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DATA ANALYSIS IN SYSTEMS WITH ALTERNATIVE ENERGY SOURCES

Abstract. *The development of information, network and microprocessor technologies has formed the necessary conditions in the creation of local energy-efficient systems with electric energy generation and consumption in local energy system where the optimal ratio between electricity supply and electricity consumption is achieved. Power supply in such systems is provided by alternative energy sources, which include, in particular, solar batteries and wind power plants. The optimal functioning of the local energy system is based on the maximum coincidence of the profiles of generation and consumption of electric energy in the system. The alternative energy sources generation profile is characterized by a direct dependence on the weather conditions of the location where the described energy sources are located. Thus, the generating power of a solar battery depends on the illumination and temperature of the solar panel. These parameters, in turn, are affected by environmental factors such as cloud cover, air temperature, humidity and wind speed. In addition to the factors mentioned above, wind direction and atmospheric pressure affect the power of the wind turbine. In order to predict the required generation profile and match it with the consumer profile, it is necessary to identify the relationship between the data obtained both from the environmental parameters monitoring unit, which is an element of the local energy system and from the meteorological data provided by the relevant meteorological service.*

Keywords: *local electrical system; alternative energy sources; environmental parameters; generator and consumer graphs; relationship between meteorological data.*

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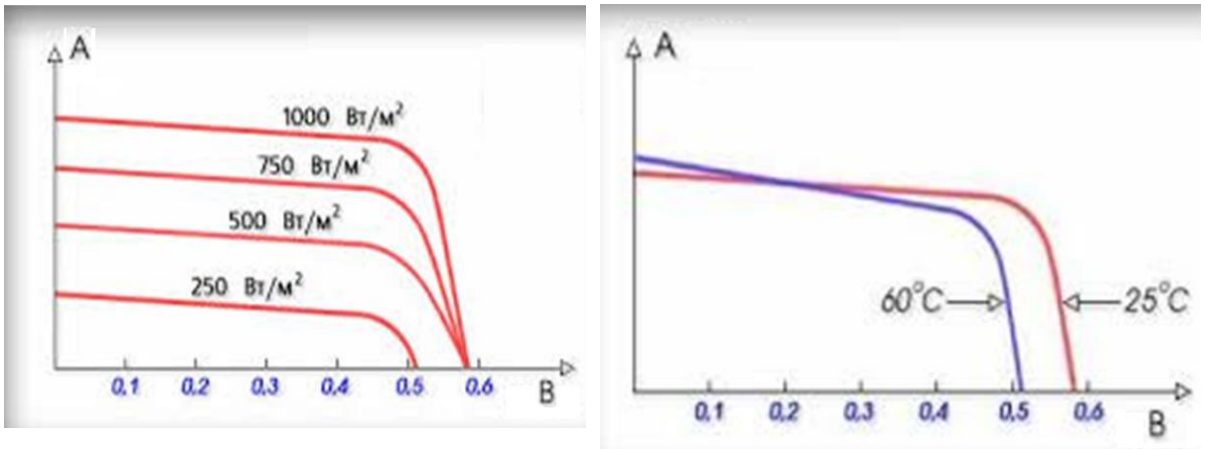
АНАЛІЗ ДАНИХ В СИСТЕМАХ З АЛЬТЕРНАТИВНИМИ ДЖЕРЕЛАМИ ЕНЕРГІЇ

