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Analysis of methods for generating electricity from secondary energy resources

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Analysis of methods for generating electricity from secondary energy resources

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Abstract. This article explores several ways to extract electrical energy from ionization processes that are produced in different homogeneous concentrated environments as a secondary energy resource. The principles of operation of existing methods as well as the applications of these methods have been researched. Bipolar membrane reverse electrodialysis method, reverse electrodialysis method, is an electrical potential generation formula of pressure-slowed osmosis methods used in obtaining electrical energy. as well as the principle of operation is analyzed. This study aims to identify and compare the existing methods and methodologies of energy harvesting, and is an effective technology for the application of these methods in large volumes of fresh and salty liquids. The proposed technology involves the experimental electrolysis processes and the determination of the output of different results at different concentrations of solutions.

INTRODUCTION

As a result of the analysis of electricity consumption in today's mining enterprises, the need for electrical energy is increasing. As well as the fact that Comm enterprises are located far from the electric power plant, it is necessary to study other methods of production of electricity, namely the use of secondary energy resources (IERS), as well as to conduct scientific research. Currently, 3 large groups can be cited as secondary energy resources that we can see in Figure 1 below.[1-9]

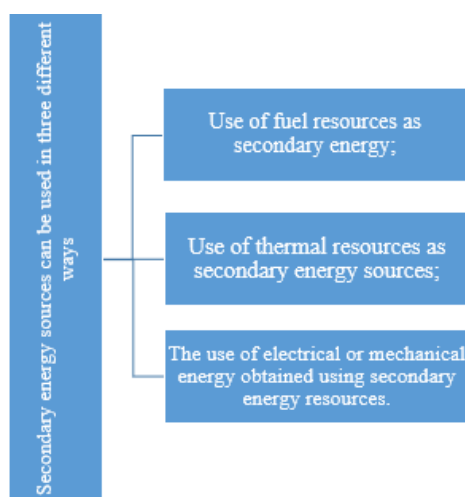


FIGURE 1. Schematic diagram of the directions of using their IERS

It can be seen from this that the fuel energy is the re-use of heat from the smoke and ash of the burned fuel. as well as heat resources as heat-permeable materials, taking heat in a state that has used the properties of heat and reuse [10-15]. The possibility of using electricity and mechanical energy in the case of using IER resources, that is, the methods of obtaining and using electricity using electrolysis processes from liquids, alkalis, acids, brine of various concentrations used are widely used in the world and research is being carried out [16-20]. Such methods are common in the world:

1. bipolar membrane reverse electrodialysis method;
2. reverse electrodialysis method;
3. The possibility of using electric

EXPERIMENTAL RESEARCH

These methods are considered to be significant in obtaining electricity in low-concentration acidic mixtures, both in alkaline and in waters with low salinity.

The bipolar membrane reverse electrodialysis method is an electrochemical technology that generates an electrical voltage using the energy of the uneven distribution of ions between two solutions with different salt concentrations (e.g. salt and fresh water). Can be used primarily to generate electricity using neutralization, representing an effective way to reuse waste. The bipolar membrane consists of two layers:

- Cation exchanger layer-transfers only positively charged ions (Na^+ , K^+);
- Anion exchanger layer- only transfers negative ions (Cl^- , SO_4^{2-});



As a result, the total ion flow through the membrane increases, the electro-chemical potential of the system increases. Under the influence of an electric field, the degree of ionization increases sharply and increases the potential field. This method involves several processes in which electrical energy coagulation depends on the concentration gradient between salt and fresh water's a result, the total ion flow through the membrane increases, the electro-chemical potential of the system increases. Under the influence of an electric field, the degree of ionization increases sharply and increases the potential field [27-56]. This method involves several processes in which electrical energy coagulation depends on the concentration gradient between salt and fresh water. The waters pass through alternately located chambers, which are successively crossed by the anionic alternating layer – the cationic alternating layer – the bipolar membrane layers, and separated by their membranes. Concentration abundance and gradient force ions into the mortar and natural diffusion occurs due to the abundance of ions in the saline solution and the scarcity of ions in the fresh water. This diffusion is regulated by the layers in the membranes. For example, the anion layer of the membrane transports ions such as Cl^- . The exchange layer is Na^+ . The main bipolar membranes produce additional ions by splitting water into H^+ and H^- .

