General characteristics of networks and features of electricity consumers in rural areas

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General characteristics of networks and features of electricity consumers in rural areas

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Abstract. In addition to the reliability of power supply quality of electricity consumers are one of the most important characteristics of the electrical systems. It has a significant impact on the efficiency of electrical receivers and the technical and economic performance electric networks. In the modern developed networks providing quality indicators of energy acceptable for consumers, requires significant cost of funds and materials, as well as the collection and processing of more information. This explains the importance of the questions of power quality in the complex problem of the design and operation of electrical systems. If the provision in the electrical systems normalized values of the frequency is mainly due to the balance of active capacity and characteristics of the appropriate equipment on the electrical stations, the quality of the voltage at the consumer is determined mainly by cost distribution networks. For consumer's rural areas referred to the costs are most of the total production costs and electricity transmission, so questions quality assurance voltage networks always were in the focus of research, design, and operational organizations. Particular attention these questions acquire at present in connection with the rapid growth of electricity consumption in agriculture and the relevant development of rural networks. The huge positive effect electrification to fully manifest only when consumers are delivered electricity is quite high quality. Reduction of the quality of significantly impairs performance electrical receivers and leads to marked electro receivers damage.

1. Introduction

In recent years, in our country and abroad increased research on the problem of quality assurance of electricity. An important role in the decision of this problem has approved by State standard 13190 – 97 "Norms of the quality of electrical energy in its receivers connected to the electric networks of general purpose". Improving the power quality and accounting of the factor in the design and operation of electricity requires consideration of many important aspects of factors influencing on the quality of energy assessment methods of its quality, the relationship quality indicators and efficiency, ways to improve the quality of energy and methods of their choice [2].

Under the electrical networks in rural areas understand the network passing on the countryside and supplying electric energy on the village, electrical systems for melioration and water management, the enterprise and organizations, asking for household and cultural tinning of the rural population, as well as other consumers, located in rural areas.

The purpose of this work is to study the quality of electric energy of consumers connected to General-purpose electric networks. Improving the quality of electricity and taking this factor into account in the design and operation of electric networks, factors that affect the quality of energy, methods for evaluating its quality, the relationship between quality and efficiency indicators, ways to improve the quality of energy, and methods for selecting them.
The research objective is:

1. Analysis of the state of rural electric networks electricity distribution system in rural areas.
2. Research of permissible limits of voltage deviations in consumers, justification of rational scales of standard sizes of equipment for voltage regulation, determination of the optimal combination of centralized and local control means.

The object of research is consumers of electric energy in rural areas.
The subject of research is the process of consumption and the characteristics of electricity.

2. Methods

The system power distribution in rural areas is formed on the basis of networks three types of:

1. Feeding, is used to power transmission from the tire district energy systems to the intermediate transformer substations. These networks consist of line power 110 or 35 kV and transformer substations with the voltage 110/35; 110/20; 110/10; 35/10 or 35/6 square meters.
2. Distribution Networks, the average voltage which includes distribution line voltage 35,20,10 and 6 kV and transformer substation 35/0.4; 20/0.4; 10/0.4 and 6/0.4 square meters.
3. Distribution Networks, a low voltage. They consist of a line voltage 0.38/0.22 kV and directly power the electrical receivers connected to them.

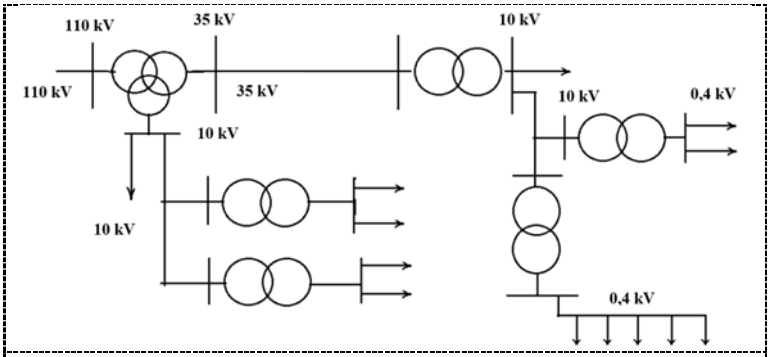

Figure 1. The scheme of three-stage power supply system rural areas

The differences electric networks rural areas of networks of industrial enterprises and cities are due to the main features of the distribution networks medium voltage that need to cover a large number of consumers relatively low power, scattered the vast territory.

Power supply rural areas are carried out by three-stage system power distribution 110/35/10/0.38 kV with three-stage of transformation. Voltage supply networks are 35 kV, and voltage distribution networks secondary voltage 10 kV (figure1).

