V International Scientific and Technical Conference Actual Issues of Power Supply Systems

Multi-criteria optimization method for improving technical and economic indicators in the development of urban distribution networks

AIPCP25-CF-ICAIPSS2025-00360 | Article

Multi-criteria optimization method for improving technical and economic indicators in the development of urban distribution networks

Abdurakhim Taslimov [1], Feruz Raximov[2,a)], Farrukh Rakhimov[2], Baxodir Azizov[3]

[1]Tashkent state technical university named after Islam Karimov, Tashkent, Uzbekistan
[2]Navoi State University of Mining and Technologies, Navoiy, Uzbekistan
[3] Andijan State Technical Institute, Andijan, Uzbekistan

[a)] Corresponding author:feruz.raximov.2017@mail.ru

Abstract. The article proposes a multi-criterion optimization approach, which allows for a comprehensive assessment of the technical and economic tasks arising in the process of modernization of urban distribution power networks. This approach stemmed from the need to justify investment costs in newly built cities, and to increase energy efficiency and improve operational reliability in existing networks. The study was carried out on the example of 17 transformer substations powered from the 34th distribution point under the Navoi City Power Supply Enterprise; lines lengths, load indicators, cable cross-sections and transformer capacities were included in the analysis framework. The voltage levels of 10 kV and 20 kV were compared on the basis of technical and economic indicators. The capital costs of cable and transformer points were estimated through regression equations relying on real prices. Network reliability was calculated with System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI) and Energy Not Supplied (ENS) indicators. The results showed that the 20 kV variant improved power losses by 30-40% and reliability indicators by 35-40%.

INTRODUCTION

The stable operation of urban distribution power networks is the most important component of modern energy systems. An increase in urbanization levels, an increase in the number of consumers, and the stochastic nature of loadings require higher levels of reliability, continuity, and energy quality from distribution networks. At the same time, the renovation of existing infrastructure, the modernization of cable lines, the reconstruction of transformer substations require large financial investments [1,2]. Therefore, the issue of optimizing urban Power Networks is considered as a multidimensional task that simultaneously includes technical, economic and operational criteria. Currently, there are various approaches to improving the efficiency of distribution networks, including reliability indicators SAIDI, SAIFI, ENS, operating costs, power transmission losses and minimizing capital costs. However, these criteria are mutually exclusive, and reducing one criterion may lead to an increase in another [3]. For example, to achieve high reliability, additional reserve lines or substations are required, which leads to a sharp increase in investment costs. Therefore, finding the optimal solution requires a “multi-criteria” rather than a “single-criteria” optimization approach [4].

In this study, a mathematical model is developed that jointly minimizes investment costs (CAPEX), operating costs (OPEX) and network reliability indicators in urban distribution power networks. In the optimization process, the Pareto-front approach, weighted normalization, clustering algorithms (K-means), as well as feasibility constraints are taken into account. The proposed method provides an effective control mechanism when making decisions on the modernization of the network (updating cables, replacing Transformers, configuring the circuit) [5]. In addition, the integration of several target functions into a single decision-making system makes it possible to more transparently assess the compromises between technical and economic factors. As a result, the developed methodology provides a solid analytical framework for choosing development scenarios that ensure the long-term energy efficiency and reliability of urban distribution networks [6].

EXPERIMENTAL RESEARCH

As an object of research, a real exploitation plot was selected, which will be provided from the 34th distribution point of the Navoi City Power Supply Enterprise. This network is a radial scheme, connecting to different categories of consumer groups through several networked circuits connected in series from the main supply lines an object of research, a real exploitation plot was selected, which will be provided from the 34th distribution point of the Navoi City Power Supply Enterprise. This network is a radial scheme, connecting to differ. These sections include *L-264*, *L-NSMTU*, *L-550*, *L-542*, *L-Stadium-1* and their serially branched combinations. For each section, the line length varies from 0.25 km to 3.333 km, and the active power load from 124 kW to 1784 kW. This data is then used as a starting point to determine power losses, currents, voltage deviations and reliability indicators. The capacity of transformer substations serving the network is as follows: S_{nom} (250; 400;630; 1000} kVA.

