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A RISK-BASED AUDIT METHODOLOGY FOR ELECTRICITY LOSSES IN DISTRIBUTION UTILITIES: EVIDENCE FROM UZBEKISTAN

Xojimuradov Zuxriddin Shukurullo o‘g‘li
PhD Candidate,
Tashkent State University of Economics

Abstract. Electricity losses are the largest expense of distribution utilities, yet they are typically recorded in aggregate and audited using general-purpose procedures. At the Jizzakh branch of Hududiy Elektr Tarmoqlari (HET) JSC, losses amounted to UZS 207.3 billion, or 90.3% of selling expenses, in 2024. This paper develops and calibrates a risk-based audit methodology for such losses. The audit risk model is extended by dividing control risk into technical (metering and data systems) and administrative components; the required detection risk and monetary-unit sample sizes are derived analytically; and the loss statistics of all 14 HET branches for 2024–2025 are examined using analytical procedures. Overall materiality (5% of selling expenses) is UZS 11.48 billion, equivalent to approximately one percentage point of the branch’s loss ratio, while a systematic 0.5% bias in input metering alone would misstate the loss amount by UZS 5.58 billion, exceeding specific materiality (UZS 3.44 billion). With an audit risk of 0.10, the required sample size decreases from 99 monetary units under the current control environment to 42 when both control components are remediated. The analysis shows that all 14 branches reported lower loss ratios in 2025 (relative declines of 3–35%). However, the commercial component of losses was negative in eight branches and decreased in only four, while the reported decomposition could not be independently recalculated. Jizzakh and Samarkand are assigned the highest audit priority. The 47-day audit programme is revised to address an insufficient allocation of time to planning and the absence of a scheduled confirmation of purchased electricity volumes. The results provide auditors of regulated distribution utilities with a transparent basis for determining the scope and sample sizes of electricity loss audits.

Keywords: electricity losses, audit risk, materiality, monetary-unit sampling, analytical procedures, distribution utilities, Uzbekistan.

Аннотация. Потери электроэнергии составляют крупнейшую статью расходов электросетевых распределительных предприятий, однако обычно учитываются в агрегированном виде и проверяются с использованием общих аудиторских процедур. В Джизакском филиале АО «Худудий электр тармоклари» (HET) в 2024 г. расходы, связанные с потерями электроэнергии, составили 207,3 млрд сумов, или 90,3% расходов на реализацию. В статье разрабатывается и калибруется риск-ориентированная методология аудита таких потерь. Модель аудиторского риска расширена путём разделения риска средств контроля на техническую (системы учёта электроэнергии и обработки данных) и административную составляющие. Необходимый уровень риска необнаружения и объёмы выборки методом монетарных единиц определены аналитическим путём, а статистические данные о потерях электроэнергии во всех 14 филиалах HET за 2024–2025 гг. исследованы с применением аналитических процедур. Общая существенность, установленная на уровне 5% расходов на реализацию, составляет 11,48 млрд сумов, что эквивалентно приблизительно одному процентному пункту коэффициента потерь филиала. При этом систематическая погрешность учёта поступающей электроэнергии на уровне 0,5% может привести к искажению величины потерь на 5,58 млрд сумов, что превышает специальный уровень существенности (3,44 млрд сумов). При аудиторском риске 0,10 необходимый объём выборки сокращается с 99 монетарных единиц при существующей системе внутреннего контроля до 42 при совершенствовании обеих составляющих контроля. Анализ показывает, что в 2025 г. все 14 филиалов отчитались о снижении коэффициентов потерь (относительное сокращение составило 3–35%). Вместе с тем коммерческая составляющая потерь имела отрицательное значение в восьми филиалах и сократилась только в четырёх, а представленную детализацию потерь не удалось независимо пересчитать. Джизакский и Самаркандский филиалы отнесены к категории наивысшего аудиторского приоритета. Программа аудита продолжительностью 47 дней скорректирована с учётом необходимости увеличения времени на планирование и включения ранее не предусмотренной процедуры подтверждения объёмов приобретённой электроэнергии. Полученные результаты формируют прозрачную основу для определения объёма и масштабов аудиторских процедур при проверке потерь электроэнергии в регулируемых распределительных электросетевых предприятиях.

