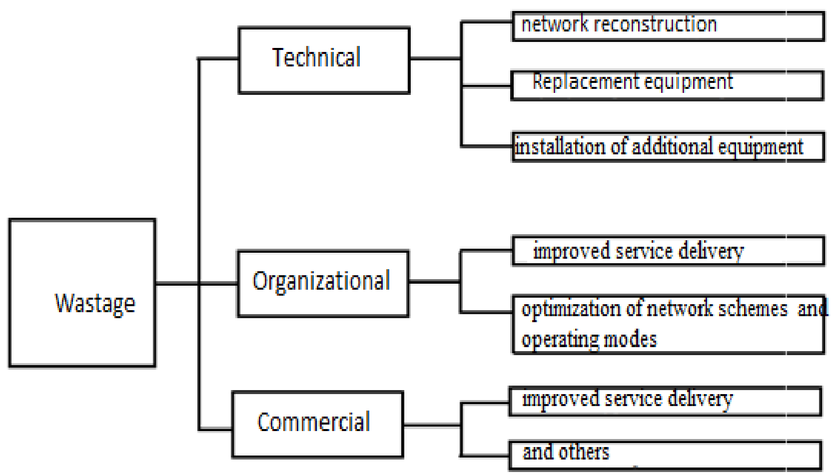
a- electricity, b- power, c- resistance triangles

The power loss on a line with multiple loads is the sum of the power losses per site.



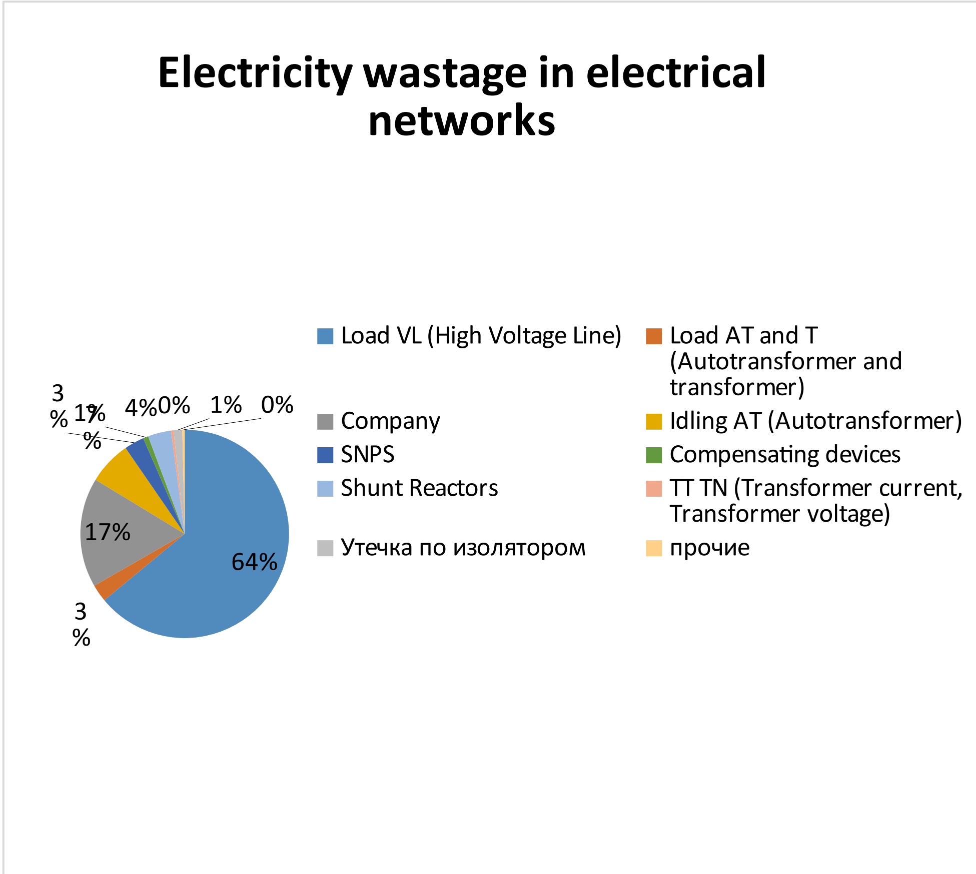
$$\Delta P\Sigma = \Delta P_1 + \Delta P_2 + \Delta P_3 + \ldots + \Delta P_n \quad (5)$$

$$\Delta Q\Sigma = \Delta Q_1 + \Delta Q_2 + \Delta Q_3 + \ldots + \Delta Q_n \quad (6)$$



Energy loss mitigation measures are implemented during design and operation. Operation activities are always performed during the mode optimization.