The transformer capacity for each transformer substation is selected based on the load level, development prospects and operational requirements. Thus, the transformer capacity is taken into account as a low-variable parameter in the optimization model. Two options with a voltage of 10 kV and 20 kV are considered in terms of the network voltage level [7,8].

The model is constructed in such a way that by setting the U_{nom} parameter to 10 kV and 20 kV, it becomes possible to compare investment costs, reliability, and technical performance for both options [6].

For cable lines, real cable brands and cross-sections reflecting the current network at the Navoi City Electricity Supply Enterprise are accepted. In particular, the conductor cross-section F for ASB-3×240 mm^2, APvEP-3×120 mm^2, ASB-3×120 mm^2 and similar brands is entered into the model. Thus, for each section, the line type and cross-section F_i, length L_i, load P_i, and transformer capacity at the connection point S_j are determined [6].

When assessing the efficiency of urban distribution power networks, several interconnected and, in some cases, contradictory criteria are usually taken into account. In this study, the main focus is on the following two areas:

- CAPEX costs necessary for the modernization of cable lines and transformer substations, the construction of new plots or the reconstruction of existing ones;
- increasing network reliability-reducing the frequency and duration of unplanned interruptions, providing consumers with uninterrupted electricity, bringing the level of electricity supply closer to regulatory requirements.

In addition, as secondary but important technical indicators, active power losses ΔP, annual energy losses ΔW, compliance with the permissible voltage range $\Delta U \leq U_{perm.}$ are also controlled and included in the model in the form of restrictions. Thus, the issue of multi-criterion optimization is formulated on the principle of “low investment + high reliability + compliance with technical restrictions” [9-12].

The capital costs required for cable lines and transformer substations are based on proposed regression models. The cost per 1 km for cable lines is determined as follows:

$$Z_{KL}(F,U) = 112.22 + 1.35F + 3.7U_{nom}, \text{ million UZS /km} \quad (1)$$

where: F- cable cross-section, mm^2; U_{nom}- nominal network voltage, kV (10 or 20); Z_{KL}- capital costs for 1 km of cable line, million UZS/km.

The investment costs for a transformer substation are given by the following expression:

$$Z_{TP}(S,U) = 8.35 + 0.111S_{nom} + 1.07U_{nom}, \text{ million UZS} \quad (2)$$

where: S_{nom} - nominal power of the transformer, kVA; U_{nom} - nominal voltage on the high voltage side, kV; Z_{TP} - investment cost required for the construction or reconstruction of one transformer station, million UZS.

Based on these formulas, the total investment costs for the network are expressed as follows:

$$CAPEX = \sum_{i=1}^{m} Z_{CL(F_i,U_{nom})} \cdot L_i + \sum_{j=1}^{m} Z_{TP}\big(S_{nom,j}, U_{nom}\big), \text{ million UZS} \quad (3)$$

where: n – the number of cable sections under consideration (in our case 17); m – the number of transformer points; L_i – the length of the section line, km; F_i – the cable cross-section selected for the section, mm^2; $S_{nom.j}$ – the nominal power of the transformer, kVA [13- 18].

Through this expression, individual investment costs for voltage levels of 10 kV and 20 kV are calculated and then participate as one criterion in multi-criterion optimization.

Network reliability is directly related to the continuity of electricity supply to consumers and is usually described in modern standards by the following integral indicators:

- SAIDI - the average annual interruption duration of consumers, hours/consumer;
- SAIFI - the average annual number of interruptions of consumers, measured in interruptions/customer;
- ENS - the amount of energy not delivered to consumers, measured in MWh/year [19,20].

For radial urban networks, these indicators are usually expressed in terms of the element failure frequency λ_k and the restoration duration r_k as follows:

$$SAIDI = \frac{1}{N_{tot}} \sum_k \lambda_k r_k N_k \tag{4}$$

$$SAIFI = \frac{1}{N_{tot}} \sum_k \lambda_k N_k \tag{5}$$

$$ENS = \sum_k t_{out,k} P_k \tag{6}$$

where: N_{tot} – the total number of consumers connected to the network; N_k – the number of consumers within the impact range of the element accident; λ_k – the annual failure frequency of the element, 1/year; r_k – the average duration of troubleshooting or recovery, hours; P_k – the load capacity affected by the element accident, kW; $t_{out,k}$-the duration of the complete [21].

