Electrical load graphs and indicators

Rasulov *A.N.*[1], Ruzinazarov *M.R.*[1,]*

Tashkent State Technical University named by Islam Karimov, Tashkent, 100095, Uzbekistan

Abstract. The article provides methods for analyzing power consumption modes, discusses the main directions for improving the efficiency of economic incentives for the rational use of electricity with a tense energy balance during hours of maximum load of the power system and insufficient filling of the electrical load schedule at night, while improving the methods of economic regulation of accounting for electricity consumption, regulating electrical load schedules.

1 Introduction

It is advisable to plan and manage power consumption modes using and analyzing electrical load graphs. When developing the operating modes of the power system, the maximum load and active power balance, the total demand for electricity for the period under review, the expected change in load during the day, and a number of other factors are taken into account. Daily calculated load schedules allow to analyze the operating mode of electrical equipment of industrial enterprises for the past and subsequent periods of mode regulation, as well as to develop measures to optimize power consumption modes in the near future. Load schedules are used to determine the declared power during the hours of daily maximum load of the power system for the estimated period of planning and limiting power consumption [1, 2].

2 The current state of the investigated problem

In world practice, the study of the most important objects Graphs of electrical loads of industrial enterprises are characterized by a certain change in power consumption during the day. In this case, said change in load is determined by a base value, limited to those usually related to night time and zones of semi-peak and peak loads. These zones, respectively, refer to periods of low power consumption and to the hours of morning and evening load peaks.

The schedules of an enterprise with continuous production are determined by a fairly uniform power consumption during the day. Enterprises operating in one or two shifts have electrical load schedules that vary in their power consumption during the day. An analysis of the electrical load graphs of electrical industry enterprises shows their significant uneven power consumption during the day, exceeding in most cases the morning maximum load in relation to the evening one. At the same time, the time intervals of the morning and evening load maxima of the analyzed enterprises coincide with the maximum of the energy system [5-14].

As the main indicators of the daily schedules of the electrical load of industrial enterprises, which most fully characterize the dynamics of changes in the mode of power consumption, the following can be taken:

Load curve fill factor

$$K_3 = \frac{P_{cp}}{P_{мак.с}}$$

Coefficient of non-uniformity of the load curve

$$K_H = \frac{P_{\min.c}}{P_{мак.с}}$$

Maximum factor

$$K_M = \frac{P_{мак.с}}{P_{cp}}$$

Number of hours of use of the maximum active load

$$T_{мах} = \frac{W_r}{P_{мак}}$$

Where P_{cp}- the average load per day, kW; $P_{\min}$ f_0 c, P(мax.c)- respectively, the minimum and maximum load per day, kW; W_r- the amount of electricity consumed per year, kWh; P_{max}– annual maximum load, kW.

The problem of compacting the schedules of the electrical load of enterprises is of great economic

* Corresponding author: ruzinzarov88@bk.ru

importance for the consumers themselves, especially for the power system. Leveling the level of power consumption at the enterprise helps to improve the rhythm of production, the fullest load of technological and power equipment, greater consistency in the work of the main, procurement and auxiliary industries, improve planning [15-21].

Of exceptional importance is the regulation of power consumption in industrial enterprises contributes to the rational consumption of fuel for the generation of electricity, increase the level of operation and reliability of equipment at power plants.

In order to interest industrial enterprises in the greatest reduction in load during peak hours of the power system, it is envisaged, by mutual agreement between the power system and the enterprise, to set a power limit not for the entire period of passage of the maximum load, but for individual agreed hours of the specified period. In this case, consumers are used - regulators with a significant, more than 30%, power reduction [22-26].

Analysis of power consumption modes is carried out in a certain sequence.

The construction and analysis of load graphs and the determination of indicators of power consumption modes are carried out. In this case, the actual daily winter and summer load curves are used, obtained for the most characteristic periods of time, determined by various power consumption modes.

After constructing the load schedules, an analysis of the changes in these schedules is carried out both for individual production areas and for the enterprise as a whole.

