**Assessment of electricity consumption indicators in textile industry enterprises**

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**Abstract.** This article examines issues aimed at determining the specific electricity consumption indicators per unit of product for textile industry enterprises, including those producing sewing and knitting products. Traditional methods of energy consumption management used in industrial enterprises include modeling, standardization, and forecasting. The effective use of energy resources is assessed by the specific consumption of energy resources per unit of output. The specific electricity consumption per unit of output has a dynamic value, and changes in the technological process, an increase in production volume, as well as the depreciation (or change in type) of energy-intensive equipment over time lead to changes in the value of this indicator. Based on the results of scientific research, the application of a method for adjusting specific electricity consumption values allows for highly accurate calculations and enables the identification of electricity saving reserves in industrial enterprises.

**INTRODUCTION**

In the context of integration into the global economy, the development of the textile industry has been designated as a priority task for the economy of the Republic of Uzbekistan. As a result of creating favorable investment conditions in the country, fundamentally modernizing production, and placing special emphasis on manufacturing finished products, the textile industry is becoming one of the leading sectors of the economy. The rapid development of all branches of the textile industry, an increase in the number of enterprises in this sector, a rise in production capacity, and growth in export potential are leading to an increase in the energy consumption of these branches [1-3]. This, in turn, highlights the necessity of conducting scientifically-based research to ensure rational use of energy resources in textile industry enterprises, including those producing sewing and knitting products. The aim is to minimize the specific electricity consumption per unit of product in manufacturing processes while simultaneously increasing efficiency [4-6]. Traditional methods of energy consumption management used in industrial enterprises include modeling, standardization, and forecasting. The efficient use of energy resources is evaluated through the specific consumption of energy resources per unit of product. Existing methods for assessing energy consumption consider hourly productivity as the main influencing factor. Specifically, depending on the technological process, calculations for production departments are carried out either taking into account technological factors or without considering them. Energy characteristics are compiled for these departments, and the patterns of changes in the indicators of consumed electrical energy are determined. To determine specific electricity consumption using the experimental standardization method, practical measurements of electricity consumption must be conducted for each production process. The complexity of applying this method in industrial enterprises is due to the large number of electricity-consuming equipment present in these facilities. The computational-analytical method for determining specific electricity consumption norms involves calculations based on the technical specifications of electricity-consuming equipment. When applying this method, the workload and operating regime of the enterprise, as well as other individual factors influencing specific energy consumption, are taken into account. The computational-statistical method of standardizing specific electricity consumption is based on processing statistical data on absolute and relative electricity consumption for the period under consideration. When determining the standards, all factors influencing the value of specific electricity consumption are taken into account. The norms are established based on the resulting values of production volume and nomenclature, using data from electricity consumption meters [7-8].

**EXPERIMENTAL RESEARCH**

For the effective and comprehensive organization of the research work, the joint venture "BIRYUZA GROUP" LLC, located in the Zangota district of Tashkent region, was selected as the object of study. This textile enterprise was established in 2011 and is considered a large Uzbekistan-Turkey joint venture. In accordance with the Decree of the President of the Republic of Uzbekistan dated January 21, 2022, No. UP-53 "On measures to stimulate deep processing and production of finished products with high added value at textile and sewing-knitting enterprises, as well as their export," "BIRYUZA GROUP" JV LLC produces high-quality and competitive sewing and knitting products through complete processing of cotton fiber and exports them to various countries around the world. The rational use of electricity at a sewing and knitting enterprise is largely determined by technological factors, since increasing production, improving quality, and reducing energy consumption contribute to a reduction in production costs. Identification of reserves for saving electrical and thermal energy in enterprises and associations, reduction of losses in electrical and thermal networks, rationalization of technological processes, introduction of new technologies and modernization of existing equipment, and more complete use of low-potential energy should be carried out. It is also necessary to improve control over the rational use of electrical and thermal energy. Since there is no electricity consumption in the sections of the technological process at the enterprise, experimental measurements were carried out in each section on all electricity-consuming equipment located in the sections and their active capacities were calculated. The results obtained are presented in Table 1 below.

**TABLE 1.** Information on the main departments of JV “BIRYUZA GROUP” LLC that consume electricity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| № | **Name of Department** | **2022** | **2023** | **2024** |
| **Power consumption, kWh** | **Power consumption, kWh** | **Power consumption, kWh** |
| 1 | Technological needs | 5995355.1 | 6788483.2 | 7673506.8 |
| 2 | Compressor room | 608224.4 | 630359.2 | 702504.1 |
| 3 | Water cooling devices | 573468.7 | 581870 | 648465.4 |
| 4 | Boiler room | 260667.6 | 339424.2 | 432310.2 |
| 5 | Water supply | 173778.4 | 242445.8 | 281001.7 |
| 6 | External and internal lighting of the enterprise | 521335.2 | 610963.5 | 540387.8 |
| 7 | Other downloads | 556091 | 504287.3 | 529580 10807756.1 |
|  | **Total** | **8688920.4** | **9697833.2** | **10807756.1** |