RESEARCH RESULTS

For cable lines, the *k* and r_k values will be related to their type (air or cable line), conductor cross section F_i, length L_i laying conditions. And the frequency of failure and the duration of recovery for transformer points are accepted according to the age of the device, the load level and the operating modes [20].

This study assumes the following integral function as a reliability criterion:

$$f_{rel} = \alpha_1 \cdot SAIDI + \alpha_2 \cdot SAIFI + \alpha_3 \cdot \frac{ENS}{ENS_{baz}} \tag{7}$$

where: α_1, α_2, α_3 is the normalizing weight coefficients, ENS_{baz} is the volume of energy that is not supplied by the base (in-state) grid.

Through this, the reliability criterion is also considered as one of the many-criterion functions that can be minimized. Based on the above investment and reliability models, the multi-criteria optimization problem is written as follows:

$$\begin{cases} f_1(x) = Z_{inv}(U_{nom}) \to min, \\ f_2(x) = f_{rel}(x) \to min, \\ subject\ to: \\ \left| \Delta U_i \right| = \Delta U_{max}, \\ I_i \le I_{therm}(F_i, U_{nom}), \\ S_{load,j} \le k_{load} \cdot S_{nom,j}, \\ F_i \epsilon \{F_{diskret}\},\ S_{nom,j} \epsilon \{250, 400, 630, 1000\}. \end{cases} \tag{8}$$

where x is the parameter vector being optimized, which includes cable cross sections F_i, transformer power $S_{nom,j}$, as well as some design parameters under the network scheme [21].

The problem is solved in vector-criteria form and is supplemented in subsequent stages with algorithms for generating the Pareto front, clustering solutions, and selecting the most optimal option for the decision maker.

Let's take an analytical look at the cost comparison table presented in Table 1 for 10 kV and 20 kV in terms of cable cross sections

TABLE 1. Investment costs of 1 km of cable line (million UZS/km)

Cable cross-section, mm^2	Z_{CL} (million UZS/km)		Difference (%)
	$Z_{CL\text{-}10\,kV}$	$Z_{CL\text{-}20\,kV}$	
120	243.7	280.7	+15.2
95	277.4	314.4	+13.3
120	311.2	348.2	+11.9
150	351.7	388.7	+10.5
185	398.9	435.9	+9.3
240	473.2	510.2	+7.8

It is worth noting that at a voltage level of 20 kV, the capital cost of cable lines is on average 7–12% higher than at 10 kV. However, this additional cost is fully compensated by a significant reduction in energy losses in the network, an increase in voltage stability and a decrease in the thermal load of electrical equipment, as will be shown in the following sections [22-51].

In addition, at a higher voltage level, the reduction in current extends the service life of cables and transformers and significantly reduces operating costs. Therefore, a slight increase in the initial investment confirms the practical validity of the optimized model and increases the overall technical and economic efficiency of the network.

TABLE 2. TS costs at 10 kV and 20 kV voltage levels (million UZS)

S_{nom} (kVA)	Z_{TS} (million UZS)		Difference (%)
	10 kV TS cost	20 kV TS cost	
250	46.8	57.5	+22.9
400	63.45	74.15	+16.8
630	88.98	99.68	+12.0
1000	130.05	140.75	+8.2

Table 2 shows the capital costs for transformer substations (TS) at 10 kV and 20 kV voltage levels. For nominal powers between 250 and 1000 kVA, the transition from 10 kV to 20 kV results in an increase in the cost of the TS from 8.2% to 22.9%, reflecting the higher insulation level and construction requirements of 20 kV equipment.

TABLE 3. Technical indicators for 10 kV and 20 kV networks (example: 1000 kW load)

Parametr	10 kV	20 kV	Difference
Current (A)	57.7	28.8	-50%
Power losses (kW)	3.4	1.0-1.4	-60%
Voltage deviation	4.8-6.2%	1.9-3.4%	two times

Table 3 presents a comparative analysis of the main technical parameters of the distribution networks operating at voltage levels of 10 kV and 20 kV. Under conditions with a load capacity of 1000 kW, calculations show that increasing the voltage from 10 kV to 20 kV will lead to a twofold reduction of the current (from 57.7 A down to 28.8 A. As a result of the decrease in current, the active power losses are reduced from 3.4 kW to 1.0-1.4 kW, and the total losses are reduced to 60%. As a result, active power losses are reduced from 3.4 kW to about 1.0–1.4 kW (around 60%), and voltage deviation improves from 4.8–6.2% to 1.9–3.4%.

