Parametric Adaptation of Data the Software and Hardware System of Electrical Consumption Management

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Abstract: The article considers the software implementation of parametric adaptation of data on the electrical consumption of objects based on rank analysis, which allows creating scientific and methodological prerequisites for ensuring reliable data storage, cleaning, formatting, verification, smoothing and primary statistical processing, and determining the reference data layer with the greatest predictive abilities on the basis of integral indicators. The procedure of parametric data adaptation is implemented in the subsystem of the software and hardware system of electrical consumption management of the regional electrotechnical system in the form of an automated workplace.

1 INTRODUCTION

At the moment, significant changes are taking place in the world community in the field of information technology development. The main directions of their implementation are business structures, state institutions, research enterprises, etc. In the writings of many scientists, it is stated that a new technological order, with the use of new information technologies, has taken place. Software and hardware solutions based on artificial intelligence, expert decision support systems, and Internet of Things technologies are already able to replace a person in certain areas. Investments in such projects have become very popular and will continue.[0]

In Russia, a large number of investment projects are being implemented in the electric energy sector. They are aimed at the development and implementation of situational centers and software and hardware system (SHS) for managing energy resources and electric grid modes. Any electric energy company has a large number of information and analytical systems and another system that process huge amounts of data. In addition, the data is stored in various formats and databases, access to which is not always allowed. In this regard, there is a difficult task associated with their high-quality processing, cleaning and verification.

2 MANUSCRIPT PREPARATION

A team of authors of the Kaliningrad Scientific School under the leadership of Professor V. I. Gnatyuk (Gnatyuk, V.I., Kivchun, O.R., Lutsenko, D.V., 2020) has developed (SHS) electrical consumption management of the regional electrical complex (Fig. 1).

The interface and automated workstations (AW) SHS are written in C# in the Visual Studio software environment. SHS includes subsystems for parametric adaptation, forecasting and normalization of data on electrical consumption. The article will consider in detail the subsystem of parametric adaptation of data. Its basis is an algorithm for cleaning, checking and verifying data on electrical

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consumption, which is programmatically executed in the form of AW (Fig. 2).

Figure 1: The main stage of the hardware and software complex.

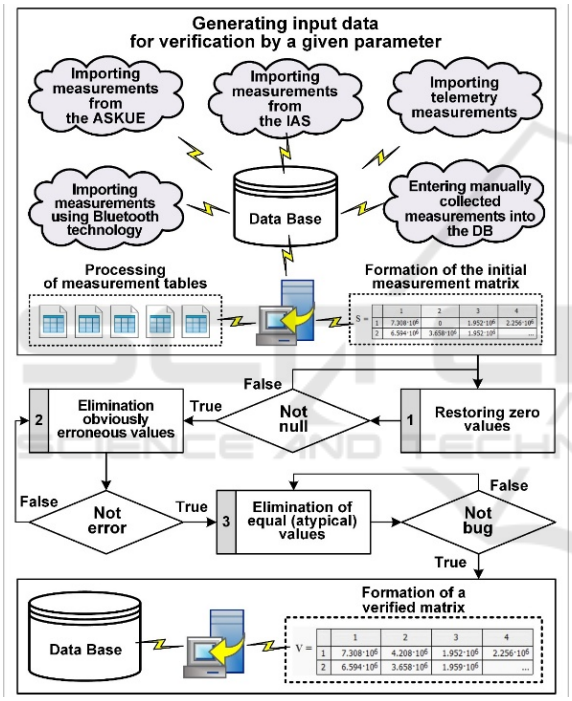

Figure 2: Algorithm for cleaning, checking and verifying data on electrical consumption.

At the first stage of the algorithm, a matrix of initial – "raw" data on electric power consumption is formed. It includes data imported from automated systems for monitoring and accounting of electrical, information and analytical systems, telemetry systems and collected manually.

3 RESULTS AND DISCUSSION

Data processing was carried out on the basis of the methodology of rank analysis [4]. Therefore, the "raw" data is presented in the form of a rank parametric distribution, the values in which are ranked from a larger value to a smaller one. Then this distribution is approximated (Gnatyuk, V.I., Polevoy, S.A., Kivchun, O.R., Lutsenko, D.V., 2019).