The analysis of changes in the electrical load curves of enterprises in the electrical industry shows their significant density in all the main parameters that determine their formation. The load curves were characterized by pronounced daytime and evening load maxima for all the enterprises under consideration, both for the summer and winter periods. So, for example, for the summer schedule, the filling factor kz for the analyzed period varied from 0.39 to 0.75, and the number of hours of using the daily maximum load T max changed from 9.3 to 17.3%. For the winter period, k z in the range of 0.48 to 0.85 m T max from 11.6 to 16.84. At the same time, the main consumers that determine the formation of load schedules for the analyzed enterprises were energy-intensive installations: foundry installations, electrothermal furnaces and installations; installations of contact cooking; electroplating installations; compressor rooms for generating compressed air, ventilation units; aquifers [5, 27-29]

To fill the night period of reducing the load in the future, the issues of intensive introduction of robotics and automated production complexes are of great importance. The widespread introduction of "unmanned technology" will greatly contribute to increasing labor productivity, and the most effective regulation of power consumption modes, a significant reduction in the cost of generating electricity in power systems.

Variable calculations to determine the effectiveness of measures to regulate power consumption modes at industrial enterprises [7, 30-35] should be carried out taking into account that the understatement by the consumer of the declared capacity and the corresponding payment for the declared capacity during the peak hours of the power system can lead to a decrease in output during the specified period and the need to produce a large amount of products at other hours, i.e. equalities must be fulfilled:

$$nT = n_1(T - T_1) + n_2T_1 = na_1(T - T_1) + na_2T_1 \quad (1)$$

where nis the hourly production before changing the power consumption mode; n_1and n_2- respectively, the hourly output of products outside the zone of maximum load and during hours of maximum; T - the planned annual number of hours of operation of the enterprise; T_1- the duration of the enterprise during the period of maximum load of the power system; h, a_1- coefficient taking into account the increase in hourly output outside the zone of maximum load of the power system; a_2is a coefficient that takes into account the decrease in the hourly output of products by the consumer in the zone of the maximum load of the power system [4].

The annual economic effect of the consumer, taking into account the change in output and the specific consumption of electricity when operating in the zone of maximum load - the power system and the rest of the period is determined from the expression [30]

$$\begin{aligned} Э_Г &= a\Delta P + ny[T(1 - a_1b_1) + T(a_1b_1 - a_2b_2)] + n\omega[T(1 - a_1b_3) + \\ &+ T(a_1b_3 - a_2b_4)]\beta - \Delta K(E_4 + E_a) - \Delta\Phi \end{aligned} \quad (2)$$

Where ΔP_{is} the decrease in the enterprise's capacity during peak hours of the power system kW, γis the cost per unit of production (without the constant part and cost of electricity before changing the mode of power consumption; b_1,b_2are coefficients that take into account changes in the consumption of raw materials, materials per unit of output outside the zone of maximum load of the power system and in the zone T_1;b_3 b_4- coefficients taking into account the change in the specific consumption of electricity outside the zone of maximum load of the power system and in the zone T_1; ω- specific power consumption per unit of production before the implementation of adjustment measures; a - the main rate of the two-part tariff for 1 kW of the declared capacity sum / (kW * year); β–

additional payment for 1 kWh of electricity according to the established tariff, UZS/(kWh); ΔK- additional capital investments associated with a change in the mode of power consumption, soums, E_4- the standard coefficient of efficiency of capital allocations; E_a- coefficient of depreciation; ΔΦ- change in the wage fund in connection with the regulation of electricity consumption, soum.

After the transformation of expression (2), the effectiveness of the adjustment measures is determined by the inequality:

$$a > \frac{\Delta K(E_H + E_a) + \Delta \Phi}{\Delta P} + \frac{ny}{\Delta P}[T(a_1 b_1 - 1) + T_1 a_2 b_2 - a_1 b_1)] + \frac{n\omega}{\Delta P}[T(a_1 b_3 - 1) + T_1(a_2 b_4 - a_1 b_3)]\beta \quad (3)$$

When the load decreases during peak hours of the power system due to an increase in output during other hours, the total amount of output remains unchanged. In accordance with expression (1), the change in hourly output will be determined by the relationship between the coefficients a 1 and a 2 :

$$a_1 = \frac{T - a_1 T_1}{T - T_1}; \quad a_2 = \frac{T}{T_1} - a_2 \frac{T - T_1}{T - T_1} \quad (4)$$