Ключевые слова: потери электроэнергии, аудиторский риск, существенность, выборка методом монетарных единиц, аналитические процедуры, распределительные электросетевые предприятия, Узбекистан.

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INTRODUCTION

Electricity distribution utilities purchase energy at wholesale prices and sell it to end users, so the difference between the energy received into the network and the energy billed represents both a physical and a financial quantity. Technical losses arise from energy dissipation in conductors and transformers, whereas non-technical energy losses arise primarily when electricity delivered to consumers is not accurately metered or billed because of theft, metering errors or billing failures. Unpaid electricity bills constitute a separate collection and receivables issue (Antmann, 2009; Smith, 2004). In Uzbekistan, the financial significance of electricity losses is considerable. At the Jizzakh branch of Hududiy Elektr Tarmoqlari (HET) JSC, electricity losses amounted to UZS 207.3 billion, or 90.3% of selling expenses of UZS 229.6 billion, in 2024, compared with 88.8% in 2022 (HET JSC Jizzakh branch, 2022–2024). For the company as a whole, the loss ratio was reported at 9.96% in 2025 (HET JSC, 2025), and the World Bank (2025) has noted that substantial commercial losses, including payment arrears, continue to affect the financial sustainability of the country's energy sector.

Despite their financial significance, electricity losses are not treated as a separate accounting object. Under the national chart of accounts in force until the end of 2024, losses of different types were recorded collectively within selling expenses (account 9410), and the relevant instructions did not provide dedicated accounts for electricity losses by type (Ministry of Finance, 2002). Consequently, the auditor receives a single aggregate balance whose composition (normative technical losses, above-norm losses, commercial losses and unexplained differences) is not directly identifiable in the ledger. Moreover, the balance itself represents the difference between two metered energy flows generated by technical systems operating outside the accounting function.

LITERATURE REVIEW

International Standards on Auditing (ISA) are recognised for use in Uzbekistan under a procedure approved by the Cabinet of Ministers in 2022 (Cabinet of Ministers, 2022). These standards require auditors to identify and assess the risks of material misstatement and to determine the nature, timing and extent of further audit procedures in response to those risks (ISA 315; ISA 330; Ministry of Economy and Finance, n.d.). However, they do not specifically address cost structures dominated by a single measured quantity, such as electricity network losses. The existing literature on electricity losses is predominantly technical or enforcement-oriented: it classifies electricity theft methods and detection technologies (Depuru et al., 2011; Smith, 2004) and recommends loss-reduction programmes for utilities (Antmann, 2009). Studies conducted in Uzbekistan address the standardisation of technological losses (Shodiyev, 2024) and the accounting of revenue and settlements in a distribution company (Suyunov, 2026). The literature reviewed for this study did not identify a published Uzbekistan-specific audit methodology devoted explicitly to electricity losses. The scope and limitations of the literature search should, however, be acknowledged.

The aim of this paper is to develop a risk-based audit methodology for electricity losses in distribution utilities and to calibrate it using data from HET JSC. Three research questions are addressed. RQ1: What do materiality and the structure of the loss ratio imply for the scope of the audit? RQ2: How does the control environment affect the required detection risk and sample size? RQ3: Which branches and which characteristics of the reported loss statistics should receive priority in the audit programme? The contribution is threefold: an audit risk model in which control risk is divided into technical and administrative components; a link between materiality, the loss ratio and sample size; and an analytical screening protocol with explicit red flags, applied to all 14 branches.

RESEARCH METHODOLOGY

Design and Data. The study follows a design-and-calibration approach. First, the audit risk model is adapted to the operational characteristics of a distribution utility. Second, audit planning parameters are calibrated using data from the Jizzakh branch, for which the structure of selling expenses for 2022–2024 and the volume of electricity losses in 2024 (493.6 million kWh) are available (HET JSC Jizzakh branch, 2022–2024). Third, analytical procedures, as defined in ISA 520, are applied to the loss ratios of all 14 regional branches for 2024 and 2025 and to the commercial component of losses reported for the same branches (HET JSC, 2025). The loss ratio represents the proportion of energy purchased by a branch that is not sold to consumers. The data are internal and unpublished; the branch-level extracts used in the analysis are reproduced in Table 3 and Figure 1. Monetary values are expressed in Uzbek soums (UZS); "bn" denotes billion (10^9), "mln" denotes million and "pp" denotes percentage points. All calculations are the author's own.

