Intellektual boshqaruv tizimlari va raqamli platformalardan foydalanish orqali yuklamalarni optimal boshqarish

Ikromjon U. Raxmonov [1], Nurbek N. Qurbonov[1, a)], Li Zhang[2], Nimatullayev A. Ilhom[3], No‘mon, N. Niyozov [1, a)]

[1]DSc, prof., Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; ilider1987@yandex.com https://orcid.org/0009-0002-0761-0787

[1,a)]PhD, dots. Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; nurbek.kurbonov.96@gmail.com https://orcid.org/0000-0003-2076-5919

[2]PhD., dots. Shandong Universiteti, Jinan, Shandong provinsiyasi, 250061, Xitoy; zhleee@sdu.edu.cn; https://orcid.org/0000-0002-5913-2513

[3]Vazirlar Mahkamasi huzuridagi Elektr energiyasi, neft mahsulotlari va gazdan foydalanishni nazorat qilish inspeksiyasi, Toshkent, 100047, O‘zbekiston; i.nimatullayev@uzenergoinspeksiya.uz https://orcid.org/0009-0002-0761-0787

Dolzarbligi: energiya iste’molchilarining miqdori va energiya iste’moli yildan-yilga oshib, yuklamalarni boshqarish, energiya iste’molchilarining texnik holatini nazorat qilish tobora murakkablashib bormoqda. An’anaviy yuklamalarni boshqarish usullari energetika tizimida yuklamalarning noto‘g‘ri taqsimoti, o‘ta yuklanish va shu kabi muammolarni keltirib chiqarmoqda. Bundan tashqari yuklamalarni optimal boshqarish bilan bog‘liq muammolarda tashkiliy texnik tadbirlarni tezkorlikda ishlab chiqish, qabul qilish va ijro etish bilan muammolari dolzarbliligini saqlab kelmoqda. Ushbu o‘rinda intellektual boshqaruv tizimlari va raqamli platformalardan foydalanish samarali yechim hisoblanib, ushbu maqolada sanoat korxonalarida energiya resurslaridan samarali va oqilona foydalanishni ta’minlash, yuklamalardan optimal boshqarish maqsadida raqamli platformalar orqali tashkiliy-texnik tadbirlarni joriy etish, boshqarish masalalari ko‘rib chiqilgan.

Maqsad: ushbu maqolada sanoat korxonalarida intellektual boshqaruv tizimlari va raqamli platformalardan foydalanish orqali yuklamalarni optimal boshqarish usullari va algoritmlarini ishlab chiqish asosiy maqsad qilib olingan. Bu energiya iste’molini rejalashtirish, monitoring qilish va baholashni avtomatlashtirish orqali energiya samaradorligini oshirish imkonini beradi.

Usullari: tashkiliy-texnik tadbirlarni rejalashtirish va monitoring qilish, raqamli platforma orqali energiya balansini shakllantirish, samaradorlikni baholash, energiya iste’molini nazorat qilishni avtomatlashtirish, boshqaruvda raqamli platformadan foydalanish va yechimlarni tanlash uchun moslik darajasini baholash kiradi.

Natijalar: yuklamalarni optimal boshqarish, energiya samaradorligi oshishi, xarajatlarning qisqarishi, resurslarning tejalishi, jarayonlarning avtomatlashtirilishi va boshqaruv samaradorligining oshishi asosida korxonada energiya iste’molini optimal boshqarish va texnik tadbirlarni samarali bajarishga imkon yaratdi.

Kalit so'zlari: intellektual boshqaruv tizimlari, raqamli platformalar, energiya samaradorligi, yuklamalarni boshqarish, sanoat korxonalari, tashkiliy-texnik tadbirlar, avtomatlashtirilgan monitoring, energiya resurslarini optimallashtirish, xarajatlarni qisqartirish, energiya iste’molini nazorat qilish.