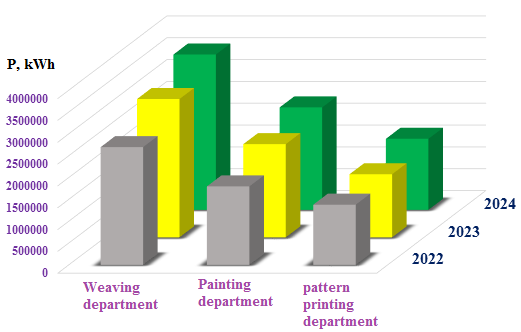
The electricity consumption of the enterprise in 2022, 2023, 2024 by department is presented in Table 1. The distribution of electricity consumption across all departments that make up the production process of the enterprise has remained stable during 2022, 2023, 2024. At the same time, the highest energy consumption in these departments corresponds to technological needs, while the lowest consumption corresponds to water supply. In order to conduct an in-depth study of electricity consumption at the textile enterprise of JV “BIRYUZA GROUP” LLC, which is the object of the study, scientifically based research was conducted on the technological equipment available at the enterprise. JV “BIRYUZA GROUP” LLC has installed technological equipment manufactured by countries such as Turkey, Germany, and China. The enterprise produces knitted fabrics of various densities, namely 300-350, 220-300, 160-200 g/m2. For the production of these products, the enterprise consumes almost 11 million kWh of electricity per year and produces 8 thousand tons of knitted fabrics. The technological needs of the main production process of the enterprise are met and include the following workshops:

- weaving workshop;

- painting workshop;

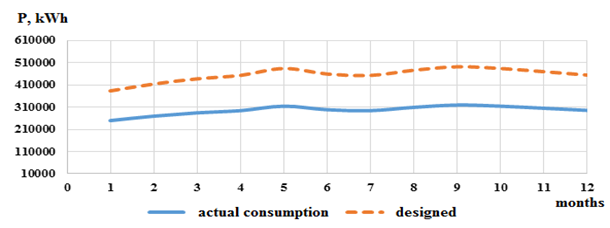
- pattern printing workshop;

The distribution of electricity consumption in these workshops for 2022, 2023, 2024 is presented in Figure 1.

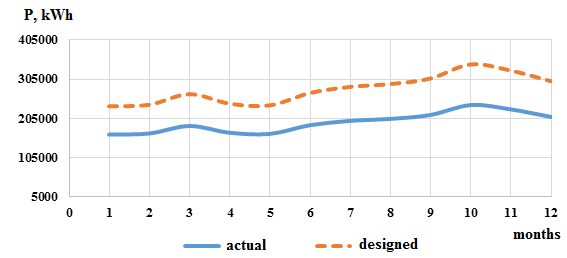


**FIGURE 1**. Electricity consumption by department of technological needs of JV “BIRYUZA GROUP” LLC for 2022-2024

The data presented in Figure 1 above means that during 2022, 2023, and 2024, an increase in electricity consumption was observed in all the main departments that make up the technological process. The weaving department had the highest energy consumption, accounting for 47% of the total energy consumption of technological needs in 2024. Accordingly, the dyeing and printing departments accounted for 31% and 21.5%, respectively. The dynamics of changes in the actual and projected indicators of electricity consumption of the main departments that make up the production process of the enterprise was built for 2024 by month (Figures 2-4).



**FIGURE 2.** Dynamics of changes in electricity consumption indicators of the weaving department



**FIGURE** **3.** Dynamics of changes in electricity consumption indicators of the painting department

As a result of the conducted research, it was found that the electrical energy consumption specified in the project in textile enterprises is higher than the actual value, which indicates that not all electrical equipment operates simultaneously, as indicated in the project, and as a result, it is necessary to take into account the coefficient of simultaneous operation of equipment when calculating the actual value of the specific electrical energy consumption per unit of product. The coefficient of simultaneous operation of electrical equipment located in each department is determined as follows:

 (1)

Here, actual consumption of electrical equipment, the rated power of the equipment according to the equipment's passport is the number of equipment. The coefficient of simultaneous operation of equipment for each production department:

* for the weaving department
* for the painting department
* for the pattern printing department

**RESEARCH RESULTS**

Using the coefficient of simultaneous operation of the equipment determined above, the enterprise's comparative electricity consumption indicators are determined as follows:

Electricity consumption in the knitted fabric weaving process of the enterprise (for 2024):

 (2)

Electricity consumption in the painting process of knitted fabric:

 (3)

Electricity consumption in the process of printing patterns knitted fabric:

 (4)

Total electricity consumption in the main processes of knitted fabric production:

 (5)

Total electricity consumption of auxiliary processes in knitted fabric production:

 (6)

Total electricity consumption of the enterprise:

 (7)

Here, The load, in addition to the main and auxiliary needs required in the technological process, is considered to be the boiler room, water supply, etc., kWh; losses in lines and transformers, this value should not exceed 5% of the total electricity consumption in textile enterprises; This is the utilization coefficient, which is equal to 0.9 for textile enterprises [9-10].