The reverse electrodialysis method is a membrane electrochemical process in which electricity is produced using the natural diffusion energy of ions between two solutions where the concentration of salts varies dramatically. Salt water ions tend to migrate to fresh water. When the chemical energy hidden in their migration is converted into orderly motion through membranes, an electric current is generated. The physicochemical nature of the reverse electrodialysis method is that the difference in ion concentration based on the Nernst equation produces a potential in the galvanic element [21-26].

The Nernst equation shows the Relativistic voltage value generated in Oracle electrodes (electrically conducting force as source), and its representation has the following representation:

$$\xi = \frac{R \cdot T}{z \cdot F} \ln \frac{C_{\text{tuzli}}}{C_{\text{chchuk}}} \quad (2)$$

where: R – is the universal Gas Constant ($R = 8.31 \text{ J}/(\text{mol} \cdot \text{K})$), T – is the absolute temperature of the liquid, z – is the number of charges of the ions, F - Faraday constant ($F = 96485 \text{ C/mol}$), $\frac{C_{\text{saline}}}{C_{\text{rat}}}$ – is the ratio of concentrations of salt water and fresh water.

RESEARCH RESULTS

This method is similar to the bipolar membrane method but does not have a bipolar membrane in the middle. The principle of operation is the same. These methods are compared to the main parameters in Table 1 below.

TABLE 1. Comparison table of bipolar membrane method and reverse electro dialysis methods

Indications	Reverse electro dialysis method	Bipolar membrane electro dialysis method
Voltage	Medial	2-3 times higher
PH stability	Weak	Strong
Water decomposition	No	Boron (H^+ and OH^- are formed)
Energy efficiency	Medial	High
Acid/base formation	No	Available

The pressure-slowed osmosis method is a technology that draws energy from the osmotic pressure difference between two solutions of different concentrations. It is also called "blue energy", meaning that it is one of the sources of electricity and can be used where sea and river water mix. It is used by separation through a semi-permeable membrane. According to the law of the nature of osmosis: fresh water moves towards the saline solution. During this transition period, osmotic flow occurs. If pressure is applied to the Salt side, the speed of water movement slows down — so the technology is called "pressure slowing". A special semi-permeable membrane is used in this process. Its function: to transfer only water molecules, not salt ions (Na^+ , Cl^-). As fresh water passes through the membrane, the volume of fluid on the Salt side increases, which increases the internal pressure. The energy of this watercourse is converted into hydraulic energy and electricity is generated from turbines' pressure is applied to the Salt side, the speed of water movement slows down pressure.

$$\pi - P \quad (3)$$

where π is the osmotic pressure, P is the external pressure.

If $\pi < P$ continues the flow of water and an Energia is obtained. In this method, fresh water moves through the membrane towards the salt water. Then, as the volume increases on the salt water side, the hydraulic pressure force becomes hazel. The generation of electrical energy is in the following sequence. Current energy $\rightarrow$ mechanical energy $\rightarrow$ electrical generator $\rightarrow$ electrical energy. Also on the osmotic energy $\rightarrow$ hydraulic pressure $\rightarrow$ electrical energy chain $\pi < P$ continues the flow of water and an Energia is obtained. A.

$$\pi = iMRT \quad (4)$$

where i is the Vant Hoff coefficient, M is the molar concentration of the solution. There is also a lot of electricity if the osmotic pressure is large.

CONCLUSIONS

From the above, the initial data was presented in the form of a table (in Table 2) and the main parameters of each method were compared.

TABLE 2. Comparison table of methods for obtaining electricity from IER

Parameters	Pressure-retarded osmosis method	Reverse electro dialysis method	Bipolar membrane reverse electro dialysis method
The main source of energy	Osmotic pressure difference $\rightarrow$ hydraulic pressure	Salt concentration difference $\rightarrow$ ion migration	Salt difference + energy of water dissociation through a bipolar membrane
Membrane type	Semi-permeable, only water passes through	AEM va CEM ion selective membrane alar	AEM + CEM + BPM (bipolyare Membran)
Ionenlernen roli	Salzionen passieren die Membran nicht, nur Wasser passiert sie	Ionen passieren ordentlich	H^+ - und OH^- Additivausbeuten
Art der erzeugten Energie	Hydraulikdruck $\rightarrow$ Turbine $\rightarrow$ elektrische Energie	Elektrochemisches Potential $\rightarrow$ direkte elektrische Energie	Erhöhtes elektrochemisches Potential $\rightarrow$ Hochspannung
Steuerelemente	Pump, Hydraulic block	Electrode, Membrane module	Electrodes + bipolar membrane elements
Analogon des natürlichen Prozesses	Osmosis	Ion diffusion	Ion dissosiasiyasi + diffuziya

Thus, using the methods described above, the bipolar membrane reverse electro dialysis method, based on the methods used to obtain electric Energia from the IERS, is a more efficient method.