Анотація. *Розвиток інформаційних, мережевих та мікропроцесорних технологій сформував необхідні умови для створення енергоефективних локальних систем генерації та споживання електричної енергії локальних енергетичних систем, в яких досягається оптимальне співвідношення між електропостачанням та електроспоживанням. Електропостачання в таких системах забезпечується альтернативними джерелами генерації електричної енергії, до яких відносяться, зокрема, сонячні батареї та вітроенергетичні установки. Оптимальне функціонування локальних енергетичних систем ґрунтується на максимальному співпадінні профілів генерації та споживання електричної енергії в системі. Профіль генерації потужностей альтернативних джерел електроенергії характеризується прямою залежністю від погодних умов місцевості, в яких розташовані джерела енергії. Так, генеруюча потужність сонячної батареї залежить від освітленості та температури панелі сонячної батареї. На зазначені параметри, в свою чергу, впливають такі чинники оточуючого середовища, як хмарність, температура повітря, вологість та швидкість вітру. На потужність вітрогенеруючої установки впливають, крім вище означених факторів, також напрямок вітру та величина атмосферного тиску. Для того, щоб спрогнозувати необхідний генеруючий профіль і поставити йому у відповідність споживчий профіль, необхідно виявити співвідношення між даними, що отримуються з блоку моніторингу параметрів навколишнього середовища, який є елементом локальних енергетичних систем та метеоданими, які забезпечують відповідні метеорологічні служби.*

Ключові слова: *локальна електрична система; альтернативні джерела енергії; параметри навколишнього середовища; графіки генератора та споживача; зв'язок між метеорологічними даними.*

Introduction. Alternative sources of electricity are characterized by a pronounced dependence on environmental conditions (meteorological conditions) in the spatial location in which they are located. Yes, the power of the solar battery directly depends on the illumination and temperature of the solar panel. Illumination is a meteorological characteristic that is described by the cloudiness coefficient. The higher the cloud cover, the lower the illumination of the solar panel with a corresponding decrease in the electric power generated by the solar battery (Fig. 1a). In addition, the heating of the solar panel also leads to a decrease in generating power (Fig. 1b). The temperature of the solar panel is directly affected by the level of illumination, the temperature and humidity of the surrounding air, the presence or absence of wind. In the case of a wind generator, its generating power depends on the wind speed and atmospheric pressure.



а) б)

Figure 1. **Influence of illumination a) and temperature b) on the generation capacity of the photocell**

Problem announcement. The main task of the optimal functioning of the energy system with alternative energy sources is to find consistency between the electricity generated by these sources and its consumption. To do this, they draw up the desired schedule of electricity consumption, which shows the time intervals during which this or that electrical device is turned on. Knowing the consumer power of each device, it is possible to turn it on for the period of time when there is sufficient electrical power generated by the photo battery (Fig. 2). and a wind generator.

Therefore, there is an urgent need to form a schedule of generating capacity based on the weather forecast provided by the meteorological service. In order to build such a schedule, it is necessary to establish a relationship between the meteorological data provided by the meteorological service and the data obtained from the sensors of the environment monitoring module located in the same spatial location where the alternative energy sources are located.

Results of the research. The data received from the sensors and the meteorological service are transmitted to the site, where with the help of the operator ϕ they are formed in the form of events (A^0, B^0, C^0, ...), changes in events (A^1, B^1, C^1, ...), changes in changes in events (A^2, B^2, C^2, ...). Using the operator ε, events and changes are placed in phase space with the corresponding phase coordinates X and Y. Using universal and existential quantifiers, relational predicates of phase coordinates are formulated that describe the relationship between these coordinates in phase space (Fig. 3).