Using the above formula, the total electricity consumption of the enterprise was determined, and based on the results obtained, the total specific electricity consumption of the enterprise was calculated for 2024 and is presented in Table 2:

 (8)

Here, – volume of manufactured product, kg.

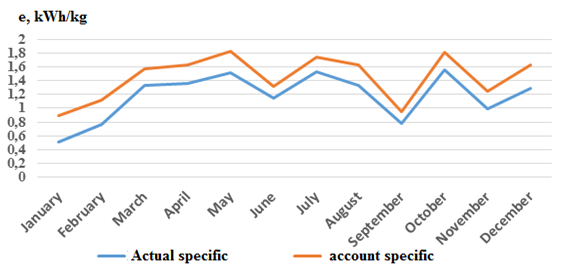
When assessing the reserves of electricity savings in textile enterprises, improving the methods for determining the specific electricity consumption per unit of product leads to the expected result. This can be explained as follows based on the data in Table 2 above: there is a difference between the actual and the specific consumption indicators determined using the proposed method, and it was determined that there are reserves of electricity savings of 3.4% in the knitting department, 2.8% in the dyeing department, and 1.1% in the printing department [11-15].

**Table 2.** Difference between the specific and actual electricity consumption indicators of

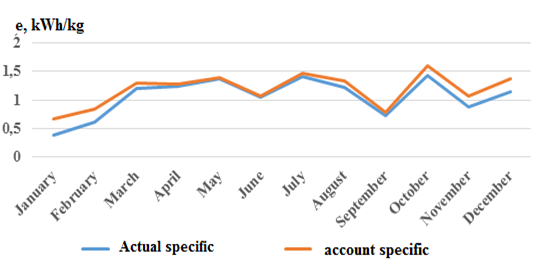
JV “BIRYUZA GROUP” LLC

|  |  |  |  |
| --- | --- | --- | --- |
| **Name of Department** | **Actual specific electricity consumption, kWh/kg** | **Specific consumption indicator determined using the proposed method, kWh/kg** | **Existingelectricity saving reserve** |
| Weaving | 0.89 | 0.52 | 3.7 % |
| Painting | 0.66 | 0.38 | 2.8 % |
| Pattern printing | 0.51 | 0.40 | 1.1 % |

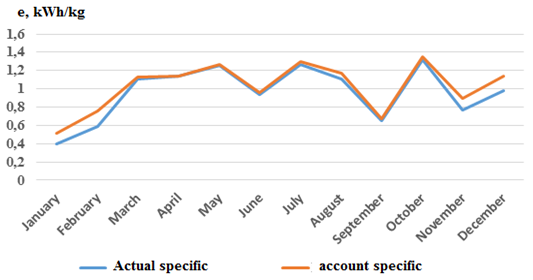
As a result of scientific research conducted on the specific consumption of electricity per unit of product in each department of the enterprise's production process, there is a 2.5% error between the currently used method and the proposed method in determining the specific consumption indicators, and the existence of energy savings reserves of up to 2.5% in the joint venture "BIRYUZA GROUP" LLC, which is the object of the research, was scientifically substantiated (Figures 5-7).



**FIGURE 5**. Specific electricity consumption indicators of the weaving department



**FIGURE 6.** Specific electricity consumption indicators of the painting department



**FIGURE 7.** Specific electricity consumption indicators of the printing department

It is known that the specific energy consumption indicator per unit of product is a dynamic value, and changes in the technological process, an increase in the volume of products, as well as a decrease (or change in the type) of equipment with high energy capacity over time lead to a change in the value of this indicator. Based on scientific research, it is possible to calculate the specific energy consumption values ​​​​with high accuracy in such cases using the correction method. The following main changes were taken into account when determining the specific energy consumption indicators using the correction method:

- changes in the nomenclature of the manufactured product;

- changes in the volume of the manufactured product;

- changes in the composition or type of technological equipment [9-10].

When applying the correction method, the specific electricity consumption is determined taking into account the electricity consumption and production volume of all departments that make up the technological process of the enterprise for the planned period.

 (9)

Here, – value of specific electricity consumption for the planned period, kWh/kg;

– total electricity consumption of the enterprise, kWh;

– The amount of electrical energy reduced (or increased) as a result of organizational and technical measures implemented at the enterprise, measured in kWh;

 – volume of products manufactured during the planned period, kg.