Audit Risk Model. The standard audit risk model expresses audit risk as the product of inherent risk, control risk and detection risk (Arens et al., 2020). For electricity losses, the audited quantity represents

the difference between energy purchased and energy sold. The first flow is measured at the interface with the wholesale supplier, while the second is derived from consumer metering and billing. Both flows are processed through automated metering and control systems (AMCS), which are technically distinct from the administrative controls governing recording and classification. Control risk is therefore divided into a technical component (CR

- metering accuracy, AMCS reliability and integration of meter data with the ledger) and an administrative component (CR

- written procedures, allocation of responsibilities and review). The model is

$$AR = IR_N \times CR_T \times CR_M \times DR \quad (1)$$

where AR is the acceptable audit risk, IR_N the network-specific inherent risk and DR the detection risk. Each risk is assessed on a three-level scale: low (0.1–0.3), moderate (0.4–0.6) and high (0.7–0.9). Acceptable audit risk is set at 0.10 and is lowered to 0.05 as controls mature. The detection risk required to hold audit risk at the chosen level is

$$DR^* = \min\{1, AR / (IR_N \times CR_T \times CR_M)\} \quad (2)$$

Because ISA330 (¶18) requires substantive procedures for each material class of transactions, account balance and disclosure irrespective of the assessed risks, $DR^* = 1$ is read as “substantive analytical procedures only”, not as the absence of testing.

Materiality and sample size. Overall materiality (OM) is set at 5% of selling expenses and specific materiality (SM) for the loss line at 30% of OM, reflecting the fraud-risk characteristics of the balance (ISA 320; ISA 240). The sample for substantive testing of the loss line is sized by monetary-unit sampling. If no misstatement is expected, the probability that a sample of n monetary units contains no misstatement of at least the tolerable amount is approximately $\exp(-n \cdot TM/BV)$, where BV is the book value of the population and TM the tolerable misstatement. Requiring this probability not to exceed DR^* gives

$$n = (BV / TM) \times \ln(1 / DR^*) \quad (3)$$

rounded up. The factor $\ln(1/DR^*)$ is the Poisson reliability factor of monetary-unit sampling (Arens et al., 2020), for example 3.0 at $DR^* = 0.05$. Here TM is set equal to SM; a lower tolerable misstatement, such as performance materiality below SM (ISA320), raises n in inverse proportion.

Monetary equivalents of the loss ratio. Two conversions link the loss ratio to the financial statements. At a given volume of energy received and a given valuation, the loss line L varies in proportion to the loss ratio λ (a fraction), so one percentage point of the ratio is worth

$$V_1 = 0.01 \times L / \lambda \quad (4)$$

A systematic relative bias ε in the metering of input energy, with consumer sales unchanged, shifts the measured loss line by

$$\Delta L = \varepsilon \times L / \lambda \quad (5)$$

because L/λ is the value of the energy received at the book valuation of losses.

Analytical screening protocol. Following ISA520, the loss statistics of the 14 branches were screened with five procedures: (i) distribution and tier shift, using the utility’s own thresholds of 8%, 11% and 13%; (ii) rank persistence between 2024 and 2025, measured by Spearman’s coefficient; (iii) relative change in the loss ratio; (iv) sign and additivity of the reported components; and (v) reconciliation of the company-wide figure to the branch figures. Two flags were then assigned to each branch. Flag A (exposure): a 2025 loss ratio above 13%. Flag C (implausible commercial component): a negative component below −0.10pp, or a component within ±0.10pp of zero at a loss ratio above 13%, in which practically the entire loss is classified as technological. Branches with both flags have priority 1, with one flag priority 2 and with none priority 3. The 0.10pp tolerance is a judgemental allowance for rounding.

