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PROSPECTS OF TRANSITION THE DISTRIBUTION NETWORKS OF UKRAINE TO NOMINAL VOLTAGE OF 20 KV

The paper is devoted to the solution of the important scientific-engineering problem, aimed at the increase of carrying capacity and reduction of electric energy losses in distribution electric networks of the Unified energy system of Ukraine. One of the ways of electric energy saving in electric networks is transition of distribution networks voltage of 6(10)kV at higher voltage level, in particular, 20kV. Application of 20kV voltage in the existing distribution networks enable to shift to higher level of energy supply of the consumers of the Ukraine, increase carrying capacity as compared with the existing networks within the limits of the same area, reduce technological losses, improve the quality of electric energy, energy safety and reliability of energy supply systems operation, considerably reduce energy dependence of the country.

Key words: *electric power system, distribution electric networks, energy saving, carrying capacity, power losses.*

Introduction

Before 2014 annual consumption of equivalent fuel in Ukraine was approximately 210 m of tons and it is referred to energy deficient countries: it imports 75% of the necessary volume of natural gas and 85% of crude oil and petroleum products. Low level of energy resources supply of Ukraine with its own resources could be explained by excessive wastefulness of its economy. Power consumption of Ukrainian gross domestic product (GDP) 2.6 times exceeds average level of power consumption of the developed countries of the world. The problem of energy resources saving nowadays becomes the problem of great importance, when energy independence equals virtually the state independence.

Nowadays distributive electric networks are in a very difficult state, it is stipulated by high level of physical and moral wear of electric installations, considerable losses of electric energy in the process of its transmission, low level of automation, etc. Growth of electric loadings often leads to technical limitations in existing networks. To provide supply of new consumers new lines are constructed, as a rule, parallel to existing lines. However, this does not always solve the problem of the supply of the consumers with the electric energy in needed amounts and quality.

National Commission of Ukraine, that performs state regulation in the sphere of power engineering, pays special attention to quality indices of services dealing with transmission and supply of electric energy that are characterized by the indices of average duration of disconnections (SAIDI) and average frequency of disconnections (SAIFI) in the network. Efficiency index of quality (SAIDI) for urban area was established to be 150 minutes, for rural area – 300 minutes. Analysis of quality indices of the companies in Ukraine shows that nowadays SAIDI index by an order exceeds normative indices. For the companies, that made a decision to pass to stimulating regulation, this means the necessity to reduce 5 times the average duration of energy supply interruptions during 10 years.

One of the promising ways of electric energy losses decrease in electric network is application of nominal voltage of 20kV instead of conventional 6kV and 10kV [1-5].

The aim of the research is investigation of the prospects of using the technologies of electric energy transmission at nominal voltage of 20kV in distributive electric grids of Ukraine.

Results of the research

The most developed countries of Europe realized the transition of 6-10 kV electric grid to 20kV voltage class in the second half of the 20th century. For instance, in France the transition of distribution electric grids to 20kV was realized as far back as in 1962. Nowadays electric grids of 20 kV operate in Austria, Germany, Italy, United States, Finland, France and other countries [2]. In the USSR, 20 kV electric grids were developed only on the territory of Baltic Republics. Today certain experience in the sphere of application of the technologies of electric energy transmission at 20 kV in distribution grids has Russian Federation. In Ukraine urban distribution grids, operating at 110 kV voltage, for which basic technological and circuit engineering solutions were formulated in the middle of the last century, are still developed. By the beginning of the 21st century they became inefficient, out-of-date and non-competitive. From the experience of the developed countries of Europe and taking into account historically formed approaches to the construction of distribution grids in our country, it is suggested to transfer the distribution grids from nominal voltage of 6-10 kV at 20 kV. And in future – transition from three-stage system of electric energy transmission and distribution (110-35-(6)10 kV) into two-stage (110-20 kV), as it is shown in Fig.1 [6].

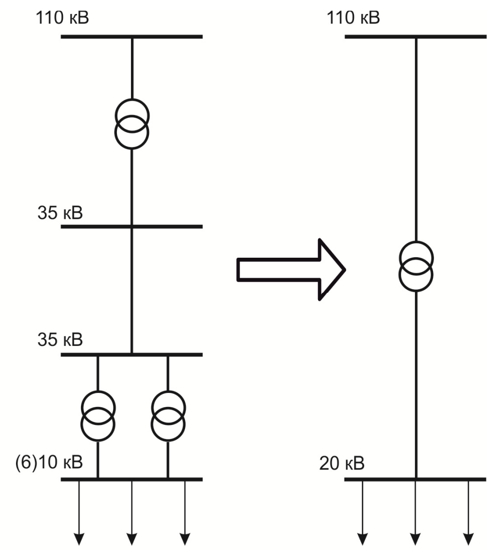

Fig 1. Illustration of the transition of electric energy distribution system from three-level into two-level.