In this case, the extraction of electricity from alkaline low-concentration acidic saline mixtures showed important ways in the production of electricity in mining enterprises.

REFERENCES

1. Khasan Murodov and Askarbek Karshibayev, Development of the management system of technical indications of high-power charger-discharger rectifier device. // E3S Web Conf. Volume 417, 2023 III International Conference on Geotechnology, Mining and Rational Use of Natural Resources (GEOTECH-2023).
2. M. Ufert, B. Bäker, Battery Ageing as Part of the System Design of Battery Electric Urban Bus Fleets. // Ufert M., Bäker B. (2020) Battery Ageing as Part of the System Design of Battery Electric Urban Bus Fleets. Science and Technique. 19 (1), 12–19.
3. Gurreri, L.; Cipollina, A.; Tamburini, A.; Micale, G. Electrodialysis for wastewater treatment—Part II: Industrial effluents. In Current Trends and Future Developments in Bio-Membranes: Membrane Technology for Water and Wastewater Treatment—Advances and Emerging Processes; Basile, A., Comite, A., Eds.; Elsevier: Amsterdam, The Netherlands, 2020; pp.
4. Andrea Zaffora, Andrea Culcasi, Luigi Gurreri, Alessandro Cosenza, Alessandro Tamburini *, Monica Santamaria and Giorgio Micale Energy Harvesting by Waste Acid/Base Neutralization via Bipolar Membrane Reverse Electrodialysis Article in Energies · October 2020
5. Khasan Murodov, Askarbek Karshibayev, and Shukhrat Abdullayev, Analysis of the process of balanced charging of the battery group with high capacity, E3S Web of Conferences **548**, 03012 (2024) <https://doi.org/10.1051/e3sconf/202454803012>
6. A. S. Zhuraev, S. A. Turdiyev, S. T. Jurayev, and S.S. Q. Salimova, "Characteristics of packing gland seals in hydraulic systems of quarry excavators and results of comparative analysis of experimental tests," Vibroengineering Procedia, Vol. 54, pp. 252–257, Apr. 2024, <https://doi.org/10.21595/vp.2024.24051>
7. Akbar Zhuraev, Sardorjon Turdiyev; Analyses and studies of working fluid flow in the hydraulic system of hydraulic excavators at the Auminzo-Amantaytau open pit mine. AIP Conf. Proc. 4 November 2025; 3331 (1): 030067. <https://doi.org/10.1063/5.0305703>
8. Mislibaev I.T., Makhmudov A.M., Makhmudov Sh.A. Theoretical generalisation of functioning modes and modelling of operational indicators of excavators. // Mining information-analytical bulletin. - 2021. №1. p. 102-110. DOI: 10.25018/0236-1493-2021-1-0-102-110
9. Makhmudov Sh, Makhmudov A, Khudojberdiev L, Izzat Rakhmonov, "Criteria for assessing the performance of mining and transport equipment of mining enterprises," Proc. SPIE 12986, Third International Scientific and Practical Symposium on Materials Science and Technology (MST-III 2023), 129860P (19 January 2024); doi: 10.1117/12.3017722
10. Atakulov L.N., Haydarov Sh.B., Polvonov N.O. Impact forces on side and middle rollers. SPIE 12986, Third International Scientific and Practical Symposium on Materials Science and Technology (MST-III 2023), 129860Q (19 January 2024); doi: 10.1117/12.3017724
11. Atakulov L.N., Kakharov S.K., Khaidarov S.B. Selection of optimal jointing method for rubber conveyor belts. Gornyl Zhurnal, 2018. (9), 97-100. DOI:10.17580/gzh.2018.09.16
12. O.Jumaev, M. Ismoilov, D. Rahmatov, A. Qalandarov, Enhancing abrasion resistance testing for linoleum and rubber products: A proposal for improved device operation, E3S Web of Conferences 525, 05012 (2024) <https://doi.org/10.1051/e3sconf/202452505012>
13. Ataulayev N.O., Muxammadov B.Q., Idieva A.A., Research of dynamic characteristics of magnetic modulation current converter with negative feedback // International Journal of Advanced Research in Science, Engineering and Technology, India, 2020, November, Vol. 7, Issue 11. – P. 15749-15752. http://www.ijarset.com/volume-7-issue-11.html?utm_source=chatgpt.com
14. N. Ataulayev, 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>
15. Shirinov S.G., J.S. Olimov, I.Z. Jumayev, M.K. Sayidov Analysis of patterns of electricity consumption in mining and processing enterprises. Vibroeng. Procedia 2024, 54, 308–313. <https://doi.org/10.21595/vp.2024.24073>
16. Jumayev, Z.I., Karshibayev, A.I., Sayidov, M.K., & Shirinov, S.G. Analysis of climate-meteorological and technological factors affecting electricity consumption of mining enterprises. Vibroengineering Procedia, Vol. 54, pp. 293-299 (Apr. 4 2024). <https://doi.org/10.21595/vp.2024.24047>