Artificial intelligence (AI) tools were used to a limited extent, accounting for approximately 10% of the overall research preparation process. Their use was primarily confined to language refinement, technical editing, and structural support. The selection of research methods, analysis and interpretation of findings, formulation of scientific conclusions, and overall scientific responsibility remained entirely with the author.

ANALYSIS AND RESULTS

Materiality and the monetary meaning of the loss ratio (RQ1). Table 1 summarises the audit planning parameters for the Jizzakh branch in 2024. Selling expenses amounted to UZS 229.63 billion, of which electricity losses accounted for UZS 207.32 billion (90.28%). Overall materiality is therefore UZS 11.48 billion, while specific materiality is UZS 3.44 billion. The loss amount is 18.1 times overall materiality and 60.2 times specific materiality. Consequently, the balance is not only material but also pervasive: an audit of selling expenses is, in substance, an audit of electricity losses (Table 1).

Table 1
Planning quantities for the loss line, Jizzakh branch of HET JSC, 2024

Quantity	Value	Derivation
Selling expenses	UZS 229.63 bn	Branch data
Electricity losses (loss line, *L*)	UZS 207.32 bn (90.28% of selling expenses)	Branch data
Loss volume; book value per kWh	493.6 mln kWh; UZS 420	207.32 bn ÷ 493.6 mln kWh
Overall materiality (*OM*)	UZS 11.48 bn	5% × 229.63 bn
Specific materiality (*SM*)	UZS 3.44 bn	30% × *OM*
Loss line ÷ *OM*; ÷ *SM*	18.1; 60.2	207.32 ÷ 11.48; 207.32 ÷ 3.44
Loss ratio 2024 (λ)	18.58%	Table 3
Value of one percentage point (V_1)	UZS 11.16 bn	Equation (4): 0.01 × 207.32 ÷ 0.1858

Note: bn = billion; mln = million. Source: HET JSC Jizzakh branch (2022–2024); author's calculations.

Equation (4) shows that one percentage point of the loss ratio corresponds to UZS 11.16 billion. Accordingly, overall materiality is equivalent to 1.03 pp of the loss ratio, while specific materiality corresponds to 0.31 pp. A difference of approximately one percentage point between the reported loss ratio and the ratio obtained from a recalculated energy balance would therefore already be material to the financial statements. The decline reported for 2025 (from 18.58% to 13.74%, or 4.84 pp) is equivalent, at the 2024 volume and valuation, to UZS 54.0 billion, or 4.7 times overall materiality. Consequently, the reported improvement itself requires supporting audit evidence.

Equation (5) quantifies the sensitivity to measurement accuracy. A systematic bias of +0.5% in input metering, with sales remaining unchanged, would overstate the loss amount by UZS 5.58 billion (0.49 times OM and 1.62 times SM). A bias of 0.2% would result in a misstatement of UZS 2.23 billion (65% of SM), while a bias of 1% would result in a misstatement of UZS 11.16 billion, approximately equal to overall materiality. The loss amount therefore depends critically on the accuracy of the two metered energy flows. This explains why technical control risk is assessed separately from administrative control risk and why confirmation of the volume of electricity purchased from the wholesale supplier (ISA 505) is an essential audit procedure rather than a formality.

Control Environment, Detection Risk and Sample Size (RQ2). Inherent risk is assessed as high (IR= 0.8) because the balance is highly concentrated (90.3% of selling expenses), is derived from two metered energy flows, includes technological and commercial components that are difficult to distinguish, and is affected by tariff changes and seasonality. According to the author's preliminary observations, some branch practices may involve limited AMCS–ledger integration, manual processing of metering data and inconsistencies in accounting procedures. These observations require verification through documented process reviews, interviews and tests of controls before definitive conclusions can be drawn. Accordingly, both control risk components are assessed as high (CR= CR= 0.8). With an acceptable audit risk of 0.10, the required detection risk is 0.195, and Equation (3) yields a sample size of 99 monetary units (Table 2). Reducing the acceptable audit risk to 0.05 increases the required sample size to 141 monetary units (+42%) (Table 2).

