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RURAL ELECTRIC POWER NETWORKS RECONSTRUCTION: A COST-BENEFIT ANALYSIS

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Summary. This article provides the economic justification and detailed explanation for the installation of an Automated System for Commercial Electricity Metering and Control (ASCEMC) during the reconstruction of the electric power networks in rural areas. ASCEMC capabilities and advantages are described.

Key words: losses, savings, calculation, payback, rural area, costs.

Formulation of the problem. The electricity supply to industrial enterprises and the municipal and residential sectors in rural areas has its own unique characteristics compared to the power supply of industrial enterprises and cities. The main specific feature is the need to deliver electricity to numerous relatively low-power consumers dispersed across a wide territory. The primary problems include low electricity quality, frequent power supply interruptions due to natural phenomena, and high electricity consumption by dispersed low-power consumers.

One of the ways to solve these problems is the implementation of an Automated System for Commercial Electricity Metering and Control (ASCEMC). The benefit of using ASCEMC in a rural electric network lies in electricity savings and a reduction in equipment repair costs. To carry out the reconstruction of the electric grid with the introduction of ASCEMC, it is necessary to conduct an economic assessment of its efficiency.

Basic research materials. The following served as the core research materials: technical parameters and schemes of the existing electric grid in the Priluksky rural district, statistical data on electricity losses for the period of 2023–2024, commercial offers for ASCEMC equipment and its installation, current electricity tariffs, and methodological guidelines for conducting the economic evaluation of investment projects.

Currently, an increase in electricity losses is observed virtually everywhere in rural areas. These losses can be conditionally divided into four groups:

1. Losses due to metering system errors, caused by low accuracy classes and non-standard operating conditions of measuring current and voltage transformers, meters, and so forth.

2. Losses in invoicing resulting from insufficient or erroneous information about concluded contracts, the use of special tariffs, or benefits.

3. Losses due to electricity theft caused by unauthorized consumer connections, fraud with metering devices, and so forth.

4. Losses in payment collection caused by payments are made later than the set date, long-term or bad debts, and unpaid bills. Within the framework of monetary deficits experienced by the electricity provider, losses take precedence due to non-payment for electricity and delayed payments. To reduce commercial losses, power sales controllers regularly visit consumers, write out, and send payment receipts. Nevertheless, the situation regarding these components is not improving, which indicates the feasibility of implementing ASCEMC with the ability to exert operational influence on the energy supply process.

ASCEMC Capabilities and Advantages. ASCEMC is a comprehensive software and hardware complex that significantly simplifies the monitoring and control of technological processes in power installations.

The system allows for the automatic monitoring and regulation of various parameters, such as pressure, temperature, rotational speed, and others, to optimize the performance and efficiency of the installation.

ASCEMC includes numerous sensors and measuring instruments, as well as software for processing and analyzing the collected data. Due to this, the system allows for a substantial increase in the level of automation and control of technological processes in power installations. This, in turn, increases the efficiency and cost-effectiveness of power companies and helps save resources.

The implementation of ASCEMC will allow power supply organizations and consumers to utilize new technological capabilities regarding the use of metering data, such as:

- Effective monitoring of energy flow throughout its entire technological cycle (production, transmission, distribution, and consumption).
- Calculation of the weighted average half-hourly combined active power during the daily peak electrical loads of the power system.
- Compilation of electricity balances recorded at a specific time, which makes it possible to determine the real (not calculated) amount of electricity losses in the electric grids.
- Implementation of a tool for locating sources of unaccounted consumption (theft) of electrical energy.
- Ensuring the interface between the ASCEMC databases and operational calculations for consumed energy and power, with automated allocation of the corresponding information to consumers' personal accounts and the generation of payment documents.

The advantages of implementing the ASCEMC system include reduced labor costs for employees of energy-saving organizations, as well as a reduction in commercial electricity losses in the electric networks due to the integration of high-precision commercial equipment, as shown in Table 1.

Calculation Methodology. The calculation of economic efficiency was performed in accordance with the methodologies set forth in the methodological guidelines for the evaluation of the efficiency of scientific,

scientific and technical, and innovative developments and their implementation [2-3].

Table 1 – Initial Data for Calculating the Economic Efficiency of Power Supply Reconstruction

Parameters	Existing Equipment: Induction Meter	Proposed Equipment: ASCEMC System (or Automated Meter Reading (AMR) System)
1. Electric Energy Consumption, kWh	499904	499904
2. Equipment Service Life (T), years	8	30
3. Operating Life of Existing Equipment until Replacement (T_E), years (or Remaining Service Life)	5	–
4. Depreciation Rate (D_R=100/T), %	12,5	3,3
5. Annual Allocation Rate for Maintenance and Repair, %	2,75	4,95
6. Electricity Tariff (C_E), BYN (Belarusian Rubles) per kWh: – from 23:00 to 06:00 during the peak load period – from 06:00 to 15:00 during the off-peak load period – from 15:00 to 23:00 during the mid-peak load period	0,26389	0,15833 0,303 0,277708

Capital investments in this case consist of the following key elements:

- Costs for the acquisition of modern electronic electricity metering devices and the Data Concentrator Unit or DCU.