In some areas are used and two-stage distribution system 110/35/0.38, 110/20/0.38 and 110/10/0.38 and the trend and improve the nominal voltage distribution networks technical and economically justified.

At the three-stage system 110/35/10/0.38 kV rated power supply of district transformer substation (DTS) voltage 35/10 kV determined by the economic considerations. Power supply the substation relatively small, and as a rule, do not exceed 4000 – 5000 kVA [3].

From the supply substations voltage 35/ 10 kV electric power is distributed exhaust линями 10kV, the number of which usually do not exceed five-six. Go to each of these lines attached to a few tens of lowering transformer substations (TS) voltage 10/0.4 square meters.

Located in the villages or near agricultural enterprises. The power of each TS is usually from 25 to 250 – 400 kVA.

Electrical receivers attached to the exhaust from the TS distribution lines 380/220kV. These lines carry out four-wire, with muffled grounded neutral. Single-phase Electrical receivers have rated voltage 220V and are included between the phase and zero- wire and three-phase electric motors include on a linear voltage 380.

From the electric networks in rural areas usually eats a large number of a variety of consumers who can be divided into the following groups:

a) houses in rural settlements and regional centers;
b) the hospital, schools, clubs, shops, bakery and other companies serving the population;
c) production consumers;
d) enterprise of different departments for processing agricultural products;
e) other consumers.

3. Results and Discussion

In particular, a group should be allocated agro-industrial complexes large enterprises for the production of rural economic products on an industrial basis. Schemes of power supply of these complexes of different from the schemes power supply in areas dispersed of agricultural load and close to the corresponding schemes for industrial enterprises. In spite of the variety of production Electrical receivers, they can be divided into two groups: осветительно- thermal devices and engines. Depending on the sizes and the production of the total power electrical receivers from a few kilowatts to a few hundred kilowatts. Chart production of consumers has a more complex configuration and depends on the type of enterprises, shift work, and other features of technological processes. As a rule graphics load of production enterprises has a day maximum [4].

The system distribution of electric energy in rural areas, as a rule, is formed on the basis of three types of networks. The first type of networks, which can be called supply networks (conditionally they can also be called high voltage networks), are used to transfer electricity from buses of district power systems to intermediate transformer substations These networks consist of 110 or 35 kV power lines and transformer substations with a voltage of 110/35; 110/20; 110/10; 35/10 or 35/6 kV.

Networks of the second type can conditionally be called medium-voltage distribution networks. They include distribution lines with voltage of 35, 20, 10 kV and transformer substations 35/0.4; 20/ 0.4; 10/0.4 and 6/0.4 kV.

Finally, the third type of network can be called low voltage distribution networks. They consist of lines with a voltage of, as a rule, 0.38/0.22 kV and directly power the electrical receivers connected to them.

The differences between the electric networks of rural areas and the networks of industrial enterprises and cities are mainly due to the characteristics of medium-voltage distribution networks, which should cover a large number of consumers of relatively low power, scattered over a vast territory.

On the main part of the inhabited territory of the Republican Republic, the rural power supply is carried out through a three-stage 110/36/10/0.38 kV power distribution system with three stages of transformation. The voltage of the supply networks is 35 kV, and the voltage of the distribution networks of medium voltage is 10 kV (Figure 1.1). This scheme is further considered in more detail.

In some areas, two-stage distribution systems of 110/35/0.38, 110/20/0.38, and 110/10 /0.38 kV are also used, and the tendency to increase the nominal voltage of distribution networks is technically and economically justified.

With a three-stage system of 110/35/10/0.38 kV, the nominal capacities of the feeding district transformer substations (RTS) of 35/10 kV are determined by economic considerations. They depend on the specific surface load of agricultural consumers dispersed in the food zone, as well as on the presence of a concentrated, usually non-agricultural load. If this latter is absent, the capacities of the supply substations are relatively small, and, as a rule, it exceeds 4000-5000 kVA.

From power substations with a voltage of 35/10 kV, electricity is distributed by 10 kV outgoing lipia, the number of which usually does not exceed five-six. To each of these lines are connected up to several dozens of step-down transformer substations (TS) with a voltage of 10 / 0.4 kV, located in rural settlements or near agricultural enterprises. The power of each transformer is usually comprised of 25 to 250-400 kVA.

Calculations show that more than half of the total rural electricity costs are the costs of medium and low voltage distribution lines. For economic reasons, these lines are usually filled by air. For such lines, over 70-80% of the cost is the cost of the construction part. Therefore, an effective way to reduce the cost of electricity supply in rural areas is to improve the methods of mechanical calculation of wires and supports, the use of conductive and building materials, which can reduce the cost of the construction part of the lines, as well as reduce their ethnic length by improving the scheme (configuration) [5].

