Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Models and methods of optimization of electricity consumption control in industrial enterprises

To cite this article: A I Qarshibaev *et al* 2020 *J. Phys.: Conf. Ser.* **1679** 022074

Models and methods of optimization of electricity consumption control in industrial enterprises

A I Qarshibaev, B Sh Narzullaev and H Sh Murodov

Department of Electrical power engineering, Navoi State Mining Institute, Navoi, Uzbekistan

E-mail: murodov.xasan@inbox.ru

Abstract. This article examines the development of models for determining and regulating the value of active and reactive power based on the analysis of the state of normal operation introduced into the system by the enterprise at the highest loads of consumers. In contrast to the methods existing in practice, when the energy characteristics of consumers of electrical energy exceed the standard values, an optimal method for controlling the modes of consumption of electrical energy is proposed. As an example, the energy characteristics of technological electrical installations of the production workshops of the Navoi Machine-Building Plant are given, in order to control the modes of electricity consumption, to maintain the maximum and minimum values of the active and reactive power of consumers of electrical energy.

1. Introduction

At present, the automatic regulation of electricity consumption modes at industrial enterprises is one of the most pressing issues in the energy system. Industrial enterprises suffer not only from fines that are paid as a result of non-compliance with established standards for electricity consumption, but also as a result of the mandatory shutdown of technological equipment directly involved in the production process. Between the power system and industrial enterprises, based on the normal operating state at the highest load of consumers of electrical energy, the maximum half-hour (0.5 hour) power consumption ordered by the enterprise for the power system acts as the limit value. If during a quarter the maximum number of hours of operation of the electric power system exceeds 5% of the maximum, half-hour capacity of the enterprise's asset at the established rate, the enterprise pays an additional fee to the electric system [1]. In connection with the above, the problem arises of regulating the value of active and reactive power in order to determine the optimal value of the asset of the half-hour power of the proposed power system and not exceed its established norm. To prevent such circulation, it is necessary to create an information-logical scheme for controlling the modes of power consumption of technological electrical appliances of industrial enterprises, as well as to develop optimal methods and models of control.

2. Method

Information-logical diagrams allow studying methods of controlling power consumption modes of industrial enterprises, building mathematical models and performing the following functions of controlling power consumption modes:

- the task of regulating the half-hour capacity asset of the enterprise;
- the task of compiling normative tables of consumers of active power of a shop at industrial enterprises;
- the task of regulating the reactive power of the enterprise;
- the task of maintaining the voltage in the nodes of the electrical network of the enterprise within the established norms.
- the task of regulating the half-hour capacity asset of the enterprise;

$$\sum_{n=1}^{N} \mathrm{P}_n(f) - \sum_{m=1}^{M}\sum_{k=1}^{K_1} \mathrm{P}_{kl}(f)\,\mathrm{x}_{kl} \le P_c \quad (1)$$

here $P_n(f)$ – is the corresponding active power (n^{th} input, that is, the place of connection to the computer); $P_{kl}(f)$ – is first quarter number, k - ordinal number of years;
P_c – is limitation on the load of assets of industrial enterprises (at the time of normal operation, this value is taken as the equivalent of the current capacity in the power supply system).

If the amount of energy consumed by the consumer's electrical energy at industrial enterprises $\sum_{n=1}^{N} \mathrm{P}_n(f) - \sum_{m=1}^{M}\sum_{k=1}^{K_1} \mathrm{P}_{kl}(f)\,\mathrm{x}_{kl}$), P_c is less than or equal to the value, the volume of electrical energy consumed by the enterprise is less than or equal to the value, the volume of electrical energy consumed by the enterprise exceeds P_c normally, or vice versa, the volume of electrical energy consumed by the enterprise, exceeds the norm, or vice versa, the volume of electrical energy consumed by the enterprise exceeds.

Using the above formula (1), we will be able to regulate the maximum active half-hour power consumed by the enterprise by technologically electrical devices.

3. Result and discussion

A clear picture of the difference between the consumption of loads of an industrial enterprise and the regulatory limit of the capacity of an asset is shown in figure 1.

The red line in this graph represents the limited amount of active power in the contract between the Navoi machine-building plant and the electric grid, and the blue line is the cost of active power consumed in the standard of technological electrical devices in the machine-building workshop of the plant.