- Capital works and costs for design and survey activities.

The book value of the existing equipment is:

$$BV=3 \cdot 145.60=436.80 \text{ BYN}$$

Table 2 – Quantity and Price of ASCEMC Equipment

Item Description	Quantity, pcs. (lin. m.) (pieces and linear meters)	Unit Cost, BYN	Total Cost, BYN
Meter CE318BY R32.146.JA.VFL	3	270	810
ASCEMC Cabinet "Energomera-A" with DCU-164-01B (Data Concentrator Unit)	1	1700	1700
Cable KVPEf-1x2x0.52	30	0,42	12,60
Wire TPiP3-5x2x0.5	20	0,29	5,80
Total	–	–	2528,40

Capital Investment Calculation. The calculation of capital investments considers the cost of equipment, costs for installation, transportation of equipment, and preparing the premises for installation.

The price of equipment and materials totals 2,528.40 BYN.

The capital investments for the projected variant are determined by the formula:

$$CI = C_{TC} \cdot \left(1 + \frac{K_T}{100} \cdot \frac{K_M}{100}\right) \quad (1)$$

Where:

CI – Capital Investments, BYN;

C_{TS} – Price of technical means/equipment, BYN;

K_T – Coefficient accounting for packaging and transportation costs, K_T=20 %;

K_M – Coefficient accounting for installation costs, K_M=10 %.

Annual Operating Costs. The annual operating costs (AOC), which represent the sum of all allocations and expenses associated with the operation of the power transmission line, are determined by the formula:

$$AOC=A+M_R+E_C+O_E \quad (2)$$

Where:

AOC – Annual Operating Costs, BYN;

A – Depreciation (Amortization) deductions, BYN;

M_R – Maintenance and Repair expenses, BYN;

E_C – Costs for consumed energy resources (Energy Consumption), BYN;

O_E – Other Expenses, BYN.

Table 3 – Technical and Economic Indicators of the Project

Parameters	Options		Change ±(2-1)
	1	2	
1. Number of Connection Points	3	3	
2. Electricity Consumption, kWh per year	499904	499904	–
3. Book Value of Existing Equipment, BYN	435,60	–	–
4. Capital Investments in New Equipment, BYN	–	3286,92	–
5. Operating Costs (OPEX), BYN per year	133305,96	127757,94	-5548,02
5.1 Depreciation (Amortization) Deductions, BYN	54,45	108,47	54,02
5.2 Costs for Maintenance and Repair	11,98	162,70	150,72
5.3 Electricity Expenses (or Energy Costs)	131919,67	126221,84	-5697,83
5.4 Other Expenses	1319,86	1264,93	-54,93
6. Losses from Electricity Supply Interruptions, BYN per year (or Damage from Outages)	243099,50	97239,79	-145860
7. Net Present Value (NPV), BYN	3763945,75	2252179,5	-1511766

Conclusion. The implementation of the ASCEMC system within the framework of the electric grid reconstruction in the Priluksky rural district, replacing the existing induction meters, significantly reduces electricity payment costs due to differentiated accounting of energy consumption at various times of the day.

The payback period for the capital investments is less than one year. This is substantiated by a reduction in operating costs and the achievement of a total discounted cost (or Net Present Value, NPV) in the proposed project amounting to 1,511,776 BYN.

References

1. ТКП 385-2022 (02230) Нормы проектирования электрических сетей внешнего электроснабжения напряжением 0,4-10 кВ сельскохозяйственного назначения, Минск, 2022. – 69 с.

2. Методические рекомендации по оценке эффективности научных, научно-технических и инновационных разработок и их внедрения: постановление Государственного комитета по науке и технологиям Респ. Беларусь, 20 апреля 2017 г., № 9 // Министерство сельского хозяйства и продовольствия Республики Беларусь. [Электронный ресурс]. – URL: https://mshp.gov.by/documents/nts/a4e25cd93eb26108.html (дата доступа: 03.10.2025).

3. ТКП-460-2017 (33240) Порядок расчета величины технологического расхода электрической энергии на ее передачу по электрическим сетям, учитываемой при финансовых расчетах за электроэнергию между энергоснабжающей организацией и потребителем (абонентом), Минск, 2017. – 108 с.