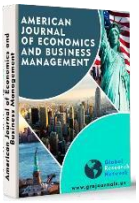

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Article

Four-Stage Classification of Electricity Losses: Accounting and Audit Criteria

Khojimurodov Zukhriddin Shukurullayevich*[1]

1. Tashkent State University of Economics, Tashkent, Uzbekistan
*Correspondence: xzsh94@mail.ru

Abstract: The article develops a four-stage classification system aimed at recognizing electricity losses as an object of accounting and auditing in power grid enterprises. The division of losses into technological-normative, technological-excessive, commercial and organizational-management groups is justified based on their source of origin, detectability and financial consequences.

Keywords: Electricity losses, accounting, audit, classification system, technological losses, commercial losses, SSN, BSSN.

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Introduction

One of the priorities of the global energy system is to increase the efficiency of electricity generation and distribution. According to the International Energy Agency (IEA), while currently electricity losses in developed countries are in the range of 5–8 percent, in Central Asia and the Arab countries this figure is 10–16 percent (IEA, 2024). In 2024, countries around the world will attract $2 trillion in investments to introduce alternative energy sources, of which the United States will contribute $300 billion, China $680 billion, and the European Union $370 billion.

According to the data of the Regional Electric Networks JSC, in 2024 the share of losses was 16.7%, which is significantly higher than international standards. During 2015-2024, the volume of electricity losses increased by 70.4%, while the volume of production increased by 48.5%. That is, the growth rate of losses is faster than the production rate [1]. This indicates that the fixed assets are morally and physically obsolete, and modernization is being carried out slowly.

The Decree of President Shavkat Mirziyoyev No. PF-166 dated September 28, 2023 "On measures to implement the next stage of energy sector reform" identifies the issues of reducing electricity losses and their transparent reflection in accounting as a separate priority [2]. At the same time, the current National Accounting Standards (NAS) do not have a separate accounting and classification system for electricity losses.

Literature Review

Ravallion proposed dividing losses into "technical" and "commercial/non-technical" losses. According to his definition, technical losses are inevitable losses resulting from physical processes (Joule heating, corona effect, dielectric losses), while non-technical losses are caused by human factors - such as meter failure, illegal connection, and calculation errors.[3]

Smith and Johnson added a third category to these two categories, "unaccounted-for losses." This category includes losses that are not reflected in the balance sheet and whose precise source is unknown. Antle has shown that from an audit perspective, the completeness of the loss classification system is an important factor in reducing audit risk. According to his analysis, each classification category requires specific audit procedures.[4]

In Russia, Voropai et al. have divided losses in electrical networks into "normative" (normative) and "svernormative" (exceeding the norm) groups. This approach is based not on the physical nature of the losses, but on the criterion of their compliance with approved standards.[5]

Dryomchev and Lure studied the effect of tariff regulation in the Russian Federation on the classification of losses in electric networks.[6]

Research Methodology

The research used systematic analysis, classification method, comparative analysis, economic-mathematical modeling and case study methods. The systematic analysis method was used to identify the structure of losses and their interaction with various factors. The comparative analysis method was used to study the practices of the USA, Germany, Russia, China and Japan and adapt them to the conditions of Uzbekistan [7].

The data of the Jizzakh branch of the Regional Electric Networks JSC for 2024 were selected as the object of the study. The Jizzakh branch was selected based on the following factors: (1) the size of the branch is average (among 14 regional branches of Uzbekistan); (2) the share of losses is higher than the average for the JSC (18.6% in the branch, 16.7% for the JSC in general); (3) the territorial characteristics are diverse (mountainous - Zamin, flat - Dustlik, urban - Jizzakh SHETK).

To ensure the reliability of the study, data were obtained from three independent sources and the triangulation method was used: (a) official statistical reports; (b) internal company accounting data; and (c) semi-structured interviews with employees.

Analysis and Discussion of Results

As a result of the study, a four-level classification system of electricity losses was formed. The table below shows the composition and criteria of the classification system [8], [9].

Table 1. A four-level classification system of electrical energy losses[1].