The desire to reduce the length of distribution networks has led to their formation as branched radial networks. Such networks are known to have several features. Firstly, the current loads of the same line, for example, in the beginning, and the end are sharply different, which can lead to difficulties when performing sensitive protection of networks from short circuits. Secondly, the voltage values at different points of the network significantly differ from each other, which one of the main reasons is complicating the task of ensuring the proper voltage quality for consumers.

Another feature of branched radial networks is the appearance of additional difficulties in solving the problem of the reliability of power supply to consumers. As one of the means of increasing reliability, network redundancy is often used - the construction of ring bridges between 10 kV distribution lines, departing from the same or different supply substrates. In these cases, in emergency conditions, it is quite difficult to ensure an acceptable voltage quality since the wire cross-sections of the lines are usually selected according to loads of normal modes [6].

When designing another main element of distribution networks - consumer substations - they also strive for the greatest cost-effectiveness. Many years of operating experience has led to the use of a mast type open transformer substation with a single transformer in rural areas as a standard solution. The simplest electrical connections typical of these substations are stored in closed transformer substations as well as in complete transformer substations. Currently, all newly constructed and reconstructed substations, as a rule, are designed using commercially available complete transformer substations (CTS). The use of mast substations is allowed in some cases, taking into account the presence of timber, climatic conditions, etc.

Agricultural supply networks differ from similar networks in other energy sectors with relatively large transmitted capacities. This affects mainly the characteristics of the equipment required for the network. So, for example, on 35 kV overhead lines, due to the comparatively small cross-section of the wires, it is possible to mainly use four-pin insulators. Low power step-down transformers with a higher voltage of 110 kV, etc. are required.

Compared with non-agricultural networks in rural networks, wires of relatively small cross-sections and transformers of relatively lower power are often used as a substitute. For these network elements, the share of active resistance in total impedances is higher than in wires of a larger cross-section and in transformers of greater power. As a result, active power has a significant impact on voltage losses in networks, which must be taken into account when evaluating various means of improving voltage quality [7].

Electricity networks in rural areas usually feed a large number of diverse consumers, which can be divided into the following groups:

a) dwelling houses of employees in rural settlements and district centers;
b) hospitals, schools, clubs, shops, bakeries, laundries, other enterprises serving the population;
c) industrial consumers (livestock farms, grain cleaning centers, greenhouses, fruit storages, mills, garages, boiler houses, etc.);
d) enterprises "Selkhoztehnikik" and "Mezhkolkhozstroi", grain collection points and cotton-receiving enterprises of different departments for the processing of agricultural products (dairies, canneries, meat plants, etc.);
e) other consumers, including industrial enterprises, etc.

Depending on the size and volume of production, the total capacity of power receivers installed at agricultural facilities ranges from several kilowatts to several hundred kilowatts.

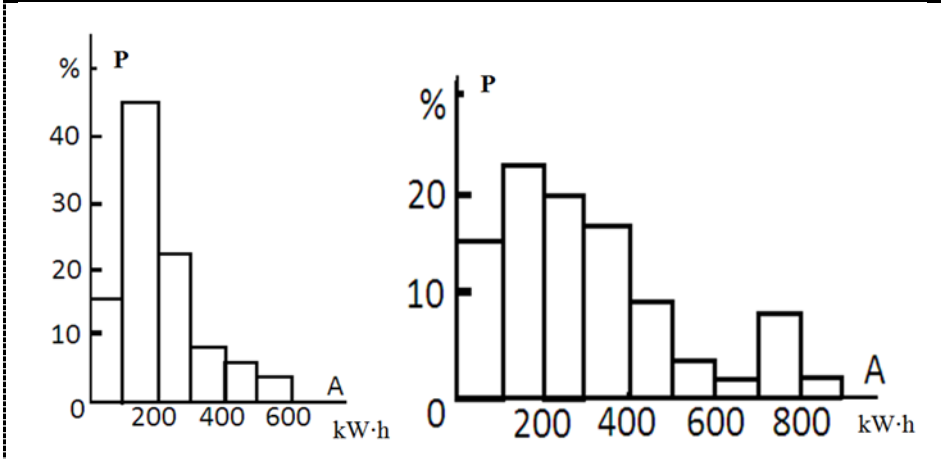

Figure 2. Distribution of the number of residential buildings n in a rural locality depending on the annual electricity consumption *A*

Moreover, the demand coefficients for active power are approximately 0.4-0.7, and for reactive power 0.1-0.3.

In addition to active and reactive loads, an important characteristic of industrial consumers is the maximum engine power used in various agricultural facilities.