Table 2
Required detection risk and monetary-unit sample size for the loss line under alternative control environments (Jizzakh branch, 2024)

Control environment	CR_T	CR_M	$IR_N \times CR_T \times CR_M$	DR^*, *AR* = 0.10	*n*	DR^*, *AR* = 0.05	*n*
Current: no AMCS–ledger integration, no written procedures	0.8	0.8	0.512	0.195	99	0.098	141
Technical controls remediated	0.5	0.8	0.320	0.313	71	0.156	112
Administrative controls remediated	0.8	0.5	0.320	0.313	71	0.156	112
Both remediated	0.5	0.5	0.200	0.500	42	0.250	84
Low-risk controls	0.3	0.3	0.072	1.000[a]	—[a]	0.694	22

Note: IR_N = 0.8 in all rows; *BV* = UZS 207.32 bn; *TM* = *SM* = UZS 3.44 bn (*BV*/*TM* = 60.19); $n = (BV/TM) \times \ln(1/DR^*)$, rounded up. [a] Required detection risk exceeds 1 (1.39) and is truncated at 1: substantive analytical procedures only (ISA 330, 18). Source: author's calculations.

Remediation of controls reduces the required audit effort. If either component is reduced to a moderate level (0.5), $DR*$ increases to 0.313, and the sample size decreases to 71 (−28%). If both components are reduced to this level, $DR*$ increases to 0.50, and n = 42 (−58%). Three considerations should be taken into account. First, the risk values are based on professional judgement, and reliance on remediated controls is justified only after their operating effectiveness has been tested (ISA 330). Therefore, Table 2 represents a planning sensitivity analysis rather than a forecast of cost savings. Second, Equation (3) assumes zero expected misstatement, and setting tolerable misstatement at 75% of SM would increase each sample size (n) by one-third. Third, only the substantive component of audit effort varies proportionally with n. Nevertheless, the results establish a transparent link between improvements in accounting practices (AMCS–ledger integration and written procedures) and audit efficiency.

Analytical Screening of the 14 Branches (RQ3). Figure 1 and Table 3 present the screening results. All 14 branches reported lower loss ratios in 2025 than in 2024. The unweighted mean decreased from 13.76% to 10.48%, while the range narrowed from 12.65 to 9.44 percentage points (pp). The number of branches with loss ratios above 13% declined from nine to four, whereas the number with ratios below 8% increased from one to two (Figure 1a). The relative decline ranged from 3.1% to 35.4% (mean: 22.6%; standard deviation: 8.7). However, six of the 14 branches reported declines within a narrow range of 26.0–28.3%, despite initial loss ratios ranging from 11.2% to 18.6%. The ranking of branches remained largely unchanged (Spearman's $\rho = 0.92$, $n = 14$, $p < 0.001$). This pattern is consistent with the implementation of a common loss-reduction programme, although it may also reflect centrally established targets or a common change in estimation methodology. Accordingly, the consistency of estimation methods across branches and reporting periods requires examination (ISA 540), while the observed pattern may also serve as an indicator of incentive-related risks (Section 3.5).

The reported components warrant further examination. The commercial component was negative in 10 of the 14 branches in 2024 and in eight branches in 2025 (Figure 1b), which is not consistent with the conventional interpretation of electricity losses. This may indicate an overestimation of normative technological losses or discrepancies in metering and energy balance calculations. The unweighted mean of the commercial component decreased from 1.03 to 0.45 pp. However, this decrease was driven by three branches: Andijan (−13.16 pp), Namangan (−3.38 pp) and Fergana (−2.82 pp). In the remaining 11 branches, the commercial component increased by a combined 11.1 pp. Consequently, the reduction in total losses was not accompanied by a reduction in the commercial component in most branches. In all 28 branch-year observations, the column reported as technological losses equals the total loss ratio. Therefore, the technological and commercial components cannot be reconciled with the total, and the reported decomposition cannot be independently recalculated from the available figures. Furthermore, the company-wide loss ratio for 2024 is reported as 12.55% in the international comparison and 13.81% in the branch-level table, compared with an unweighted branch mean of 13.76%. Depending on the figure used, the reported improvement amounts to either 3.85 or 2.59 pp. Without branch-level electricity volumes, the weighted mean cannot be reconstructed (Figure 1).