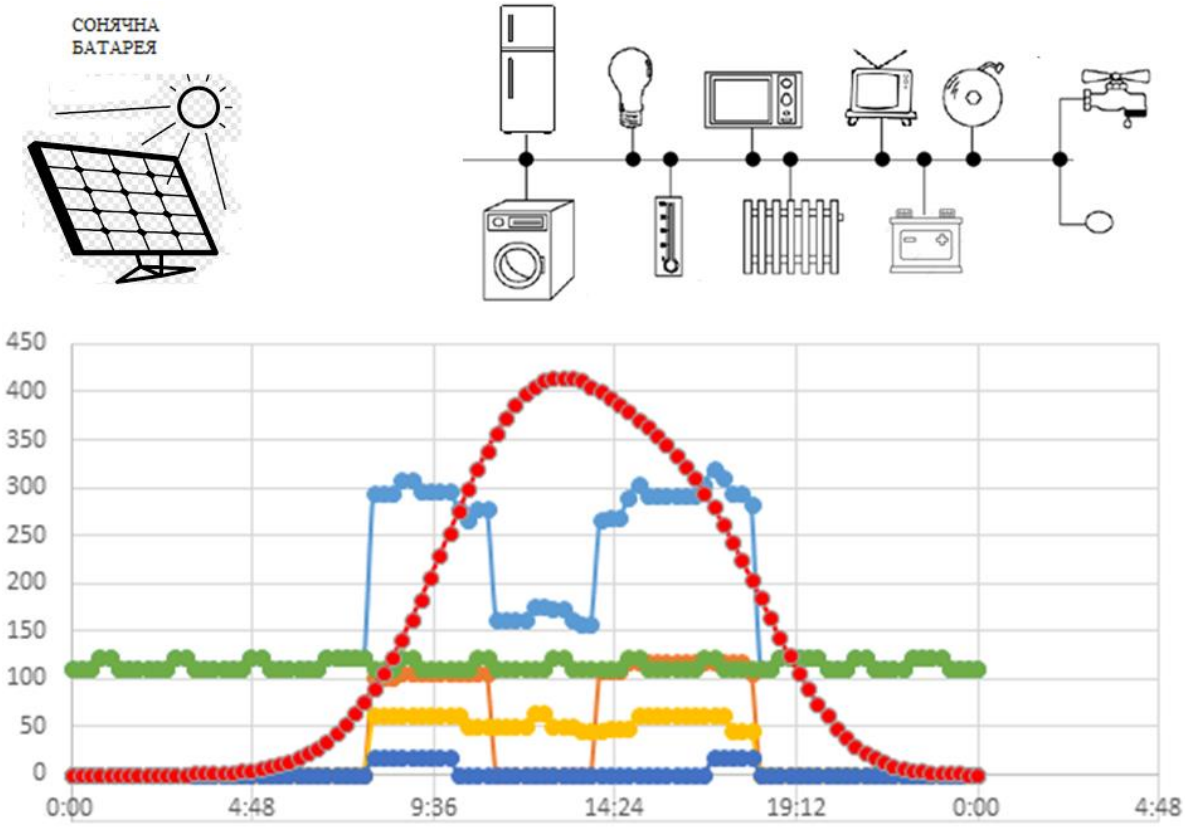


Figure 2. **Plots of generating and consuming power**

$$\forall X \forall Y (X|R|Y)$$
$$\forall X \exists Y (X|R|Y)$$
$$\forall Y \exists X (X|R|Y)$$
$$\exists X \exists Y (X|R|Y)$$