If the blue line crosses the red one, then the following relationship is obtained,

$$\sum_{n=1}^{N} \mathrm{P}_n(f) - \sum_{m=1}^{M}\sum_{k=1}^{K_1} \mathrm{P}_{kl}(f)\,\mathrm{x}_{kl} > P_c$$

an alarm is sent to alert the control computer.

The task of compiling normative tables of the main production active capacities of workshops that consume electrical energy at industrial enterprises;

The construction of normative tables of industrial enterprises' utilization is based on a broad retrospective material of electricity consumers. Regulatory charts are built on the basis of ensembles for the sale of active electric charges for electricity consumers over the past period (for a month or a quarter) [2,3,4]. If for the original ensemble there are no realizations that exceed the average value, then the value obtained for the average realization is taken as the standard. If there are realizations that exceed the average values, then these realizations are selected as characterizing the mode of irrational power consumption. The implementation of the results obtained after the average average is considered normative for the next period. Since the nature of loading tables depends on the day of the week, the latter are divided into groups depending on the degree of "proximity" of the loading tables. The mean square distance between the load curves is taken as a measure of proximity.

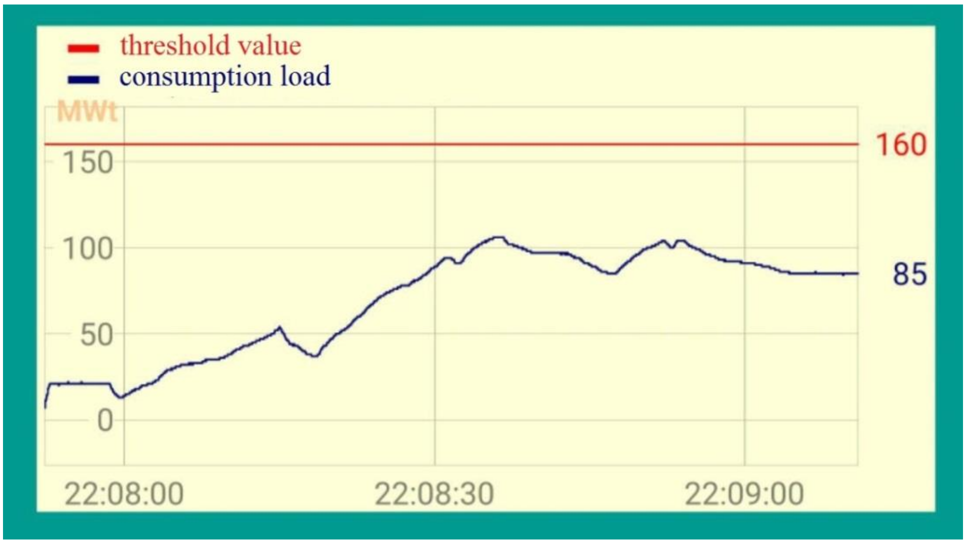

Figure 1. The normative limit of the capacity of assets taking into account the consumption of loads of industrial enterprises.

Based on the results of the analysis of power consumption modes of industrial enterprises, which have a discrete and discrete-continuous nature of production, it is possible to divide the days of the week into five groups according to the characteristics of power consumption: Monday; Tuesday; Wednesday; Thursday; Friday. Currently, the number of groups depends on the enterprises themselves (some enterprises have five days off, others have six days off). Figure 2 shows a cross-section of a standard asset charge table (thick line) of an enterprise, obtained by averaging five electrical charge applications (thin lines)[6,7].