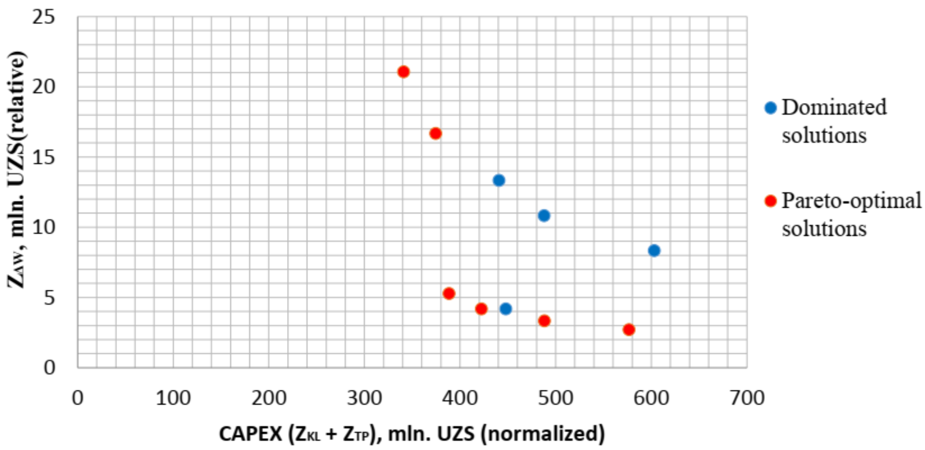

FIGURE 1. Pareto front for multi-criteria optimization in urban distribution networks.

Figure 1 shows the relationship between CAPEX (capital investment for cable lines and transformer stations) and the annual energy loss value $Z_{\Delta W}$. The graph shows that Pareto-optimal solutions (red dots) provide the most optimal balance between investment and losses. They significantly reduce annual energy losses without increasing total costs. Non-dominant solutions (blue dots), despite their higher cost, do not provide efficiency in terms of energy loss. The result shows that large-section cable (120–185 mm²) and 20 kV voltage options are the most stable part of the Pareto set, as they improve the technical performance of the network and create an economic advantage for long-term operation. This Pareto-front analysis shows that in network modernization it is necessary to pay attention not only to capital investment, but also to operational losses at the same time.

CONCLUSIONS

This study developed a multi-criterion optimization approach aimed at reducing investment costs and increasing network reliability in the process of modernizing urban distribution power grids. The proposed methodology was tested on the basis of 17 real plot data, cable line price models, transformer point investment models, technical indicators (I, ΔP, ΔW) and reliability indicators (SAIDI, SAIFI, ENS).

The results of the analysis show that switching from a 10 kV to a 20 kV network reduces power losses by 30-40%, stabilizes voltage deviations within the regulatory range, and sharply reduces the thermal load of cable lines and Transformers. It was also found that overall economic efficiency would be fully recouped in 3-5 years due to a significant reduction in losses and improved reliability, despite an increase in investment costs by 7-12%.

Pareto-front analysis made it possible to identify balanced scenarios between investment and reliability indicators. K-means clustering results have yielded three specific compromise states: solutions with minimal investment (but lower reliability), solutions providing maximum reliability (with higher cost), and technically–economically optimal solutions. Within these clusters, a configuration with a voltage of 20 kV, a cable cross section of 120 mm^2 and transformers of 400-630 kVA was considered the most optimal. This option provides the best ratio in terms of investment costs, technical parameters, and reliability indicators.

The proposed methodology is also relevant in practical terms and can be used to develop network development strategies, assess the effectiveness of capital investments, reconstruct existing infrastructure and design new electrical networks. Also, this approach simplifies the process of optimal decision-making for energy enterprises, allows you to balance the opposite requirements for technical and economic indicators.

In general, the proposed method, based on multi-criterion optimization, provides an important scientific and practical basis in improving the efficiency of urban distribution networks, achieving a level of reliable electricity supply and reducing energy losses.