17. Amirov S.F., Ataullayev N.O., Ataullayev A.O., Muxammadov A.O., Majidov B.Q., A.U. Methods for reducing the temperature components of magnetomodulation DC converter errors. *E3S Web of Conferences*, **417**, 03011 (2023). <https://doi.org/10.1051/e3sconf/202341703011>
18. Amirov S.F., Ataullayev A.O., Sayidov M.K., Togayev I.B. Methods of reduction of interference signals in electromagnetic conductors that measure fluid flow *Journal of Physics: Conference Series*, 2094(5), 052053 (2021) <https://doi.org/10.1088/1742-6596/2094/5/052053>
19. Olimov J., Ramazonov B., Sayfiyev S. Increasing efficiency of induction motor by predictive control system //E3S Web of Conferences. – EDP Sciences, 2024. – T. 525. – C. 03006. <https://doi.org/10.1051/e3sconf/202452503006>
20. 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>
21. Sultan F. Amirov, Nodir O. Ataullayev, Amin O. Ataullayev, Bobur Q. Muxammadov, and Ahror U. Majidov, Methods for reducing the temperature components of magnetomodulation DC converters errors, *E3S Web of Conferences* **417**, 03011 (2023) GEOTECH-2023 <https://doi.org/10.1051/e3sconf/202341703011>
22. Raximov, F., Taslimov, A., Majidov, A., & Norqulov, A. (2024). Optimization of losses by switching to higher voltage in distribution networks. In *E3S Web of Conferences (Vol. 525, p. 03009)*. EDP Sciences. <https://doi.org/10.1051/e3sconf/202452503009>
23. Boboqulov J., Narzullayev B, Development of a model for diagnosing rotor conditions in the parallel connection of synchronous generators with the network, *E3S Web of Conferences*. – EDP Sciences, 2024. – T. **525**. – C. 06001. <https://doi.org/10.1051/e3sconf/202452506001>
24. Narzullayev B. S., Eshmirzaev M. A, Causes of the appearance of current waves in high voltage electric arc furnaces, and methods of their reduction, *E3S Web of Conferences*. – EDP Sciences, 2023. – T. **417**. – C. 03003. <https://doi.org/10.1051/e3sconf/202341703003>
25. 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>
26. 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>
27. Melikuziev M.V., Fayzrakhmanova Z., Akhmedov A., Kasimova G. Development of an Educational Simulator's Working Logic for the Course 'Fundamentals of Power Supply'. *AIP Conference Proceedings* 3152, 050025 (2024). <https://doi.org/10.1063/5.0218875>
28. Melikuziev M.V., Nematov L.A., Novikov A.N., Baymuratov K.K. Technical and economic analysis of parameters of city distribution electric network up to 1000 V. *E3S Web of Conferences* 289, 07016 (2021) *Energy Systems Research*. <https://doi.org/10.1051/e3sconf/202128907016>
29. L.Jing, J.Guo, T.Feng, L.Han, Z.Zhou and M.Melikuziev, "Research on Energy Optimization Scheduling Methods for Systems with Multiple Microgrids in Urban Areas," 2024 IEEE 4th International Conference on Digital Twins and Parallel Intelligence (DTPI), Wuhan, China, 2024, pp. 706-711, <https://ieeexplore.ieee.org/abstract/document/10778839>
30. Shukhrat Umarov, Murot Tulyaganov. Peculiarities of simulation of steady modes of valve converters with periodic power circuit structure. III International Scientific and Technical Conference "Actual Issues of Power Supply Systems" (ICAIPSS2023). *AIP Conf. Proc.* 3152, 050004-1–050004-7; <https://doi.org/10.1063/5.0218869>
31. Murot Tulyaganov, Shukhrat Umarov. Improving the energy and operational efficiency of an asynchronous electric drive. III International Scientific and Technical Conference "Actual Issues of Power Supply Systems" (ICAIPSS2023); <https://doi.org/10.1063/5.0218876>
32. Shukhrat Umarov, Khushnud Sapaev, Islambek Abdullabekov. The Implicit Formulas of Numerical Integration Digital Models of Nonlinear Transformers. *AIP Conf. Proc.* 3331, 030105 (2025); <https://doi.org/10.1063/5.0305793>
33. Shukhrat Umarov, Murat Tulyaganov, Saidamir Oripov, Ubaydulla Boqijonov. Using a modified laplace transform to simulate valve converters with periodic topology. *AIP Conf. Proc.* 3331, 030104 (2025); <https://doi.org/10.1063/5.0305792>
34. Murat Tulyaganov, Shukhrat Umarov, Islambek Abdullabekov, Shakhnoza Sobirova. Optimization of modes of an asynchronous electric drive. *AIP Conf. Proc.* 3331, 030084 (2025); <https://doi.org/10.1063/5.0305786>
35. Islambek Abdullabekov, Murakam Mirsaidov, Shukhrat Umarov, Murot Tulyaganov, Saidamir Oripov. Optimizing energy efficiency in water pumping stations: A case study of the Chilonzor water distribution facility; *AIP Conf. Proc.* 3331, 030107 (2025); <https://doi.org/10.1063/5.0305780>

