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Prediction of electric power consumption by nuclear power plants for covering plant needs using data mining methods

M.A. Kleshchyova, A.V. Nakhabov*

Obninsk Institute for Nuclear Power Engineering, National Nuclear Research University MEPhI 1, Studgorodok, Obninsk, Kaluga Region 249040, Russia

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Abstract

In the process of its operation nuclear power plant consumes significant amounts of electric power – the so-called power consumption for coverage of plant needs. According to the practice existing in Russia, nuclear power plant must order in advance from the power supply grid operator the required quantity of electric power, while deviations of factual electric power consumption from the forecasted value one way or another entail payment of certain financial penalties. Because of this reason accuracy of forecasting the electric power consumption for the nearest coming period attains special importance. Application of different methods of data analysis for forecasting electric power consumption by NPPs using factual data is addressed and comparison of these methods between each other, as well as with those currently in application by NPPs is made. As the result, a method is suggested for forecasting NPP power consumption for coverage of plant needs with significantly higher accuracy of forecasting.

Keywords: Nuclear power plants; Energy consumption; Forecasting methods; Exponential smoothing; Support vector machines.

Introduction

Large number of consumers of electricity is included in the composition of equipment of nuclear power plant; consumption of this electric power is called consumption for coverage of plant needs. In the process of NPP operation nuclear power plant procures electric power for coverage of plant needs from the unified energy system. Procurement of electric power is performed on the basis of forecasted values. It is very important to plan as accurately as possible the consumption of electric power for coverage of plant needs: the more precise is the forecast, the higher will be the financial result. Low-quality planning of needs in power resources leads, in some cases, to the excessive payments and, thus, to the inefficient diversion of monetary funds of the nuclear power plant, and in other cases it is associated with risk of potential limitations of supplies of energy resources. That is why it is necessary to accurately determine the volume of electric power to be procured for making appropriate prepayment. Nuclear power plant takes certain risks associated with the impossibility to accurately plan the request for electric power to cover its consumption. The existing practice demonstrates that no general unified method exists for forecasting the required quantities of energy resources for nuclear power plants since enormous numbers of simultaneously going technological processes are combined to form the unique time process.

Approaches to planning electric power consumption by NPP for coverage of plant needs

As far as it is known no unified developed method of forecasting power consumption is available so far for nuclear power plants. Approaches to this problem were addressed at the Smolensk NPP. As of today requests for procurement of energy resources are made by the SNPP on the basis of visual and statistical analysis of the data for the current period. Certain average value is accepted as the forecasted value for the coming period (Fig. 1). It is clear from Fig. 2 that such

* Corresponding author.

E-mail addresses: kleshcheva_ma@mail.ru (M.A. Kleshchyova), AVNakhabov@mephi.ru (A.V. Nakhabov).

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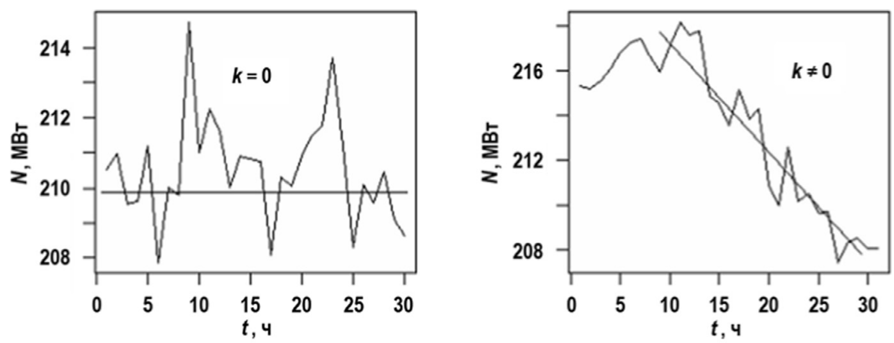
N, МВт	N, MW
t, ч	t, hours
b – статистический параметр	b – statistical parameter

Fig. 1. Existing approach to forecasting energy consumption for coverage of plant needs at the SNPP.



N, МВт	N, MW
t, ч	t, hours

Fig. 2. Drawbacks of forecasting approach accepted at the SNPP.

approach produces significant uncertainty of forecasting and does not take into account the behavior of the random value.

Forecasting methods

The time series represent a set or sequence of data arranged in chronological order and collected at evenly spaced time points. Forecasting time series is the prediction of future events on the basis of already known past events using applicable model. There exists a classification of methods which can be applied for forecasting power consumption [1]. Values of factual power consumption by the Smolenskaya NPP, the branch of the Open Joint-Stock Company “Concern Rosenergoatom”, are used as the input data.

Method of forecasting using maximum margin is based on the breaking the time series into sections. Accepting that the value of power consumption for certain preceding time period is considered to be constant and is equal to the maximum value of consumption it is possible to construct the simplest forecasting model. Method of triad medians is based on the previous method. The difference is that not the maximum but the median value for triads is taken as the forecasted value, i.e. the largest and the smallest values in the triad are rejected. Examples of such forecasts are given in Fig. 3.

Exponential forecasting is the method of mathematical transformation applied in forecasting of time series. The method is based on the calculation of exponential average values. Exponential forecasting of the series is performed using the following recurrent formula:

$$S_t = \alpha \cdot X_t + (1-\alpha) \cdot S_{t-1}, \qquad (1)$$

where S_t is the exponential average value at the time moment t; α is the smoothing parameter, $0 < \alpha < 1$. As it is clear from Eq. (1), each new smoothed value (which is at the same time the forecasted value) is calculated as the weighted average for the current observed value and the smoothed series. Exponentially reducing weights taking into consideration all the preceding observed results in the series are ascribed to older observed values. Results of smoothing depend on the parameter α. If $\alpha = 0$ than preceding observed results are completely ignored. If $\alpha > 0$ the current observed results are ignored. Exponential prediction is the simplest option of training model. Calculations are straightforward and are performed iteratively. Data set for initialization of calculations can be reduced to a single element S_{t-1} [2,6].

Parameter α must be selected as to obtain the minimum value of the sum of squares of deviations of factual electric power consumption from the forecasted values. It turned out