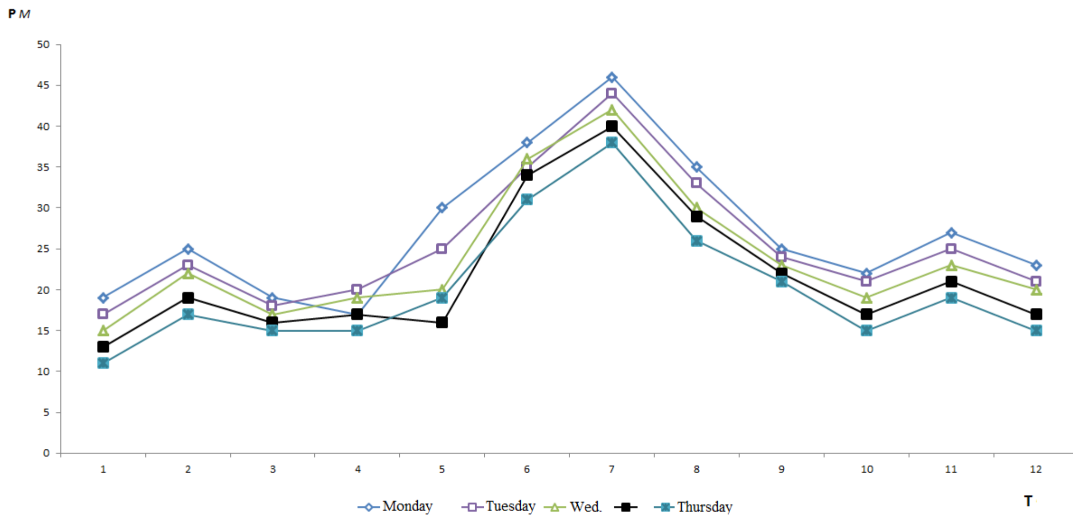

Figure 2. Normative standard scheme for loading assets of industrial enterprises.

If, when constructing a standard table of consumer loads of electricity, there is a significant discrepancy in the average statistical data, then the lower confidence limit of this table is used for making management decisions. Optimal control of active power consumption modes is achieved by maintaining the standard load of the tables established for them by the C_E of an industrial enterprise, as well as by performing the task of operational control of power consumption modes of industrial enterprises[8].

The task of regulating the reactive power of the enterprise;

$$Q_{min}(f) \leq \sum_{n=1}^{N}\left[Q_n(f) - \sum_{m=1}^{M_n} Q_m^{(n)}(f)c_{mn}\right] \leq Q_{max}(f) \quad (2)$$

here $Q_n(f)$ –is the corresponding reactive power of the enterprise (n-th input, that is, the place of connection to the computer

Q_{min} and Q_{max} – are the lowest and highest values of the daily reactive power of industrial enterprises;

$Q_m^{(n)}$ – is the reactive power of a high-voltage source installed at the main step-down substation of the enterprise;

n- is a part of the entrance;

m- is a section number connected to reactive energy;

m_n - is the total number of reactive energy source sections;

c_{mn} –is the network variable is equal to 1 if section m is included or otherwise, it is equal to 0.

If the value of reactive power consumed by industrial enterprises ($\sum_{n=1}^{N}\left[Q_n(f) - \sum_{m=1}^{M_n} Q_m^{(n)}(f)c_{mn}\right]$), is within the values of Q_{min} and Q_{max}, then the given half-hour maximum power of the enterprise is maintained, or rather, if the value of reactive power consumed by the enterprise is less than Q_{max} and more than Q_{min}. Here, the green line indicates the reactive power of the installation in normal operating condition, the red line - to the minimum the reactive power value in working condition, and the red line is at the maximum reactive power value in working condition[9].

If the green line passes below the red line or above the bard line, then an alarm will be sent to the control computer immediately.

A visual representation of the difference between the consumption of industrial enterprises of loads and the regulatory limit of reactive power is shown in figure 3.