36. Kobilov, N., Khamidov, B., Rakhmatov, K., Abdurakimov, M., Daminov, O., Shukurov, A., Kodirov, S., Omonov, S. Investigation and study of oil sludge of oil refinery company in Uzbekistan. AIP Conference Proceedings, 3304, **040076**, (2025), <https://doi.org/10.1063/5.0269039>
37. Kobilov, N., Khamidov, B., Rakhmatov, K., Daminov, O., Ganieva, S., Shukurov, A., Kodirov, S., Omonov, S. Development of effective chemicals for drilling fluid based on local and raw materials of Uzbekistan. AIP Conference Proceedings, 3304, **040077**, (2025), <https://doi.org/10.1063/5.0269403>
38. Umerov, F., Daminov, O., Khakimov, J., Yangibaev, A., Asanov, S. Validation of performance indicators and theoretical aspects of the use of compressed natural gas (CNG) equipment as a main energy supply source on turbocharged internal combustion engines vehicles. AIP Conference Proceedings, 3152, **030017**, (2024), <https://doi.org/10.1063/5.0219381>
39. Matmurodov, F.M., Daminov, O.O., Sobirov, B.Sh., Abdurakmanova, M.M., Atakhanov, F.U.M. Dynamic simulation of force loading of drives of mobile power facilities with variable external resistance. E3s Web of Conferences, 486, **03001**, (2024), <https://doi.org/10.1051/e3sconf/202448603001>
40. Musabekov, Z., Daminov, O., Ismatov, A. Structural solutions of the supercharged engine in the output and input system. E3s Web of Conferences, 419, **01015**, (2023), <https://doi.org/10.1051/e3sconf/202341901015>
41. Musabekov, Z., Ergashev, B., Daminov, O., Khushnaev O., Kurbanov, A., Kukharonok, G. Efficiency and environmental indicators of diesel engine operation when using water injection. IOP Conference Series Earth and Environmental Science, 1142, **012024**, (2023), <https://doi.org/10.1088/1755-1315/1142/1/012024>
42. Tulaev, B.R., Musabekov, Z.E., Daminov, O.O., Khakimov, J.O. Application of Supercharged to Internal Combustion Engines and Increase Efficiency in Achieving High Environmental Standards. AIP Conference Proceedings, 2432, **030012**, (2022), <https://doi.org/10.1063/5.0090304>
43. Matmurodov, F., Yunusov, B., Khakimov, J., Daminov, O., Gapurov, B. Mathematical Modeling and Numerical Determination of Kinetic and Power Parameters of Loaded Power Mechanisms of a Combined Machine. AIP Conference Proceedings, 2432, **040013**, (2022), <https://doi.org/10.1063/5.0090304>
44. Ma'ruf, K., Tursoat, A., Dilnavoz, K., Bekmurodjon, R., Ra'no, A., Saida, T., ... & Toshbekov, B. (2025). ZnO Nanoparticles Incorporated on Multi-Walled Carbon Nanotubes as A Robust Heterogeneous Nano-catalyst for Biodiesel Production from Oil. Journal of Nanostructures, 15(3), 1050-1060.
45. Safarov J., Khujakulov A., Sultanova Sh., Khujakulov U., Sunil Verma. Research on energy efficient kinetics of drying raw material. // E3S Web of Conferences: Rudenko International Conference "Methodological problems in reliability study of large energy systems" (RSES 2020). Vol. 216, 2020. P.1-5. doi.org/10.1051/e3sconf/202021601093
46. Safarov J., Sultanova Sh., Dadayev G.T., Zulponov Sh.U. Influence of the structure of coolant flows on the temperature profile by phases in a water heating dryer. // IOP Conf. Series: Materials Science and Engineering. Dynamics of Technical Systems (DTS 2020). Vol.1029, 2021. №012019. P.1-11. doi:10.1088/1757-899X/1029/1/012019
47. Sultanova Sh.A., Artikov A.A., Masharipova Z.A., Abhijit Tarawade, Safarov J.E. Results of experiments conducted in a helio water heating convective drying plant. // International conference AEGIS-2021 «Agricultural Engineering and Green Infrastructure Solutions». IOP Conf. Series: Earth and Environmental Science 868 (2021) 012045. P.1-6. doi:10.1088/1755-1315/868/1/012045
48. Sultanova Sh., Safarov J., Usenov A., Samandarov D., Azimov T. Ultrasonic extraction and determination of flavonoids. XVII International scientific-technical conference "Dynamics of technical systems" (DTS-2021). AIP Conference Proceedings 2507, 050005. 2023. P.1-5. doi.org/10.1063/5.0110524
49. Saparov Dj.E., Sultonova S.A., Guven E.C., Samandarov D.I., Rakhimov A.M. Theoretical study of characteristics and mathematical model of convective drying of foods. // RSES 2023. E3S Web of Conferences 461, 01057 (2023). P.1-5. <https://doi.org/10.1051/e3sconf/202346101057>
50. Safarov J.E., Sultanova Sh.A., Dadayev G.T., Samandarov D.I. Method for drying fruits of rose hips. // International Journal of Innovative Technology and Exploring Engineering (Scopus). Volume-9, Issue-1, November, 2019. P.3765-3768. doi: 10.35940/ijitee.A4716.119119
51. Safarov J.E., Sultanova Sh.A., Dadayev G.T., Samandarov D.I. Method for the primary processing of silkworm cocoons (Bombyx mori). // International Journal of Innovative Technology and Exploring Engineering (Scopus). Volume-9, Issue-1, November, 2019. P.4562-4565. DOI: 10.35940/ijitee.A5089.119119
52. Sultanova Sh., Safarov J., Usenov A., Raxmanova T. Definitions of useful energy and temperature at the outlet of solar collectors. // E3S Web of Conferences: Rudenko International Conference "Methodological problems in reliability study of large energy systems" (RSES 2020). Vol. 216, 2020. P.1-5. doi.org/10.1051/e3sconf/202021601094