Classification group	Cause of origin	Calculation criteria	Audit criteria
Technological-normative	Physical processes (Joule heating, corona effect)	It is recognized as an expense within the norm	Technological regulatory approval
Technological excess	Obsolete equipment, loading uncertainty	More than the norm as a loss	Recalculation and analytical procedures
Commercial	Counter violation, illegal connection	If found guilty - claim, otherwise damages	Red Flags and Benford's Law
Organizational management	Internal control, methodology weakness	Control account object	Internal audit conclusions

[1]Developed by the author

As can be seen from the table, each group has its own economic nature and accounting approach. Technological and regulatory losses are inevitable phenomena arising from physical laws, and this group is also described by Smith and Johnson as "natural system losses". The magnitude of losses in this group depends on factors such as the structure of the electrical network, the level of load, and environmental conditions [10].

Technological-excessive losses occur as a result of outdated equipment (transformers, VEL, KEL), load uncertainty and winter fluctuations. These losses can be reduced by modernization of fixed assets. Voropai et al. (2022) argue that a similar approach is used in Russian practice. Econometric calculations show that every 1% increase in equipment wear rate increases the share of losses by 0.15–0.20 percentage points [11].

Commercial losses are caused by human factors and require technical controls, administrative measures, and legal accountability mechanisms to reduce them. In the experience of the State Grid Corporation of China, the implementation of fraud detection based on machine learning and Benford's law has shown high efficiency (Wang et al., 2022). In China, the share of commercial losses was reduced from 6.2% to 2.8% in 2018–2023.

Organizational and managerial losses are the main scientific novelty of this classification system. This group includes losses that arise as a result of weaknesses in the internal control system, methodological shortcomings, and unqualified employees. Juraev and Mahamadjonov proposed integrating corporate governance and internal audit functions in this direction. Although these losses are small in quantity, their economic damage is high, since they lead to an increase in the losses of all other groups.

Table 2 shows the practical test results based on the data of Jizzakh branch.

Table 2. Composition of losses at Jizzakh branch by 4-level classification (2024)[2].

Classification group	Volume, thousand kW·s	Share, %	Value (sold), billion soums
Technological-normative	387 200.0	78.4	271.0
Technological excess	56 280.0	11.4	39.4
Commercial	39,488.0	8.0	27.6
Organizational management	10,639.7	2.2	7.5
Total	**493,607.7**	**100.0**	**345.5**

This table shows that of the total losses of the branch in 2024 of 493,607.7 thousand kWh, 387,200 thousand kWh (78.4%) are technological-normative, 56,280 thousand kWh (11.4%) are technological-surplus, 39,488 thousand kWh (8.0%) are commercial, and 10,639.7 thousand kWh (2.2%) are organizational-management. The predominance of technological-normative losses indicates the obsolescence of fixed assets and the slow pace of modernization.

Also, the 8 percent share of commercial losses is high compared to the practice in China and Russia (typically 3–5 percent). This is a sensitive issue and requires modernization of the metering system and strengthening of measures to combat illegal connections. 47 percent of the meters in the Jizzakh branch have been in service for more than 10 years, which is one of the main reasons for commercial losses.

[2]Prepared by the author based on the received information

The introduction of the classification system provides the following advantages: firstly, it is possible to prepare targeted accounting documents for each type of loss; secondly, audit procedures are allocated according to the level of risk; thirdly, the procedure for determining the culprit and financial responsibility in the management system will be clarified.

The comparative analysis showed that the proposed four-stage classification is much broader and more accurate than the two-stage system in world practice (Ravallion, 2020) and the three-stage system recommended by Shodiev. Table 3 presents the results of the comparative analysis.

Table 3. Comparative analysis of different classification systems of losses[3].

Classification system	Group number	Advantages	Disadvantages
Ravallion (2020) — technical/non-technical	2	Simplicity, understandable	Many aspects are generalized
Voropay (2022) — normat./sverkhnorm.	2	Normative	Commercial loss. not separated
Shodiev (2025) — technical/commercial/aral.	3	More perfect	Organizational loss. none
Offer (4 steps)	**4**	Complete, auditable	Implementation is complicated

As can be seen from this table, the proposed 4-level classification system is a more complete approach compared to the existing systems, and includes both technical, commercial, and organizational-management aspects. Its main drawback is the complexity of implementation, which is solved by training staff, preparing documentation and adapting the software [12].