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Управление электрически нагрузками с помощью интеллектуальных систем управления и цифровых платформ

Икромжон У. Рахмонов[1], Нурбек Н. Курбонов[1, a)], Ли Чжан[2], Ильхом, А. Ниматуллаев [3], Нумон, Н. Ниезов [1, a)]

[1]DSc, проф., Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; ilider1987@yandex.com https://orcid.org/0009-0002-0761-0787

[1,a)]PhD, доц., Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; nurbek.kurbonov.96@gmail.com https://orcid.org/0000-0003-2076-5919

[2]PhD, доц., Шаньдунский университет, г. Цзинань, провинция Шаньдун, 250061, Китай; zhleee@sdu.edu.cn; https://orcid.org/0000-0002-5913-2513

[3]Инспекция по контролю за использованием электрической энергии, нефтепродуктов и газа при Кабинете Министров Республики Узбекистан, Ташкент, 100047, Узбекистан; i.nimatullayev@uzenergoinspeksiya. uz https://orcid.org/0009-0002-0761-0787

Актуальность: рост числа и многообразия потребителей энергии и объемов энергопотребления с каждым годом усложняют управление нагрузками и мониторинг технического состояния потребителей энергии. Традиционные методы управления нагрузками часто приводят к проблемам в энергетической системе, таким, например, как неправильное распределение нагрузок и вызванных этим перегрузкам и др. Кроме того, остаются значимыми проблемы, связанные с оперативной разработкой и реализацией организационно-технических мероприятий по оптимизации управления нагрузками. Эффективным способом решения этой проблемы является использование интеллектуальных систем управления и цифровых платформ. Данная статья и повящена решению этой проблемы.

Цель: основной целью данной статьи является разработка методов и алгоритмов для оптимального управления нагрузками на промышленных предприятиях с использованием интеллектуальных систем управления и цифровых платформ. Это позволяет повысить эффективность потребления электроэнергии за счет совершенствования планирования, мониторинга и оценки объемов предстоящего энергопотребления.

Методы: используемые методы включают планирование и мониторинг организационно-технических мероприятий, формирование энергетического баланса с помощью цифровой платформы, оценку эффективности, автоматизацию контроля за потреблением энергии, использование цифровой платформы для управления и оценку совместимости при выборе решений.

Результаты: разработаны и апробированы новые методы управления энергопотреблением, позволяющие промышленным предприятиям повышать энергоэффективность, снижать затраты, экономить ресурсыов.

Ключевые слова: интеллектуальные системы управления, цифровые платформы, энергоэффективность, управление нагрузками, промышленные предприятия, организационно-технические мероприятия, автоматизированный мониторинг, оптимизация энергоресурсов, снижение затрат, контроль энергопотребления.

Optimal load management through the use of intelligent control systems and digital platforms

Ikromjon U. Rakhmonov[1], Nurbek N. Kurbanov[1, a)], Li Zhang[2], Ilhom, A. Nimatullayev [3], Numon, N. Niyozov [1, a)]

[1]DSc, Prof., Tashkent State Technical University, Tashkent, 100095, Uzbekistan; ilider1987@yandex.com; https://orcid.org/0009-0002-0761-0787

[1,a)]PhD, Assoc. Prof., Tashkent State Technical University, Tashkent, 100095, Uzbekistan; nur-bek.kurbonov.96@gmail.com; https://orcid.org/0000-0003-2076-5919

[2]PhD, Assoc. Prof., Shandong University, Jinan, Shandong Province, 250061, China; zhleee@sdu.edu.cn; https://orcid.org/0000-0002-5913-2513

[3]Inspectorate for Supervision of Electricity, Petroleum Products, and Gas Utilization under the Cabinet of Ministers, Tashkent, 100047, Uzbekistan; i.nimatullayev@uzenergoinspeksiya.uz https://orcid.org/0009-0002-0761-0787

Relevance: the increasing number of energy consumers and the rising energy consumption each year are making load management and monitoring the technical condition of energy consumers progressively more complex. Traditional load management methods often lead to issues in the energy system, such as improper load distribution, overloading, and similar problems. Additionally, challenges related to promptly devising, adopting, and implementing organizational and technical measures for optimal load management remain significant. Here, the use of intelligent management systems and digital platforms offers an effective solution. This article addresses the management issues in implementing and controlling organizational-technical measures through digital platforms to ensure the efficient and rational use of energy resources in industrial enterprises, aiming for optimal load management.

Aim: the primary objective of this article is to develop methods and algorithms for optimal load management in industrial enterprises through the use of intelligent management systems and digital platforms. This facilitates energy efficiency improvement by automating the planning, monitoring, and evaluation of energy consumption.