REFERENCES

1. Akram Tovbaev, Muxtarxan Ibadullayev and Mohinur Davronova. Study of subharmonic oscillation processes in ferroresonance circuits. E3S Web of Conf. Volume **525**, 2024. IV International Conference on Geotechnology, Mining and Rational Use of Natural Resources (GEOTECH-2024). https://doi.org/10.1051/e3sconf/202452503008
2. Akram Tovbaev., Islom Togaev., Uktam Usarov.,Gulom Nodirov, Reactive power compensation helps maintain a stable voltage profile across the network, AIP Conf. Proc. **3331,** 060014 (2025). https://doi.org/10.1063/5.0307209
3. Asliddin Norqulov, Feruz Raximov, Methods for evaluating financial and economic effectiveness of investment projects in the energy sector with time factor considerations, AIP Conf. Proc. **3331,** 030070-1–030070-6. https://doi.org/10.1063/5.0306104
4. Shukhrat Abdullaev., Ziyodullo Eshmurodov., Islom Togaev, A systematic analysis of the gradual increase in quality indicators of electricity using reactive power sources involves several steps, AIP Conf. Proc. **3331**, 040051 (2025). https://doi.org/10.1063/5.0306786
5. Bobur Narzullayev; Javokhir Boboqulov, Improving reliability based on diagnostics of the technical condition of electric motor stator gutters, AIP Conf. Proc. **3331**, 030032 (2025). https://doi.org/10.1063/5.0305735
6. Abdurakhim Taslimov., Feruz Raximov., Farrukh Rakhimov., Iles Bakhadirov, Optimal parameters and selection criteria for neutral grounding resistors in 20 kv electrical networks, AIP Conf. Proc. **3331**, 030048 (2025) https://doi.org/10.1063/5.0306108
7. Islom Togaev., Akram Tovbaev., Gulom Nodirov, Systematic analysis of reactive power compensation in electric networks is essential for improving electricity quality enhancing system stability, and reducing operational costs, AIP Conf. Proc. **3331**, 030099 (2025) https://doi.org/10.1063/5.0305740
8. Abdurakhim Taslimov., Farrukh Rakhimov., Feruz Rakhimov., Vaxobiddin Mo'minov, Analysis of the results of sampling the surfaces of sections of rural electric networks, AIP Conf. Proc. **3331,** 030041 (2025) https://doi.org/10.1063/5.0305783
9. Sulton Amirov, Aminjon Ataullayev, Sine-cosine rotating transformers in zenith angle converters, E3S Web of Conferences **525,** 03010 (2024) GEOTECH-2024, https://doi.org/10.1051/e3sconf/202452503010
10. A.Tovboyev, I.Togayev, I.Uzoqov, G. Nodirov, Use of reactive power sources in improving the quality of electricity, E3S Web of Conferences 417, 03001 (2023) https://doi.org/10.1051/e3sconf/202341703001
11. I.Togayev, A.Tovbaev, G. Nodirov, Assessment of the quality of electricity by applying reactive power sources, E3S Web of Conferences, 525, 03004 (2024) https://doi.org/10.1051/e3sconf/202452503004