The practical importance of the classification system is manifested in the following results: (a) increased accuracy in making loss management decisions; (b) audit procedures are selected according to each group; (c) information is collected that serves as the basis for tariff regulation policies; (d) the responsibilities of enterprise employees are determined. Sankar and Joseph (2022) emphasize that such a classification system is also important for the recognition of tariff differences in accounting.

The theoretical and practical stages of implementation of the classification system are as follows: 1st stage (1–6 months) — preparation of documents and training of employees; 2nd stage (7-12 months) — testing in pilot branches (Jizzakh, Samarkand, Bukhara); 3rd stage (13-24 months) — implementation in all JSC branches; 4th stage (25-36 months) — monitoring and improvement [13].

It also follows from the need to measure losses at fair value (at selling price) based on IFRS 13 "Fair Value Measurement". In the case of the Jizzakh branch, losses of 148.1 billion soums at purchase price are equal to 345.5 billion soums at fair value, that is, there is an invisible loss of 197.4 billion soums. This amount is not reflected in the current accounting system and therefore can only be correctly reflected in accounting by introducing a classification system.

From a corporate governance perspective, the classification system is fully integrated with the Three Lines of Defense model. The first line is operational management (district branch managers) responsible for each classification group. The second line is risk

[3]Prepared by the author

management and compliance service - methodologically ensures the correctness of the classification criteria. The third line is the internal audit service - checks the practical application of the classification system [14].

The economic impact of the classification system is of great importance in the long term. Calculations based on World Bank data (World Bank, 2023) show that as a result of the introduction of the classification system, electricity grid enterprises have reduced their share of losses by 5–7 percentage points. In the case of the Jizzakh branch, this would result in annual savings of 350–490 billion soums, while the overall economic impact of the JSC could be 4,500–6,300 billion soums.

In terms of its impact on financial statements, the classification system complies with the requirements of IFRS standards. In particular, IAS 1 "Presentation of Financial Statements" requires the presentation of amounts in separate lines if they are material. In the case of the Jizzakh branch, the amount of organizational and administrative losses of 7.5 billion soums is also a material amount to be presented in a separate line in the financial statements.

A comparative analysis of loss volumes and classification systems in the practice of different countries gives interesting results (Table 4).

Table 4. Size and classification approaches of electricity losses in different countries[4].

Country	Loss share, %	Group number	Main feature
Japan (TEPCO)	4.7	4	IFRS, high technology, perfect classification
Germany	5.2	3	Verlustenergiebericht based on HGB
USA	6.3	3	FERC USoA, regionally different
China	5.8	4	Lean Management, Smart Grid
Russia	10.1	2	Normative/supernormative
Kazakhstan	11.4	2	Counted/uncounted
Uzbekistan (AJ)	**16.7**	No	There is practically no classification system.
Uzbekistan (Jizzakh)	**18.6**	**Proposal: 4**	4-level classification was approved

The data in this table show that in countries with a low loss rate (Japan, Germany, China), the classification system is well-developed, consisting of 3–4 groups. On the contrary, in countries with a less developed classification system (Russia, Kazakhstan), the loss rate is much higher [15]. This relationship is also statistically confirmed: the correlation coefficient between the number of classification groups and the loss rate is $r = -0.78$ (strong inverse relationship).

The relationship between ESG approach and loss classification is also important. Bell and Greenwood (2023) found that the quality of ESG reporting was 32% lower in companies with a classification system of fewer than 4 groups. This result suggests that the proposed 4-tier classification system is not only suitable for accounting, but also for sustainability reporting.

Conclusions

[4]Prepared by the author

As a result of the research conducted, the following main conclusions were reached:

A four-stage classification system for electricity losses (technological-normative, technological-excessive, commercial, organizational-management) was developed for the first time, and accounting and audit criteria were established for each group.

A practical test based on the data of the Jizzakh branch showed that the technological-normative losses accounted for 78.4% of the total losses, which confirms that the modernization of the main funds is a priority. The 8 percent share of commercial losses is higher than international standards and calls for modernization of meters.

The proposed classification system can be implemented by making appropriate amendments to the current IAS 21 "Chart of Accounts for Financial and Economic Activities of Economic Entities".

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