As a matter of fact, realization of conventional complex reconstruction of the existing distribution grids of 6-10 kV with replacement of the equipment by more powerful one, does not allow to increase their carrying capacity and will not provide real economic effect, except the restoration of operation. That is why, as an optimal it is suggested to replace 6kV distribution networks that completed normative operation term by new 20 kV networks, and the next stage of realization – stage-by-stage replacement of 10 kV networks.

World experience of using the technologies of electric energy transmission at nominal voltage of 20 kV determines the following advantage as compared with 6-10 kV transmission lines [1, 3, 7]:

- greater carrying capacity of transmission lines at the same cross-section of wires ;
- reduction of technological expenditures of electric energy for its transmission;
- usage of new equipment (transformer substitutions, switch-gears) in the dimensions of the old equipment;
- decrease of the total length of 0.4 kV grids and losses in them by means of using mast poles КТП 20/0.4 kV;
- conservation of restricted areas of the over-head transmission lines;
- increase of the reliability of energy supply;
- off-loading of 6-10 kV switch gears of the existing substations and elimination of power shortage in supply centers;
- creation of power reserve for reliable energy supply of the consumers;
- improvement of quality indices of energy supply (SAIPI and SAIFI).

A number of obligatory conditions must be met for the transition to construction of 20 kV urban networks:

1. Actualization of the normative base, development of new national standards and technical regulations;
2. Availability in 110 kV supply centers power reserves on the level of 20 kV;
3. Development of 20 kV networks development concept on the territory of the specific city, realization of feasibility study, aimed at construction of corresponding electric grids;
4. Availability at the market of the equipment and cable products for rated voltage of 20 kV.

The problem of transition of electric networks on nominal voltage of 20 kV may be divided into two parts, each of them has separate approaches for the solution: transition of already existing 6 (10) kV networks at nominal voltage of 20 kV and application of 20 kV voltage during the construction of new grids. In general case such problems require feasibility study of the selected variant of new transmission lines construction. Conventionally, such problem is considered as optimization problem, that lies in determination of such variant of reconstruction (construction) of electric network, that is characterized by the least possible value of efficiency function, that reflects the resources expenditures for construction and operation of electric grid, for instance, by reduced discount expenditures

$$З = \frac{В}{Е} + К - Л \ ,$$

where Е – is the norm of the discount; К - single capital investment in considered variant of system development; В – annual current expenditures for electric grids operation; Л – liquidation (depreciated) value of the equipment to be dismounted.

On the other hand, such problem may be considered as the search of reconstruction (construction) variant of electric network in states space [8], where each state space of search corresponds the possible variant of reconstruction (construction) with the corresponding characteristics. Project practice, accepted in Ukraine, lies in preliminary generation of a certain number of possible variants with their further comparison by the determined economic criteria and selection of the most efficient variant. It should be taken into account that due to insufficient experience of the designer already at the preliminary stage the most efficient variant of the reconstruction (construction) of the electric grid may not be included into the list of the compared variants. Especially high probability of such situation appears in the process of the developments of the unique projects, connected with the application of new technologies in the sphere of transmission and distribution of electric energy. On the other hand, consideration and comparison of all possible variants of project solutions may be connected with the problem of combinatorial explosion, when too high dimensionality of searching space does not allow to determinate the most efficient project solution in acceptable terms.

Under such conditions, involvement of evolution algorithms, constructed on the principles of usage of modeling of natural selection may be efficient. Optimization problem of determination of economically efficient variant of electric grid development is replaced by the modeling of natural selection, regarding the adaptation to the conditions of the environment. Application of genetic operations to current population will generate new project solutions with new properties. Efficient adjustment of searching algorithm allows to direct evaluation process of possible project solution development to the most efficient one.

Conclusions

Application of 20 kV voltage in the existing networks of 6-10 kV allows to realize the transition to higher level of energy supply of the Ukrainian consumers, increase carrying capacity as compared with the existing networks within the limits of the existing land allocation, reduce technological losses, improve the quality of electric energy, energy safety and reliability of energy supply systems operation, substantially decrease energy dependence of the country. Besides, as a result of application of mast complex transformer substation 20/0.4 kV the length of transmission lines of 0.4 kV can considerably be reduced by approaching 20 kV voltage to the consumers and, correspondingly, decrease the relation of transmission lines of 6--20 kV length to 0.4 kV and, as a result, value of losses in 0.4 kV networks, that represent 70% of total losses in distribution electric networks of unified power system of Ukraine.

For the solution of searching optimization problem in the states space of project solution, that is characterized by the best economic effect, feasibility study of the variant of electric network development with reconstruction of existing or construction of new 20 kV electric transmission lines is necessary. As the study of all possible variants is limited by the problem of combinatorial explosion and artificial limitation of search, used in project practice may lead to the fact that the most efficient solution will not be among the variants being compared, the most efficient may be intelligent search in the complete space of states, that is based on evolution algorithms.

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