Load Graphic Modeling of Electric Power System Nods

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Abstract: **A modeling method is proposed for load graphics of active power consumption in electric power systems. The mathematical method considers main development trends of electric loads as well as process random component, the latter depending mainly on weather conditions. Utilizing former load graphic parameters, the method allows for load graphic development, which could be defined by any type of quantitative indices.**

Key words: l**oad graphics, modelling**

Accuracy of mode planning methods for electric power systems (EPS) depends on the possibility to account for the influence of nod electric load variation. This is most strongly expressed in extreme mode planning. Because of the various types of consumers in individual nods, load fluctuations are considerable. In order to improve load-planning preciseness, it is necessary to establish and maintain long-term historical databases for electric loads in the most important nods. However, these data are not sufficient for mode planning in extreme weather conditions. Therefore, it is advisable to develop a modeling method for electric load graphics in the nods providing relatively precise and prompt generation of a number of load graphics with various indices.

As active power consumption in EPS nods is a random process, a mathematical model is necessary to account for major process characteristics as well as for random fluctuations resulting basically from weather factors.

The following mathematical model seems appropriate:

$$P(h,t,m) = B(h)\,C(t)\,N(m,h)\,W(t) \qquad (1)$$

where:

B(h) and C(t) are functions, reflecting daily and weekly periodicity of the process, respectively;
h and t express discrete time of the day and week, respectively;
N(m) is a matrix of electric load parameters depending on the time of day;
W(t) – accounts for random process components;
i - nod number

For a more precise load graphic modeling, when generating the matrix N(m), the days of the week are divided into the following groups:

m = 1 – means a special day (Monday)
m =2 – means a typical working day (Tuesday, Wednesday, Thursday, and Friday)
m = 3 – means a special day (Saturday)
m = 4 – means a special day (Sunday and holidays)

The random process component of active power consumption W(t) is non-stationary [1]. In order to simplify calculations, it is presented as a stationary random process [2].

$$W_i(t) = G_{oi}(E)\eta_{oit} + \Sigma\, G_{ij}(E)\eta_{jt} + \Sigma\, G_{ik}(E)\delta_{kt} \qquad (2)$$

where:

$G_{oi}(E)$, $G_{ij}(E)$ and $G_{ik}(E)$ are transfer functions [3];
η_{oit} and η_{jt} are non-correlated random sequences;
δ_{kj} is the value sequence of weather factors

With the help of random number generator and at normal distribution, the values of random sequence members are obtained, η_{oit} and η_{jt} [3]. Then, using Eq. (2), the random component of the load graphic $W_i(t)$ is calculated for the respective nod. The value sequence of weather factors, δ_{kt}, is determined by detailed examination of their actual values. Thus, modeling of the random component of nod load becomes more accurate, but this requires a significant amount of labor-consuming calculations. If less accuracy could suffice, then it would be a lot easier to calculate value sequences for these factors, δ_{kt}, through modeling:

$$\delta_{kt}=G_{ok}(E).\eta_{okt} \qquad (3)$$

where:

$G_{ok}(E)$ is transfer function;
η_{okt} is a random sequence of non-correlated values

The functions B(h) and C(t), of the daily and weekly periodicity, respectively, have the same structure for all EPS nods. The specific configuration and main quantitative indices of these graphics for individual nods are calculated by load matrix elements $N_i(m)$. The random component of active power consumption process is modeled through transfer functions, $G_{oi}(E)$ and $G_{ij}(E)$, and non-correlated random sequences, η_{oit} , η_{jt} and δ_{kj}.

Mathematical model Eq. (1) parameters are determined through statistical analysis of historical data about active power load graphics in numerous EPS nods. Electric load modeling for specific nods requires such mathematical model parameters as necessary for the specific load type, taking into account the consumer group. In order to improve modeling preciseness, it is advisable to pre-group nods of similar consumer type and mode of operation. The mathematical model, presented by the expression (1), (2), and (3), allows broad variations of major quantitative indices of modeled load graphics, such as average value, peak factor, duty factor, etc.

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Extreme value planning of weather factors is of specific interest. The highest accuracy is achieved by considering the influence of these factors on the active loads in the respective nods based on historical data. However, this is quite a labor-consuming task. It is a lot easier to achieve relatively accurate results by choosing random sequence member values from the whole range ±3%, while assuming a normal distribution.

Assessment of mode parameters' influence as well as nod voltage and frequency levels could be accomplished through consideration of statistical parameters of active loads in terms of voltage and frequency.

The proposed method for load graphic modeling of active power in EPS nods was implemented in a research software utilizing PC 486. The software involves a control module and several calculation modules. The major calculation modules are, as follows:

- calculation module for the random process component using Eq. (2);
- transformation module for model parameters in view of obtaining load graphics of pre-determined characteristics;
- assessment module for statistical parameters of modeled graphics

The research software allows only assessment of the proposed methods for load graphic modeling. The full program realization is based on the algorithm developed.

The experiments showed that load graphics with random quantitative indices could be modeled by this method, utilizing real load graphic parameters in certain EPS nods.

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