12. G.Boynazarov, A. Tovbaev, U. Usarov, Methology of experimental research of voltage quality in electrical circuit, E3S Web of Conferences 548, 03009 (2024) https://doi.org/10.1051/e3sconf/202454803009
13. N.Ataullayev, A.Norqulov, B.Muxammadov, A.Majidov, I.Tog'ayev. Principles of protection against single phase earth faults in networks with capacitive current compensation. E3S Web of Conferences, 548, 06008 (2024). https://doi.org/10.1051/e3sconf/202454806008
14. Murodov K., Karshibayev A. Development of the management system of technical indications of high-power charger-discharger rectifier device //E3S Web of Conferences. – EDP Sciences, 2023. – T. 417. – C. 03012. https://doi.org/10.1051/e3sconf/202341703012
15. Ataullaev N. O., Dziaruhina A. A., Murodov K. S. Static Characteristics of Magnetic Modulation DC Converters with Analog Filter // Science and technology. – 2023. – T. 22. – №. 5. – C. 428-432. https://doi.org/10.21122/2227-1031-2023-22-5-428-432
16. Dinora Jalilova; Gulnora Kasimova; Zamira Shayumova; Gulmira Abidova Current status of ensuring power quality in spinning mills // AIP Conf. Proc. 3331, 070021 (2025) https://doi.org/10.1063/5.0306211
17. Eshpulatov, N., Khalmuradov, T., Rakhimov, F., Abdurayimov, S., Khurramov, A., Mullajonov, I., & Vorisova, R. (2023, March). The influence of the impact of electrical impulses on the juice outputting of the pulp. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1142, No. 1, p. 012017). IOP Publishing. **DOI** 10.1088/1755-1315/1142/1/012017
18. Eshpulatov, N., Khalmuradov, T., Rakhimov, F., Abdurayimov, S., Khurramov, A., Ruziyeva, U., ... & Maftuna, I. (2023, March). Influence of the parameters of the impact of electrical impulses on the yield of juice from the pulp. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1142, No. 1, p. 012006). IOP Publishing. **DOI** 10.1088/1755-1315/1142/1/012006
19. Karshibayev, A. I., & Jumayev, Z. I. (2023). Expanding the level of forecasting and operational planning of electric consumption at mining enterprise. In *E3S Web of Conferences* (Vol. 417, p. 03015). EDP Sciences. https://doi.org/10.1051/e3sconf/202341703015
20. Rakhmonov, I., Usmanaliev, S., Shayumova, Z., & Ruzinazarov, M. (2025, November). Carbon dioxide (CO2) filtering, capture, and storage technologies. In *American Institute of Physics Conference Series* (Vol. 3331, No. 1, p. 040024). **DOI:**10.1063/5.0305715
21. Khudayarov, M., Makhmudov, T., & Fayziyev, S. (2025, November). Tuning hyperparameters of artificial neural networks to solve problems of calculating steady-state modes and electricity losses in distribution networks. In *AIP Conference Proceedings* (Vol. 3331, No. 1, p. 030066). AIP Publishing LLC. https://doi.org/10.1063/5.0305698
22. Mahmutkhonov S., Baizhonova L., Mustayev R., Tashmatova S. Dynamic analysis of voltage-ampere characteristics and harmonic distortions in electric arc furnaces. // *AIP Conference Proceedings*. 3331(1), 2025. pp. 070023, 1–5. https://doi.org/10.1063/5.0305745.
23. Bobojanov M., Mahmutkhonov S. Influence of the consumer to power quality at the point of connection // E3S Web of Conferences 384. 2023. PP, 01041, 1-5. https://doi.org/10.1051/e3sconf/202338401041.
24. Bobojanov M.K., Karimov R.Ch., Popkova O.S., Tuychiev F.N., Makhmutkhanov S.K. Analysis of the results of experimental studies of the arc furnace DSP-30. // *Power Engineering Research & Technology*. 27(2), 2025. pp. 126–137. https://doi.org/10.30724/1998-9903-2025-27-2-126-137
25. Reymov K.M., Makhmuthonov S.K., Turmanova G., Uzaqbaev Q. Optimization of electric networks modes under conditions of partial uncertainty of initial information // E3S Web of Conferences 289, 07023 (2021). -2021, pp: 1-4, https://doi.org/10.1051/e3sconf/202128907023.
26. R. K. Kurbaniyazov, A. M. Reimov, A.T. Dadakhodzhaev, Sh. S. Namazov, B. M. Beglov. Nitrogen-phosphoric fertilizers produced by introduction of Central Kyzylkum phosphate raw material into ammonium nitrate melt. Russian Journal of Applied Chemistry. Russ J Appl Chem (2007) 80(11): 1984-88. https://doi.org/10.1134/S1070427207110456
27. Namazov, Sh.S., Kurbaniyazov, R.K., Reimov, A.M., Beglov, B.M. Hardness of the granules of ammonium nitrate doped with the Central Kyzylkum Phosphorite. Russian Journal of Applied Chemistry. Russ J Appl Chem (2007) 81(6): 1103–1106. http://dx.doi.org/10.1134/s1070427208060402.
28. Kurbaniiazov, R.K., Reimov, A.M., Namazov, Sh.S., Beglov, B.M. Nitrogen-phosphoric fertilizers obtained by interaction of the concentrated solutions of ammonium nitrate with the mineralized mass of the phosphorites of Central Kyzylkum. Russian Journal of Applied Chemistry. Russ J Appl Chem (2009) 82: 1123. https://link.springer.com/journal/11167
29. Alimov, U.K., Reimov, A.M., Namazov, Sh.S., Beglov, B.M. The insoluble part of phosphorus fertilizers, obtained by processing of phosphorites of central kyzylkum with partially ammoniated extraction phosphoric acid.