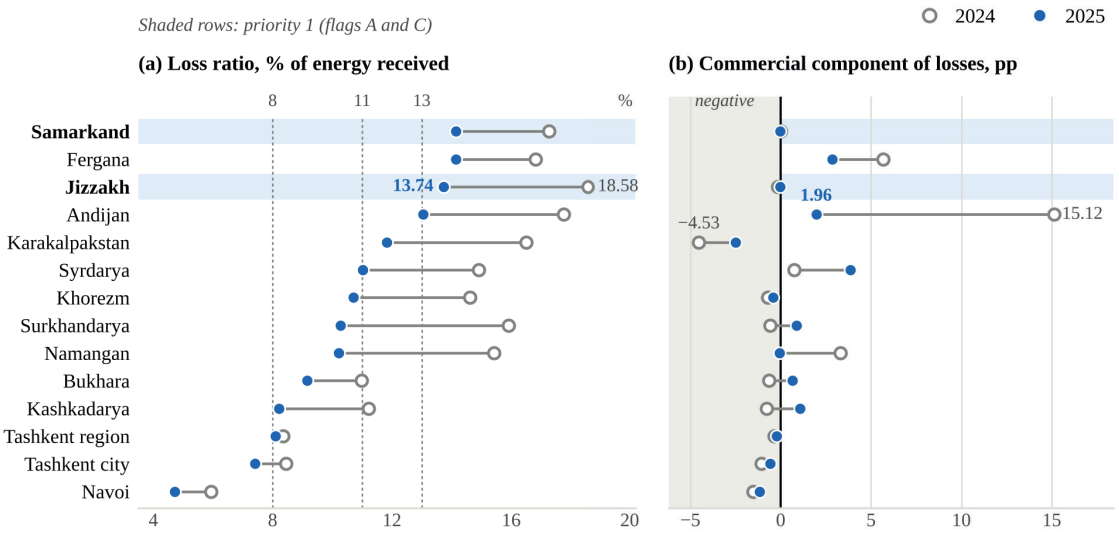


Figure 1. Loss ratio (a) and commercial component of losses (b) by branch, 2024 and 2025. Dotted lines in (a) mark the 8%, 11% and 13% thresholds of the utility's tier classification; the shaded area in (b) contains negative values, which cannot represent a loss[1].

1 Source: HET JSC (2025); author's calculations.

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Table 3 presents the comparative analysis of electricity loss ratios, commercial loss components and audit screening results for all 14 branches of HET JSC in 2024–2025. The findings indicate a consistent reduction in total electricity loss ratios across all branches. The unweighted mean decreased from 13.76% in 2024 to 10.48% in 2025, representing a decline of 3.28 percentage points (pp), with an average relative reduction of 22.6%. The largest absolute reduction was recorded in Surkhandarya (−5.64 pp), followed by Namangan (−5.20 pp) and Jizzakh (−4.84 pp). In contrast, Tashkent region recorded the smallest reduction (−0.26 pp). Despite the overall improvement, differences in loss ratios remained substantial, ranging from 4.71% in Navoi to 14.15% in Samarkand in 2025 (Table 3).

Table 3

Loss ratio, commercial component and screening flags by branch of HET JSC, 2024–2025