3 Conclusion

Reducing the load during peak hours causes additional capital investments ΔK>0and an increase in the payroll of production personnel ΔΦ>0. But at the same time, the output is provided without increasing raw materials, materials and additional electricity, so the coefficients b 1 , b 2 , b 3 , b 4 will be equal to one and the annual economic effect will be determined by the expression [4 12]

$$Э_Г = a\Delta P$$

When the load is reduced during peak hours of the power system and the planned output is maintained, $Э_г$=0. the following condition will be met:

$$a = \frac{\Delta K(E_H + E_a) + \Delta \Phi}{\Delta P} \quad (5)$$

In this case, the enterprise does not receive the economic benefit from the load control enterprises. At the same time, their implementation is expedient for the energy system and the national economy as a whole.

References

1. Salnikov A.Kh., Shevchenko L.A. Rationing of consumption and economy of fuel and energy resources. M. Energoatomizdat, 1986.
2. Gordeev V.I. Regulation of the maximum load of industrial electrical networks. Moscow: Energoatomizdat, 1986.
3. Zykin F.A., Kakhanovich V.S. Measurements and accounting of electric energy. Moscow: Energoatomizdat, 1982.
4. Pospelov G.E. Electrical systems and circuits. G.E. Pospelov, V.T. Fedik, P.V. Pychev. Minsk: Technoprint, 2004. 720s.
5. Fursanov M.I. Determination and analysis of electricity losses in electrical networks of energy systems / M.I. Fursanov. - Minsk.: Belenergosberezhenie 2005. - 207p.
6. Golovkin P.I. Energy system and consumers of electrical energy. Moscow: Energoatomizdat, 1986.
7. Mikhailov V.V. Tariffs and modes of power consumption. Moscow: Energoatomizdat, 1986.
8. R Karimov, Study of Graphs of Reactive Power Consumption at Enterprises of the Republic of Uzbekistan (AIP Conference Proceedings, 2552, 050012, 2022). https://doi.org/10.1063/5.0111524.
9. S Dzhuraev, R Karimov and ofters, Study and Analysis of Power Quality in the Electrical Networks of the Outdoor Lighting of the Dushanbe City (2022 Conference of Russian Young Researchers in Electrical and Electronic Engineering (ElConRus), 2022), pp. 1166-1169,doi: 10.1109/ElConRus54750.2022.9755782.
10. A.N.Rasulov, M.R.Ruzinazarov, N.Toirova, T.Sh.Alibekova. Graphical-analytical method for constructing load characteristics // RSES 2020. E3S Web of Conferences. 216 (2020) 01171.https://doi.org/10.1051/e3sconf/202021601171
11. Rasulov, A.N., Ruzinazarov, M.R., Novikov, N.L., Aslanova, G.N., Esemuratova, S. Loading mode of a ferromagnetic current stabilizer. // RSES 2021. E3S Web of Conferences 289,07007. https://doi.org/10.1051/e3sconf/202128907007
12. Rasulov, A.N., Rafikova, G.R., Novikov, N.L., Ruzinazarov, M.R., Esemuratova, S. Graph-analytical method of load mode analysis of ferromagnetic current stabilizer. E3S Web of Conferences 289,07006.//RSES2021. https://doi.org/10.1051/e3sconf/202128907006
13. Rafikova, G.R., Ruzinazarov, M.R., Makhmutkhonov, S.K. Features stabilization of the consumer current using electro-ferromagnetic circuits. DOI: https://doi.org/10.1051/e3sconf/201913901075
14. 10.1088/1757-899X/883/1/012102

16. A.Taslimov, M.Melikuziev, O.Matchonov, M.Ruzinazarov and M.Nasirov. Development of standard cable cross-sections of rural electrical networks // Conmechydro – 2020. IOP Conf. Series: Materials Science and Engineering. 883 (2020) 012105.
doi:10.1088/1757-899X/883/1/012105.

17. Tuychiev F.N. Three-phase pole-changing winding for asynchronous machines on the fan drive // AIP Conference Proceedings 2552. 2023. PP, 030013, 1-8. https://doi.org/10.1063/5.0112349.