Russian Journal of Applied Chemistry. Russ J Appl Chem (2010) 83(3): 545–552. https://doi.org/10.1134/S107042721030328
30. Reymov, A.M., Namazov, S.S., Beglov, B.M. Effect of phosphate additives on physical-chemical properties of ammonium nitrate. Journal of Chemical Technology and Metallurgy 2013 48(4), 391-395. http://dl.uctm.edu/journal/
31. Reymov Akhmed, Namazov Shafoat. Nitrogen-phosphorous fertilizers on the base of concentrated ammonium nitrate solution and Central Kyzylkum phosphate raw material. Polish Journal of Chemical Technology 16(3), Sep 2014, 30-35. https://doi.org/10.2478/pjct-2014-0046
32. Alisher Eshimbetov, Shahobiddin Adizov, Inderpreet Kaur, Akhmed Reymov. Is it possible to differentiate between 2-phenylaminodihydro-1,3-thiazine from 2-phenyliminotetrahydro-1,3-thiazine by spectral methods? New glance to the old problem. European Journal of Chemistry 12 (1) (2021). https://doi.org/10.5155/eurjchem.12.1.77-80.2068
33. A.Ahmadjonov, U.Alimov, P.Tuychi, A.Seitnazarov, A.Reimov, Sh.Namazov, S.Sadullayev. Effect of temperature on the kinetics of the process of nitric acid decomposition of Arvaten serpentinite. IOP Conf. Series: Earth and Environmental Science 1142 (2023) 012034. https://www.scopus.com/pages/publications/85151285667
34. Xudoyberdiev J., Reymov A., Kurbaniyazov R., Namazov S., Badalova O., Seytnazarov A. Mineral Composition of Nodular Phosphorite of Karakalpakstan and its Processing into Simple Superphosphate. (2023) E3S Web of Conferences, 449, art. no. 06005. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85178595919&doi=10.1051%2fe3sconf%2f202344906005&partnerID=40
35. Kosnazarov K., Ametov Y., Khabibullaev A., Reymov A., Turdimambetov I., Shaniyazov S., Berdimuratova A. Characteristics of dust-salt transfer from the dried bottom of the Aral Sea and the Aral region, as well as their lossout. E3S Web of Conferences. https://www.scopus.com/pages/publications/85212840616
36. Seyilkhanova A., Reymov Q., Eshmuratov A., Gulimbetov B., Medetov M., Reymov A., Berdimuratova A., Shaniyazov Sh. E3S Web of Conferences ISSN: 25550403Volume: 575. https://www.scopus.com/pages/publications/85212825022
37. Turdimambetov I., Murgaš F., Victor F., Oteuliev M., Madreimov A., Shamuratova G., Atabayev S., Reymov A. Geojournal of Tourism and Geosites. ISSN: 20650817, Volume: 57 Pages: 1941 – 1951. https://www.scopus.com/pages/publications/85213872579
38. Temirov G., Alimov U., Seytnazarov A., Reymov A., Namazov S., Beglov B. Rheological Properties and Composition of Products of Phosphogypsum Conversion with Sodium Carbonate. Russian Journal of General Chemistry. ISSN: 10703632 Volume: 94 Issue: 7 Pages: 1837 – 1847. https://www.scopus.com/pages/publications/85202786813
39. Reymov A., Turdimambetov I., Pirnazarov N., Shaniyazov Sh., Absametova D., Baymurzaev A., Orazbaev A., Usnatdinov A.,Tajetdinov S. Exploring novel techniques for measuring and identifying minuscule dust particles in the atmosphere. E3S Web of Conferences ISSN: 25550403 Volume: 575. https://www.scopus.com/pages/publications/85212822728
40. Chavliyeva F., Turakulov B., Kucharov B., Erkayev A., Reymov A., Karshiboev M., Mamajonov M. Study of obtaining potassium hydroxide by electrochemical method on the bases of flotation and hallurgic potassium chloride. New Materials, Compounds and Applications ISSN: 25217194 Volume: 8 Issue: 2 Pages: 244 – 253. https://www.scopus.com/pages/publications/85204364412
41. Kuldasheva S., Aziza A., Kulmatov R., Karimova G., Dauletbayeva R., Nortojiyeva G., Reymov A. Study and assessment of mineralogical, chemical and granulometric composition of volatile soil-sand aerosols from the dried-out part of the Aral Sea. E3S Web of Conferences ISSN: 25550403 Volume: 575. https://www.scopus.com/pages/publications/85212848932
42. M. Medetov, D. Musaev, U. Shakarbaev, A. Yusupova, J. Tajibaeva, A. Reymov, A. Yusupova, D. Bazarbaeva, B. Gulimbetov. Insect fauna of the Republic of Uzbekistan: Rare true bugs (Hemiptera, Heteroptera). Regulatory Mechanisms in Biosystems ISSN: 25198521 Volume: 15 Issue: 4 Pages: 882 – 888. https://www.scopus.com/pages/publications/85218798691
43. Kurbaniyazov R.K., Khudoyberdiev J.H., Reymov A.M., Namazov Sh.S., Radjapov R., Seytnazarov A.R. Characteristics of nodular phosphorites of karakalpakstan and their processing into granular simple superphosphate. ChemChemTech ISSN: 05792991 Volume: 68 Issue: 1 Pages: 109 – 119. https://www.scopus.com/pages/publications/85211354040?origin=resultslist
44. M.ZH.Medetov, J.K.Abdullaeva, A.M. Reymov, A.M.Miratdinova, A.K.Seytmuratov, J.D.Tajibaeva, R.S.Kadirov, N.A.Utemuratov, S.K.Kimyonazarov, J. Kudratov, R.S.Urazova, X.X.Keldiyova, U.B.Uralov. Diversity of true bugs (Hemiptera: Heteroptera) of the Southern Aral Sea Region, Uzbekistan. Biodiversitas ISSN:

1412033X Volume: 26 Issue: 7 Pages: 3125 – 3135. https://www.scopus.com/pages/publications/105014219940?origin=resultslist
45. Ulugbek Urinov, Nilufar Hamidova and Ilhom Mirzakulov . Chemical technology of oligomers production from homopolymer based on epichlorohydrin and morpholine. E3S Web of Conferences 497, 03030 (2024) ICECAE 2024. https://doi.org/10.1051/e3sconf/202449703030
46. Bakhtiyor, K., Gafurov, B., Mamatkulov, A., Shayimov, F., Tukhtaev, B. AIP Conference Proceedings, 3331(1), 080001. https://doi.org/10.1063/5.0306044
47. Khusanov, B., Keunimjaeva, A., Jalelova, M., Rustamov, S. AIP Conference ProceedingsOpen source preview, 2024, 3152(1), 030024. https://doi.org/10.1063/5.0218924
48. Khusanov, B., Arzuova, S., Radjapov, Z., Babaev, O. AIP Conference ProceedingsOpen source preview, 2024, 3152(1), 030028. https://doi.org/10.1063/5.0219241
49. Urishev, B., F. Artikbekova, D. Kuvvatov, F. Nosirov, and U. Kuvatov. 2022. "Trajectory of Sediment Deposition at the Bottom of Water Intake Structures of Pumping Stations." IOP Conference Series: Materials Science and Engineering, 1030(1). https://doi.org/10.1088/1757-899X/1030/1/012137
50. Nosirov, Fakhriddin, Abdurasul Juraev, Ibragim Khamdamov, and Nurmukhammed Kuvatov. 2023. "Economic Calculation of a Photoelectric Station for Degradation Processes." AIP Conference Proceedings. https://doi.org/10.1063/5.0130642
51. Nosirov, Fakhriddin, Oleg Glovatsky, Bekzod Khamdamov, and Armen Gazaryan. 2023. "Increasing the Stability of the Supply Hydraulic Structures." AIP Conference Proceedings. https://doi.org/10.1063/5.0218867