Analytically, the raw data is represented by the following expression:

$$[\{W_k\}_{k=1}^{n} \xrightarrow[f:W\to R]{} \{R_k\}_{k=1}^{n}] \xrightarrow[Approx]{} W = f(x), \quad (1)$$

where $\{W_k\}_{k=1}^{n}$ – set of electrical consumption values;

$\{R_k\}_{k=1}^{n}$ – set of topological ranks;

W(x) – approximation function of the rank parametric distribution;

x – rank topological measure.

At the second stage of the algorithm, the data on electrical consumption is verified. This procedure includes the search and elimination of zero, equal and obviously erroneous data. The recovery of null data is carried out using spline interpolation and the method of numerical extrapolation. The spline interpolation procedure is the process of determining the functional dependence that best describes the empirical data. This problem is solved in the model by using quadratic or cubic splines. After the implementation of these procedures, a matrix of verified values is formed, which is imported into the electrical consumption database.

It should be recalled that the database according to (1) already contains "raw" and approximation data. Therefore, at the next stage, an algorithm for parametric data adaptation is implemented, which allows you to select the highest quality values for further processing. Figure 3 shows the algorithm of this procedure.

At the first stage of the algorithm, data is imported for verification, which includes three matrices of data on electrical consumption for five years: "raw", approximation and verified data. The practical implementation of this procedure was carried out on the basis of data on the electrical consumption of large consumers of the Kaliningrad region from 2015 to 2020. The year 2020 was reserved as the verification vector, and the data from 2015 to 2019 were used for calculations (Gnatyuk, V.I., Kivchun, O.R., Lutsenko, D.V., 2020).

Based on the data contained in the three matrices, the forecast for 2020 was carried out. A technocenological method with a fixed first point was used for forecasting (Kivchun, O.R., 2021). After

receiving the results, the obtained forecast values are compared with the verification vector – with data on electrical consumption for 2020. To do this, the absolute and relative forecast errors are calculated. At the next stage, based on the analysis of integral indicators of forecast errors, a decision is made on the choice of a data layer for electrical consumption. Table 1 shows the results of calculating forecast errors.

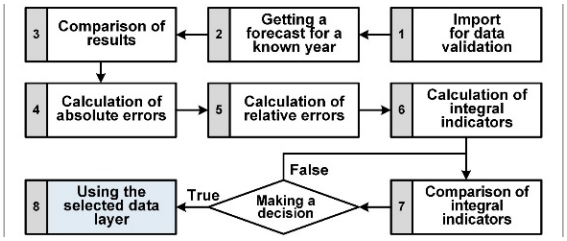

Figure 3: Data layer selection algorithm.

Table 1: Results of calculation of forecast errors.

Error name	"Raw" data	Verified data	Approximation data
	Forecasting by the method with a fixed first point	Forecasting by the method with a fixed first point	Forecasting by the method with a fixed first point
Maximum absolute error, kWh 10^8	2.7	2.4	3.9
Average relative error, %	2.4	0.6	2.3

Based on this table, we can conclude that the most qualitative layer is verified data on electrical consumption. This means that in order to obtain correct results of monitoring and rationing data on the electrical consumption of large consumers in the Kaliningrad region, a matrix of verified values fro2015 to 2020 should be used.

Programmatically, this procedure is implemented in the form of a AW software and hardware system (Fig. 4).

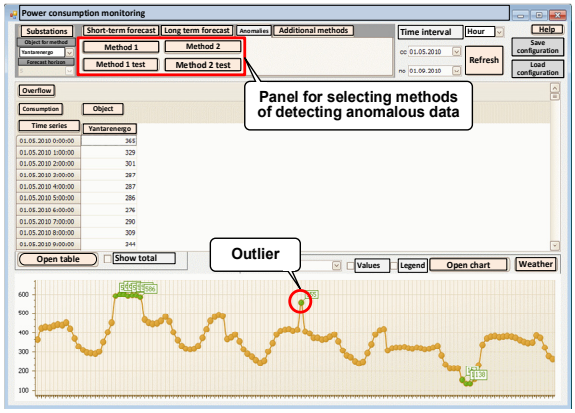

Figure 4: Automated workplace for parametric adaptation of electrical consumption data.

4 CONCLUSIONS

It is a window containing panels for selecting time parameters, resource parameters and a graphical display area for the results of the procedure. Moreover, the graphs can be displayed on a large screen, more specifically detailed – display the legend, save it in a convenient format and print it out.

Thus, the presented software implementation procedure of the parametric adaptation of data is a necessary addition to the SHS energy consumption management of the regional electrical system and allows cleaning, checking, verifying electrical consumption data, as well as selecting the highest quality data layer for further calculations.

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