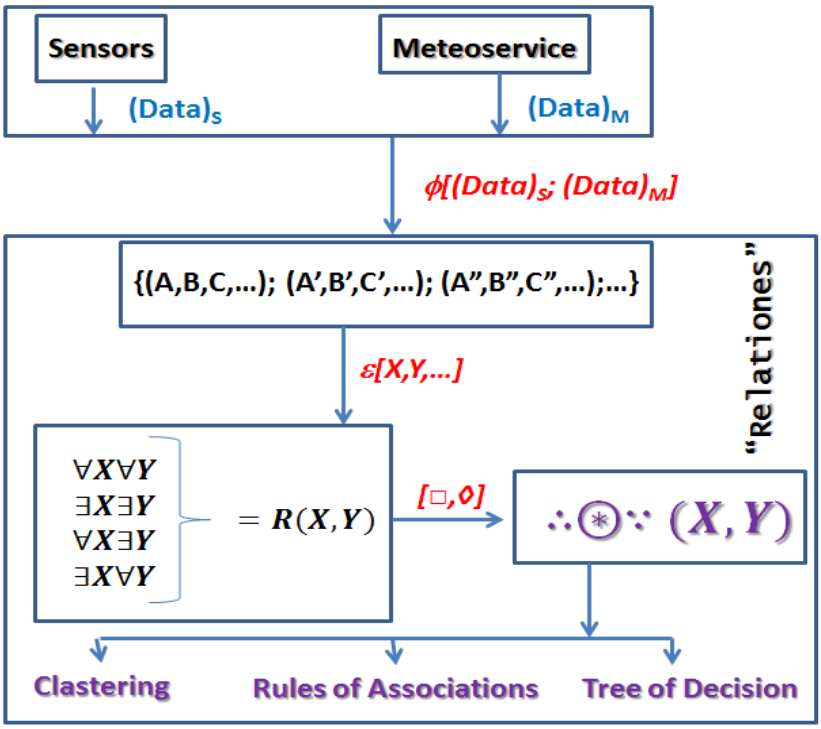


Figure 3. **Schematic diagram of the software product**

On the basis of the received predicates, either clustering of phase coordinates is performed, or association rules of these coordinates are formed, or a decision tree is built, depending on the further form of representation of the relationships between these coordinates.

Clustering consists in dividing a given set of event samples into clusters, so that each cluster consists of events characterized by the similarity of the active factors that reveal these events. Events located in different clusters are significantly different from each other. Clustering is also called data segmentation because large groups of data are divided by similarity. Clustering of the data obtained from the monitoring unit of environmental parameters and the weather service is used to identify certain relationships and trends in the set of presented data (Fig. 4a).

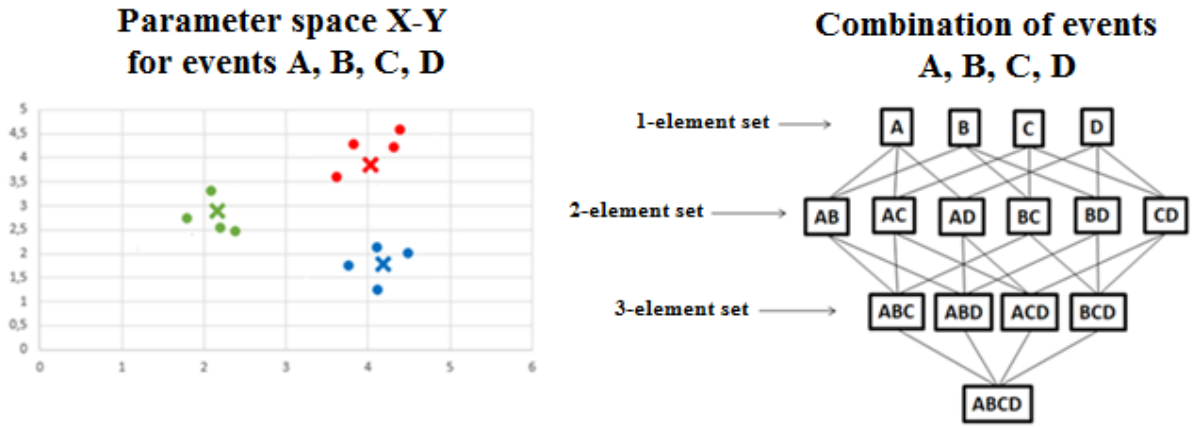


Figure 4. **Finding data correlation using a) clustering and b) formulation of associative rules**

In addition to clustering, the method of formulating associative rules is also used to find the relationship between data, which reveal relationships between variables or attributes of events that are described by the corresponding data arrays (Fig. 4b).

Conclusions. In this way, the necessary ratios are obtained, which make it possible, based on the weather forecast provided by the meteorological service, to perform a prognostic assessment of environmental parameters in the spatial location where alternative energy sources are located. This prognostic assessment, in turn, makes it possible to form a schedule for the generation of electric energy, which will be produced by a solar battery and a wind turbine.

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