Increased bandwidth increases network load. Changes in active and reactive loads of consumers cause changes in both the active and reactive power flows and wastage in the power system. Therefore, it is important to constantly monitor the level of wastage as they determine the overall network performance. A systematic approach to waste management is a complex issue and can be solved only through the use of modern economic and mathematical models and computers. The main difficulty here is the collection and processing of network status data as they are constantly changing as the load changes.



With the development of electric networks and large industrial consumers, the need for reactive power compensation in the EPS of Uzbekistan will increase. It is necessary to cancel that at present various and highly effective compensating devices (CC) are widely used in developed EPS of foreign countries: static, consisting of capacitors and inductances regulated by thyristors; synchronous - longitudinal transverse regulation and - conventional compensators. The duration of the first is within 1-3 periods (0.02-0.06 seconds) and the second is 0.1-0.5 seconds. Moreover, both types of KU can operate as in the mode of reactive power output. The unit capacities of the above-mentioned KU are in the range of 5-600 MVAr.

Inputs of synchronous compensators in Uzbekistan EPS Table.1

Name of Substation	KU installation on 01.01.07, шт X MBAp	KU power input, pcs X MVAr			
		2008-2010 yy.	2011-2015 yy.	2016-2020 yy.	Total
Khorezm	2x50	-	-	-	-
Ferghana	2x50	-	-	-	-
Uzgarish	1x50	-	-	-	-
Samarkand	1x50	-	-	-	
Sogdiana	-	-	2x100	-	2x100
Namangan	-	-	2x50	-	2x50
Total SK	6x50	-	2x100 2x500	-	2x100 2x50

Losses in power transformers of substations Table.2

Rated power, kVA	Rated voltage VN / NN, kV	Short circuit voltage,%	Loss XX, W	Short circuit losses, 750s, W	Noise level dB
250	10/0.4	6	730	3400	53
315	10/0.4	6	360	5000	55
400	10/0.4	6	1000	5700	55
500	10/0.4	6	1150	6100	56
630	10/0.4	6	1400	6600	56
850	10/0.4	6	1800	7700	58
1000	10/0.4	6	1950	8800	59
1250	10/0.4	6	2300	10500	60

1600	10/0.4	6	2750	12700	61
2000	10/0.4	6	3200	15500	62
2500	10/0.4	6	4200	19000	64

Methodology and example of calculating electricity losses

In practice, the following methods are used to determine losses:

- carrying out operational calculations;

- daily criterion;

- calculation of average loads;

- analysis of the largest losses of transmitted power in the context of day-hours;

- appeal to generalized data.

Full information on each of the above methods can be found in regulatory documents.

In conclusion, we give an example of calculating costs in a TM 630-6-0,4 power transformer, the calculation formula and its description are given below, it is suitable for most types of similar devices.

△WT=△WXX+(△W_H^1* WT/100) kWh, where

△WXX=△PXX*TO*(U1/Uном)2 – loss of idle power transformer, kW * h;△W_H^1= (△WX/WT)*100% - relative load losses of the power transformer,%

△WH=KK*△Pcp*TP* K_ϕ^2 – load losses of the power transformer, kW * h.

K_ϕ^2=(1+2Kз)/3Kз – the square of the coefficient of the form of the graph for the billing period, cu;

Kз= [WT/(Sн* TP* $\cos_\varphi$)]*10-3 - load factor of the transformer (filling schedule), cu;

△Pcp= 3*I_{cp}^2*R*10-3 – power losses in a power transformer, kW;Icp= WT/($\sqrt{3}$ *Ucp* TP* $\cos_\varphi$) - average load for the billing period, A;

R = (△ Pkz * U_n^ 2 / S_nom ^ 2) * 10-3 active resistance of the power transformer, Ohm;

Kk - coefficient taking into account the difference in the configurations of the graphs of the active and reactive loads (reference value, taken equal to 0.99),

Table.3

$S_{нт}$	Transformer rated power, MVA.	0,63
$U_{ном}$	Rated voltage, kV.	6
W_T	Consumed active electricity per month, kW * hour.	37108
$\triangle P_{XX}$	Transformer idle power loss, kW.	1,31
$\triangle P_{кз}$	Short circuit power loss, kW	7,6
T_P	The number of hours of operation of the transformer under load for the billing period, hour;	720
T_O	Transformer connection time for the billing period to the network, hour;	720
$K_к$	Coefficient of differences in configurations;	0,99
$\cos_{\varphi}$	Transformer average power factor	0,9

Now we proceed to the calculation.

△ WXX = 1001.0 kW / h; K_ ^ ^ 2 = 4.33; C3 = 0.09; R = 0.69 ohm;

△ W_H = 182.20 kW / h; Iav = 5.34; △ Rav = 0.06;

△ W_H ^ 1 = 0.491, as a result, the calculated value will be equal to 1001.0 kW / h + 0.49%

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