53. Usenov A.B., Sultanova Sh.A., Safarov J.E., Azimov A.T. Experimental-statistic modelling of temperature dependence of solubility in the extraction of ocimum basilicum plants. // International conference AEGIS-2021 «Agricultural Engineering and Green Infrastructure Solutions». IOP Conf. Series: Earth and Environmental Science 868 (2021) 012047. P.1-5. doi:10.1088/1755-1315/868/1/012047
54. Sultanova Sh.A., Safarov J.E., Usenov A.B., Muminova D. Analysis of the design of ultrasonic electronic generators. // Journal of Physics: Conference Series. International Conference "High-tech and Innovations in Research and Manufacturing" (HIRM 2021). 2176 (2022) 012007. doi:10.1088/1742-6596/2176/1/012007
55. Zulpanov Sh.U., Samandarov D.I., Dadayev G.T., Sultanova S.A., Safarov J.E. Research of the influence of mulberry silkworm cocoon structure on drying kinetics. // IOP Conf. Series: Earth and Environmental Science (AEGIS-2022). 1076 (2022) 012059. P.1-6. doi:10.1088/1755-1315/1076/1/012059
56. Tarawade A., Samandarov D.I., Azimov T.Dj., Sultanova Sh.A., Safarov J.E. Theoretical and experimental study of the drying process of mulberry fruits by infrared radiation. // IOP Conf. Series: Earth and Environmental Science (ETESD). 1112 (2022) 012098. P.1-9. doi:10.1088/1755-1315/1112/1/012098