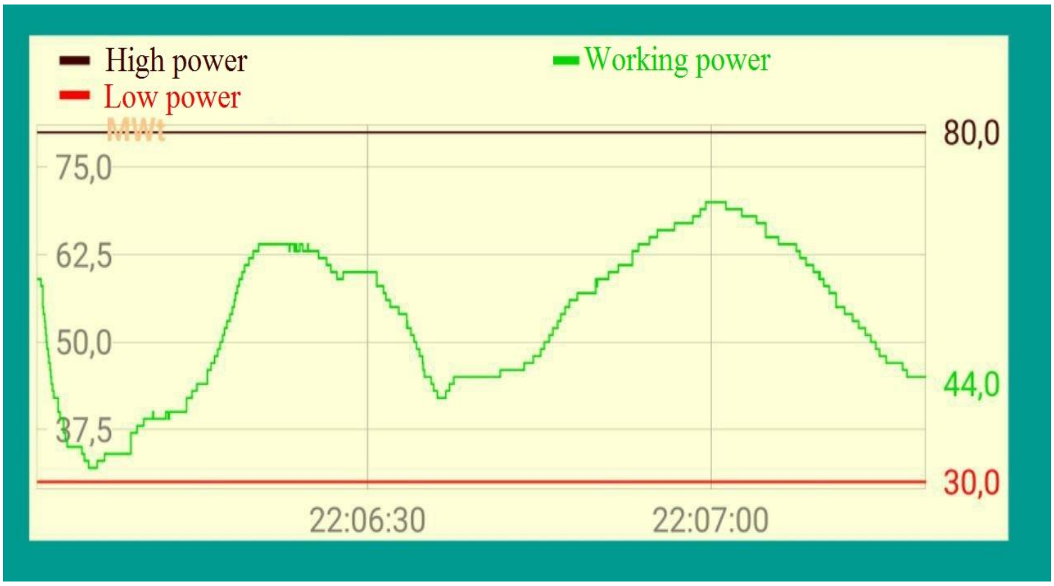

Figure 3. Regulatory limit of reactive power at consumption of loads by industrial enterprises.

The task of maintaining the voltage in the nodes of the power grid of the enterprise within the established norms.

$$U_{min} \leq U_y(f) \leq U_{max} \quad (3)$$

here U_{min} and U_{max} are the maximum and minimum voltage values that ensure the normal operation of electrical equipment;

$U_y(f)$ - is the voltage value at the point of connection of the reactive power source.

The voltage in electrical receivers of industrial enterprises should not exceed the permissible limits: Umax and Umin values established by regulatory enactments, and if the voltage exceeds these values, the company will incur heavy losses. The last method of maintaining the voltage at the nodes of the power grid of the enterprise within the permissible limits is due to the fact that the voltage value is strongly correlated with reactive power. In connection with the maintenance of voltages and their strong interdependence, it is desirable to carry out, within the framework of this task, the regulation of reactive power in the nodes of the electrical networks of the enterprise[10].

A visual representation of the fact that the voltage value consumed by technological electrical devices at industrial enterprises is within the range of maximum and minimum voltage values specified in regulatory documents, is shown in figure 4.

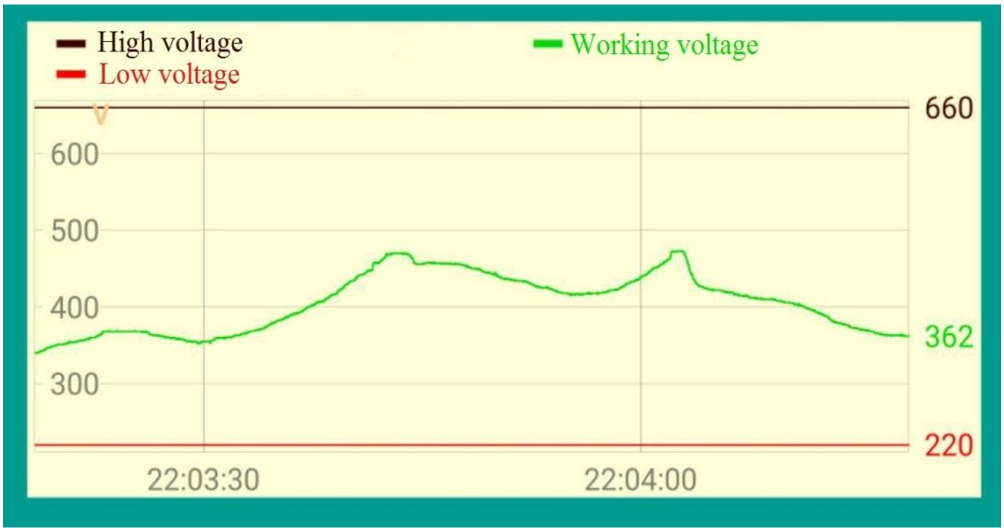

Figure 4. Voltage limit between the maximum and minimum values of the operating voltage of technological electrical devices in industrial plants.