Branch	Loss ratio 2024, %	Loss ratio 2025, %	Change, pp	Change, %	Comm. comp. 2024, pp	Comm. comp. 2025, pp	Flags	Priority
Samarkand	17.27	14.15	−3.12	−18.1	−0.01	−0.02	A, C	1
Jizzakh	18.58	13.74	−4.84	−26.0	−0.16	−0.02	A, C	1
Fergana	16.81	14.14	−2.67	−15.9	+5.68	+2.86	A	2
Andijan	17.75	13.04	−4.71	−26.5	+15.12	+1.96	A	2
Karakalpakstan	16.50	11.83	−4.67	−28.3	−4.53	−2.51	C	2
Khorezm	14.62	10.71	−3.91	−26.7	−0.72	−0.41	C	2
Tashkent region	8.35	8.09	−0.26	−3.1	−0.36	−0.23	C	2
Tashkent city	8.44	7.41	−1.03	−12.2	−1.07	−0.58	C	2
Navoi	5.93	4.71	−1.22	−20.6	−1.51	−1.17	C	2
Syrdarya	14.90	11.03	−3.87	−26.0	+0.74	+3.87	—	3
Surkhandarya	15.91	10.27	−5.64	−35.4	−0.60	+0.86	—	3
Namangan	15.42	10.22	−5.20	−33.7	+3.30	−0.08	—	3
Bukhara	10.98	9.16	−1.82	−16.6	−0.64	+0.65	—	3
Kashkadarya	11.21	8.22	−2.99	−26.7	−0.78	+1.06	—	3
Unweighted mean of 14 branches	13.76	10.48	−3.28	−22.6	+1.03	+0.45		

Note: A = 2025 loss ratio above 13%; C = implausible commercial component (negative below −0.10 pp, or within ±0.10 pp of zero at a loss ratio above 13%). Priority 1 = A and C; 2 = A or C; 3 = none. Changes are recomputed from the rounded levels (the source table shows −4.85 pp for Jizzakh). HET JSC reports a company-wide loss ratio of 9.96% for 2025 and of 13.81% (branch table) or 12.55% (international comparison) for 2024. Source: HET JSC (2025); author's calculations.

Applying flags A and C identifies two priority-1 branches, Jizzakh and Samarkand (with loss ratios of 13.7% and 14.2%, respectively, and commercial components of −0.02 pp in both branches, indicating that practically all losses are classified as technological), seven priority-2 branches and five priority-3 branches. The priority-1 group remains unchanged for any exposure threshold between 11.9% and 13.7% and any tolerance between 0 and 0.10 pp. However, because anomalies in the decomposition occur in most branches, the screening indicates a systemic reporting issue as well as branch-specific concerns. The audit programme should therefore begin with a head-office recalculation of the loss decomposition and reconciliation of the aggregate figures (WP-07), while the established priorities should guide the sequencing of on-site audit procedures.

Audit Programme: Allocation of Effort and Break-Even Analysis. Table 4 presents the three-stage audit programme, comprising planning, execution and completion. The proposed engagement is scheduled to last 47 working days, with a four-person team (188 person-days) and an estimated cost of UZS 200–250 million, equivalent to UZS 1.06–1.33 million per person-day (Table 4).

Table 4
Three-stage programme for the audit of electricity losses: designed and recommended allocation of the 47-day engagement

Stage	Days (share): designed → recommended	Main procedures and working papers	ISA anchors
Planning	6 (12.8%) → 8 (17.0%)	Understanding of the entity and its environment (WP-02); risk matrix, materiality, *DR*ˆ and sample size, programme (WP-01, WP-03)	ISA 300, 315, 320, 330
Execution	35 (74.5%) → 33 (70.2%)	Energy balance and confirmation of purchased volumes (WP-04, WP-05); AMCS–ledger reconciliation (WP-06); decomposition of losses and normative/excess split (WP-07, WP-08); entries and loss accounts (WP-09, WP-10); commercial-loss tests and attribution of responsibility (WP-11, WP-17); consumer confirmations (WP-12); analytical procedures including first-digit test (WP-13, WP-14); control tests (WP-15); tariff recalculation (WP-16)	ISA 240, 330, 500, 505, 520, 530, 540
Completion	6 (12.8%) → 6 (12.8%)	Evaluation of misstatements, conclusions and recommendations, report and quality review (WP-18)	ISA 220, 230, 450, 700
Total	47 days	Four-person team (188 person-days); estimated cost UZS 200–250 mln	

Note: shares are percentages of the 47 days. Source: author's programme; author's calculations.