The specific electricity consumption indicators per unit of output can be adjusted as follows, taking into account the changes mentioned above:

*Change in production volume.*

A change in the production volume of textile industry enterprises has an inverse proportional relationship to the specific electricity consumption per unit of output. An increase in production volume without changing electricity consumption leads to a decrease in the specific electricity consumption value, while conversely, a decrease in production volume results in an increase in the specific consumption value [16-20].

When the production volume at the enterprise changes, the specific electricity consumption rate is adjusted using the following mathematical model:

 (10)

Here, – total electricity consumption of the enterprise, kWh;

When the product volume changes, the adjustment value for specific electricity consumption is determined as follows:

 (11)

*Change in product nomenclature*

Changes in the product nomenclature (i.e., the types or range of manufactured products) directly affect the specific consumption of electricity. Today, manufacturing products based on market demand leads to changes in product nomenclature over time or seasonal periods. If the nomenclature changes, i.e., the production of new types of products begins, the following situations may occur:

1. If the complexity of technological processes increases - when the production of new products requires more energy-intensive technologies, the specific consumption of electricity increases.

2. For energy-efficient products - when new products are manufactured using less energy-intensive technologies, specific consumption decreases.

3. Production equipment efficiency - new product nomenclature may require either old or new equipment. This also affects energy consumption.

When the product nomenclature changes at the enterprise, the specific electricity consumption rate is adjusted using the following mathematical model:

 (12)

Here,,  – the ratio of each manufactured product's nomenclature to its volume;

 – change in the ratio of the nomenclature of each manufactured product to its volume;

 – Accordingly, the independent variable of the equation determined by the multifactorial model and the coefficient of the regression equation are the actual variable values.

When the product nomenclature changes, the adjustment value of specific electricity consumption is determined as follows:

 (13)

*Change in the composition or type of technological equipment*

changes in the composition or type of technological equipment have a significant technologically justified impact on energy efficiency in production processes, in particular, on the specific consumption of electricity [21-25].

Today, industrial enterprises, including textile industry enterprises, have high energy intensity, which is determined by the obsolescence of technological equipment installed in these enterprises and low energy efficiency. One of the important tasks is the minimization of specific energy consumption, the introduction of modern, energy-saving technological equipment to maximize production volume, and the modernization of existing ones. When carrying out energy work of this type at enterprises, the specific consumption of electricity can be adjusted using the following mathematical model:

 (14)

Here,  – specific electricity consumption of technological equipment of various models,

 – The planned production capacity of this technological equipment for the specified period.

The adjustment value of specific electricity consumption is determined based on the condition of the technological equipment as follows:

 (15)

Using the above-mentioned correction method for specific electricity consumption and applying mathematical models (9-15), the enterprise's specific electricity consumption was calculated, and the results are presented in Table 3 below.

**Table 3.** Specific electricity consumption indicators of “BIRYUZA GROUP” LLC, determined by the adjustment method

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Change in production volume** | | **Change in product nomenclature** | | **Change in the composition or type of technological equipment** | |
| kWh/kg | 2.21 | kWh/kg | 2.21 | kWh/kg | 2.21 |
| 10 % increased  kWh/kg | 2.431 | 300-350g/m2  kWh/kg | 2.31 | Modern, energy-saving technologies  kWh/kg | 1.818 |
| 10 % decreased  kWh/kg | 1.989 | 120-160g/m2  kWh/kg | 2.03 |

The data in Table 3 demonstrate that the proposed method enables the calculation of specific energy consumption indicators in precise values for the planned period, taking into account changes in the enterprise's production volume, nomenclature, and types of technological equipment [25-29].

**CONCLUSIONS**

Research was conducted on the electricity consumption of the “BIRYUZA GROUP” textile enterprise. The findings demonstrated that the technological processes at the enterprise and its electricity consumption are characterized by continuity. Additionally, it was established that the enterprise has a high energy capacity.

As a result of experimental studies conducted at the textile enterprise "BIRYUZA GROUP," the dynamics of changes in the actual and projected indicators of electricity consumption of the main departments of the enterprise, which organize the production process, were constructed by months. As a result, the designated electricity consumption exceeds the actual value, as indicated in the project, all electrical equipment does not operate simultaneously, and as a result, the need to take into account the coefficient of simultaneous operation of the equipment when calculating the actual value of the specific electricity consumption per unit of product was scientifically substantiated, and this coefficient was determined for each section. With the help of the coefficient of simultaneous operation of equipment, it is possible to calculate the specific consumption of electricity per unit of output with high accuracy. Considering that the specific electricity consumption indicators per unit of output in textile industry enterprises have variable values in practice, and the main reasons for this are changes in production volume and its nomenclature, as well as the deterioration of electrical equipment involved in the technological process, the specific consumption indicators were calculated using the proposed method. As a result, it became possible to determine individually adjusted values for each change.

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