18. Hoshimov F.A., Rakhmonov I.U., Niyozov N.N., Omonov F.B. Main regularities of change in energy indicators of energy consuming facilities of industrial enterprises // AIP Conference Proceedings 2552. 2023. PP, 030025, 1-7. https://doi.org/10.1063/5.0112388.

19. Bobojanov M.K., Mahmutkhonov S.K., Aytbaev S. Investigation of the Problems Non-Sinusoidal of the Voltage Form // AIP Conference Proceedings 2552. 2023. PP, 05011, 1-6. https://doi.org/10.1063/5.0113890.

20. Rismukhamedov D.A., Tuychiev F.N., Shamsutdinov Kh. Development of pole-changing windings for two-speed motors of hoistingtransport mechanisms // AIP Conference Proceedings 2552. 2023. PP, 050013, 1-7. https://doi.org/10.1063/5.0114061.

21. Rasulov A.N. Method for calculating electro-ferro-magnetic circuits // AIP Conference Proceedings 2552. 2023. PP, 05017, 1-6. https://doi.org/10.1063/5.0111530.

22. Rasulov A.N., Usmonov E.G., Melikuziev M.V. Transformer-resonant circuit for battery charging // AIP Conference Proceedings 2552. 2023. PP, 050018, 1-6. https://doi.org/10.1063/5.0111530.

23. Usmonov E.G. Amplitude-phase Characteristics of the Resonant Circuit when Using it in the Control Circuit of Thyristors Voltage Stabilizers // AIP Conference Proceedings 2552. 2023. PP, 050020, 1-7. https://doi.org/10.1063/5.0111537.

24. Melikuziev M.V. Prospects for the introduction of intellectual systems in city electric networks // AIP Conference Proceedings 2552. 2023. PP, 050021, 1-6. https://doi.org/10.1063/5.0112395.

25. Rakhmonov I.U., Najimova A.M., and Reymov K.M. AIP Conference Proceedings **2647.** 030010. (2022). https://doi.org/10.1063/5.0104788

26. Taslimov A.D. Analysis of the stability of the total costs to the deviation of the network parameters from their optimal values // AIP Conference Proceedings 2552. 2023. PP, 050023, 1-6. https://doi.org/10.1063/5.0112398.

27. Saidkhodjaev A.G. Modern automatic technology of registrations and calculating electric loading // AIP Conference Proceedings 2552. 2023. PP, 050026, 1-5. https://doi.org/10.1063/5.0111540.

28. Bobojanov M.K. Development and Research of Two Speed Motor with Pole-Changing Winding // AIP Conference Proceedings 2552. 2023. PP, 050034, 1-9. https://doi.org/10.1063/5.0114077.

29. Saidkhodjaev A.G., Nuriddinova Kh.R. Reforming of Energy Sector of Uzbekistan: Transition to Market and Increasing Generation // AIP Conference Proceedings 2552. 2023. PP, 050037, 1-5. https://doi.org/10.1063/5.0133486.

30. Rakhmonov I.U., Najimova A.M. AIP Conference Proceedings **2647.** 030011. (2022). https://doi.org/10.1063/5.0104791

31. Rakhmonov I.U., Najimova, A.M., Esemuratova Sh.M., Koptileuov T.T. AIP Conference Proceedings **2647.** 070024. (2022). https://doi.org/10.1063/5.0104793

32. Hoshimov F.A., Rakhmonov I.U., Niyozov N.N., Omonov F.B. AIP Conference Proceedings **2647.** 030025. (2023). https://doi.org/10.1063/5.0112388

33. Rakhmonov I.U., Hoshimov F.A., Kurbonov N.N., Jalilova D.A. AIP Conference Proceedings **2647.** 050022. (2023). https://doi.org/10.1063/5.0112391

34. Rakhmonov I.U., Ushakov V.Ya., Niyozov N.N., Kurbonov N.N., Mamutov M. E3S Web of Conferences **289.** 07014. (2021). https://doi.org/10.1051/e3sconf/202128907014

35. Rakhmonov I.U., Ushakov V.Ya., Najimova A.M., Jalilova D.A., Omonov F.B. E3S Web of Conferences **289.** 07013. (2021). https://doi.org/10.1051/e3sconf/202128907013