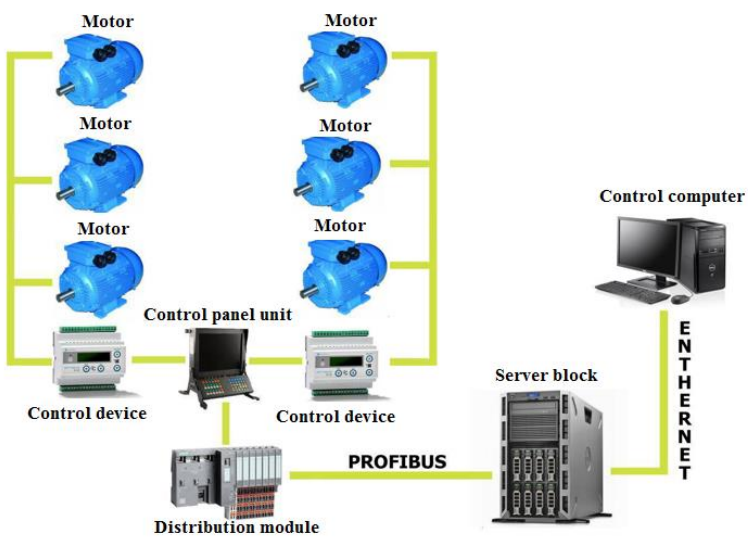

Figure 5. The structural diagram of the control model is based on the information-logical diagram of the energy consumption modes of industrial enterprises.

We use information and logical schemes, optimal control models and methods created to control the modes of consumption of electrical energy at industrial enterprises through computer programs.

The block diagram of the control model based on the information-logical diagram of the modes of electricity consumption by industrial enterprises is shown in figure 5.

We can regularly monitor technological electrical devices of industrial enterprises, the values of electrical parameters, as well as their energy characteristics, which we obtain above, in the control computer [5].

4. Conclusion

If we manage the operating modes of technological electrical devices operating at the Navoi machine-building plant, based on information-logical diagrams and introduce this control system into production as an optimal model for managing electricity consumption modes, then as a result we will be able to regularly monitor the operating modes of technological electrical devices working at the Navoi machine-building plant., this will allow you to quickly find solutions for managing the energy consumption profiles of the enterprise, as well as put loads on a more even schedule throughout the day, in addition, an increase in the efficiency of energy consumption profiles will be achieved.

References

[1] 2018 Resolution of the Cabinet of Ministers of the Republic of Uzbekistan *On additional measures to improve the procedure for the use of electricity and natural gas* **22**

[2] Ivaschenko V A, Rezchikov A F and Tyukhmatev V M 2004 Automation of operational control of power consumption at industrial enterprises *Mechatronics automation control: Tr. First All-Russia. scientific and technical conf. with int. participation* (M .: New technologies) p 426-8

[3] Tevyashev A D, Timofeeva T B and Smirnov A V 1999 Operational control of current distribution in electric power systems with a random nature of the load *Radioelectronics and Informatic* **3** 36-43

[4] Tyukhmatev V M 2005 Improving the efficiency of power consumption management at industrial *D 212.242.10 at GOU VPO Saratov State Technical University*

[5] Karshibaev A I, Narzullaev B Sh, and Rasulova B I 2020 Auxiliary management of the information-logical scheme of operating modes when using electricity at industrial enterprises *Mining Bulletin of Uzbekistan* **2(81)** 91-3

[6] Yusupbekov N, Abdurasulov F, Adilov F and Ivanyan A 2020 Application of advanced process control technologies for optimization of polymers production processes *Advances in Intelligent Systems and Computing* **1095** AISC

[7] Yusupbekov N, Adilov F and Ergashev F 2017 Development and improvement of systems of automation and management of technological processes and manufactures *Journal of Automation, Mobile Robotics and Intelligent Systems* **11(3)** DOI: 10.14313/JAMRIS_3-2017/28

[8] Yusupbekov N R, Gulyamov S M, Usmanova N B and Mirzaev D A 2017 Challenging the ways to determine the faults in software: Technique based on associative interconnections *Procedia Computer Science* **120** DOI: 10.S1016/j.procs.2017.11.290

[9] Jumaev O A, Ismoilov M T, Mahmudov G B and Shermurodova M F 2020 Algorithmic methods of increasing the accuracy of analog blocks of measuring systems J. *Phys.: Conf. Ser.* **1515** 052040

[10] Jumaev O A Sayfulin, R R, Samadov A R, Arziyev E I and Jumaboyev E O 2020 Digital control systems for asynchronous electrical drives with vector control principle *IOP Conf. Ser.: Mater. Sci. Eng.* **862** 032054