Electric power supply to agricultural enterprises is sometimes carried out from a comparatively small capacity transformer substation, and therefore the start of engines with power 14-40 kW (especially under severe start-up conditions) can significantly degrade the quality of the voltage in the network [8, 9, 10, 11, 12].

Often in rural areas, residential houses, cultural institutions, and industrial consumers connect to the same TS. The capacities consumed by individual power consumers add up to a single load on the buses of the corresponding transformer substations and further in the 10 kV lines [13, 14, 15].

Table 1. Characteristics of electrical receivers

Electro-receiver	Amount	Amount Installed power units, kW	Load factor	Power consumption, kW	Reactive power kVt
Lighting devices	-	3.0	1	3.0	-
Grain screw	1	4.5	0.75	3.37	2.40
Telfer	1	0.6	0.75	0.45	0.48
Telfer	1	1.7	0.75	1.27	1.2
Crusher	1	16	0.6	9.6	7.2

Steamer-mixer	4	2.8	0.75	8.4	6.5
Pump	2	2.8	0.85	4.75	3.6
Fan	1	2.8	0.75	2.1	1.6

Table 2. Characteristics of electrical receivers on grain flow

Electro-receiver	Amount	Installed power units, kW	Load factor	Power consumption, kW	Reactive power, kVar
Loader	1	4.5	0.7	3.14	2.5
Loader	1	1.7	0.7	1.19	1.2
Semi-cleaning	4	4.5	0.7	12.6	9.4
Winding and sorting	2	4.5	0.75	6.74	4.7
Grain dryer	4	1.7	0.6	4.08	4.6
Noria	2	1.7	0.8	2.72	2.3
Noria	2	2.8	0.8	4.48	3.4
Conveyor	1	4.5	0.75	3.37	2.4
Conveyor	2	1.7	0.75	2.54	2.3

Table 3. Characteristics of electrical forge receivers

Electro-receiver	Amount	Installed power units, kW	Load factor	Power consumption, kW	Reactive power kV
Lighting devices	-	0.7	1	0.7	-
Hammer	1	7	0.4	2.81	3.3
Horn fan	1	1.7	0.7	1.19	1.2
Sharpening machine	1	1.7	1.4	0.4	0.7

In figure 3 shows the daily schedule of the active power line voltage 0.38 kV for the winter the working day. The chart has two of the maximum: morning in 7 – 94 and evening 18 – 21h.

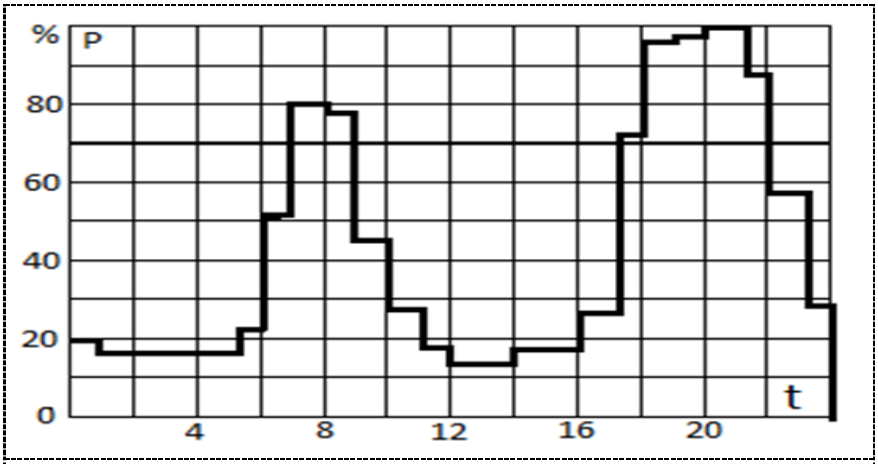

Figure 3. Daily schedule of the active power line voltage 0.38 kV

4. Conclusions

1. So often in rural areas to one in the same TS attached houses. Household institutions and industrial consumers. Power consumed by individual electric receivers are added into a single load on the tires the relevant TS and further in the lines 10 kV.

2. In connection with the growth of electricity consumption in agriculture and the corresponding increase in rural networks, they can be to form on three types of the first type- feeding (networks high voltage), the second type- distribution networks of the average voltage on 6, 10, 35kV, of the third type distribution networks low voltage 380/220V.

3. Charts municipal consumer loads have two distinct maximum determined by the capacity of lighting, the graphics load of production enterprises have a day maximum.

4. It is established that the provision of standardized indicators of electricity quality in the course of network operation requires the development and creation of appropriate systems for collecting and processing information. They should include a set of organizational and technical measures that determine how to obtain the necessary information, how to process and further use the information collected, technical means, qualifications and specialization of personnel, and others.

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