Two inconsistencies were identified in the proposed allocation of audit effort. First, planning accounts for 6 days (12.8%), below the recommended range of 15–20%, while execution accounts for 35 days (74.5%), near the upper limit of the recommended range of 65–75%. Reallocating two days from execution to planning results in 8, 33 and 6 days for planning, execution and completion, respectively (17.0%, 70.2% and 12.8%). This adjustment brings the allocation into line with the recommended proportions and provides additional time for the calibration of risks, materiality and sample size described above. Second, confirmation of purchased electricity volumes (WP-05) is included among the working papers (WPs) but is not explicitly scheduled, although input metering is the most sensitive element of the electricity loss amount (Section 3.1). Accordingly, this procedure is scheduled alongside the energy balance verification (WP-04). The first-digit (Benford's law) test included in WP-14 is appropriate for invoice-level amounts (consumption multiplied by tariff) but not for assigned or bounded numerical values (Durtschi et al., 2004; Nigrini, 2012).

The audit cost can be assessed in relation to the financial exposure. At a book valuation of UZS 420 per kWh, UZS 250 million is equivalent to 0.60 million kWh, representing 0.12% of the branch's electricity losses in 2024, 0.02 percentage points (pp) of its loss ratio and 2.2% of overall materiality. For an audit cost of UZS 200 million, the corresponding figures are 0.48 million kWh, 0.10%, 0.02 pp and 1.7%, respectively. The engagement would therefore achieve its break-even point if it enabled the recovery or prevention of misstatements or losses of a comparable magnitude. This provides a transparent break-even condition rather than relying on assumptions about the expected benefits.

Governance, Incentives and Fraud Risk. Electricity losses are managed and measured within the same organisational structure. Under the Three Lines Model, operational management (the first line) is responsible for risk ownership and measurement, risk management and compliance functions (the second line) provide support, and internal audit (the third line) provides independent assurance (IIA, 2020, 2026). Where management is also rewarded for reductions in reported electricity losses, the loss ratio becomes a performance indicator that may be subject to incentives and managerial discretion. An incentive scheme such as that proposed in the author's loss-management matrix, providing a bonus equivalent to 30% of remuneration when performance is 10% below the established norm and a penalty of 30% when the norm is exceeded by more than 15%, could increase the incentive and opportunity conditions identified in ISA 240 as fraud-risk factors. This is particularly relevant because the allocation of losses between normative and above-norm categories and the cut-off dates for meter readings involve elements of judgement and discretion.

Three safeguards are therefore proposed: (i) the basis for performance incentives should be the loss ratio verified by internal audit rather than the ratio reported by individual branches; (ii) purchased electricity volumes should be independently confirmed with the wholesale supplier (ISA 505), while meter data should be maintained under separate custody; and (iii) normative technological losses, determined using approved norms and therefore treated as accounting estimates, should be evaluated in accordance with ISA 540, including an assessment of the consistency of estimation methods across branches and reporting periods.

CONCLUSION AND RECOMMENDATIONS

This paper developed and calibrated a risk-based audit methodology for electricity losses in distribution utilities. Three principal findings address the research questions. First, at the Jizzakh branch, electricity losses account for 90.3% of selling expenses, overall materiality corresponds to approximately one percentage point of the loss ratio, and a systematic input metering bias of 0.5% would exceed specific materiality. Consequently, auditing electricity losses essentially involves examining two metered energy flows and reconciling the resulting balances. Second, dividing control risk into technical and administrative components makes the effect of improvements in internal controls on audit effort explicit. With an acceptable audit risk of 0.10, the required sample size decreases from 99 to 42 monetary units when both control components are remediated. Third, all 14 branches reported reductions in electricity loss ratios that were not consistently accompanied by corresponding reductions in the commercial component. The analysis also identified negative commercial loss components, a loss decomposition that could not be independently recalculated and discrepancies in company-wide reported figures. Jizzakh and Samarkand were assigned priority 1; however, the overall pattern indicates a systemic reporting issue that should first be examined at the central level. The 47-day audit programme was revised to address the insufficient allocation of time to planning and the absence of a scheduled confirmation of purchased electricity volumes. Further research should pilot the proposed methodology in a full audit engagement, estimate control risk using tested evidence, weight financial exposure by electricity volumes and evaluate the effectiveness of the proposed incentive safeguards.

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