Methods: the methods used include planning and monitoring of organizational-technical measures, forming an energy balance through a digital platform, evaluating efficiency, automating energy consumption monitoring, utilizing a digital platform for management, and assessing compatibility for solution selection.

Results: optimal load management, increased energy efficiency, cost reduction, resource savings, automation of processes, and enhanced management efficiency enable industrial enterprises to optimally manage energy consumption and effectively implement technical measures.

Key words: intelligent management systems, digital platforms, energy efficiency, load management, industrial enterprises, organizational-technical measures, automated monitoring, energy resource optimization, cost reduction, energy consumption monitoring.

1. Introduction

The rapid advancement of industrial technologies has led to significant increases in energy consumption across industrial enterprises. With energy costs rising and sustainability becoming a priority, industries are under pressure to manage resources efficiently. In this context, optimizing energy consumption through intelligent control systems and digital platforms is essential. These systems enable efficient management and monitoring of energy use, which not only reduces operational costs but also enhances overall energy efficiency and sustainability in the industrial sector. One of the main challenges in industrial energy management is ensuring that resources are allocated and utilized efficiently while meeting production demands. Traditional energy management approaches often rely on manual monitoring and static control mechanisms, which are insufficient for the complex and dynamic energy needs of modern industries. Digital platforms, integrated with intelligent control systems, offer a solution by enabling real-time monitoring, planning, and assessment of energy usage. These platforms provide industries with automated tools for managing energy loads, forecasting consumption, and optimizing operational strategies based on real-time data and predictive algorithms [1,2].

In Uzbekistan, where the industrial sector is a major contributor to the economy, improving energy efficiency in industrial enterprises is a national priority. The country's increasing focus on digital transformation and sustainable development aligns with the global trend toward energy-efficient practices. However, the adoption of digital platforms and intelligent systems in energy management is still in its nascent stages. Therefore, developing and implementing intelligent control systems for energy management in Uzbek industrial enterprises is both a timely and relevant endeavor. The purpose of this paper is to explore the development and application of intelligent control systems and digital platforms for optimal load management in industrial enterprises. Specifically, this research aims to provide a framework for selecting and monitoring organizational and technical measures that improve energy efficiency, reduce operational costs, and conserve resources [3,4]. Through the use of digital platforms, these processes can be automated, allowing for seamless integration of energy management into daily operations.

This research contributes to the growing body of knowledge on digital transformation and sustainable energy management in industrial enterprises [5]. By providing a practical framework and demonstrating the benefits of intelligent control systems in load management, this study offers valuable insights for practitioners, policymakers, and researchers interested in optimizing energy usage in industrial settings. Through the integration of intelligent control systems and digital platforms, industrial enterprises can achieve higher efficiency, reduce costs, and contribute to global sustainability goals.

2. Methods and materials

The study utilizes a digital platform to manage organizational and technical measures for optimizing energy consumption. Methods include planning, monitoring, and evaluating energy use through automated modules. These modules provide tools for selecting appropriate measures, tracking their execution, and assessing effectiveness, enabling enterprises to streamline energy load management.

Materials involve a structured digital interface for user levels, from operational staff to administrators, to input, monitor, and analyze data. This platform integrates real-time data processing and feedback loops, facilitating decision-making based on performance metrics. Energy balance calculations and compatibility assessments enhance the reliability and efficiency of load management within industrial settings.

3. Results and Disscussion

In recent years, continuous monitoring of energy consumption and ensuring its efficient use have become increasingly critical issues in light of growing environmental concerns and the rising cost of energy. Efficient energy management is essential not only for reducing operational costs but also for minimizing the environmental impact of industrial activities. To address this need for efficiency, a digital platform with a user-friendly interface (as illustrated in Figure 1) has been developed to facilitate quick and effective management of energy resources. This platform incorporates a specialized module called "Selection and Monitoring of Organizational-Technical Measures," which is designed to streamline energy-saving initiatives within organizations. This module is divided into two key components:

1. Planning of organizational-technical measures. This component allows users to systematically

design and organize technical measures aimed at optimizing energy usage. The planning process follows a structured algorithm, as shown in Figure 1, to ensure that all necessary steps and requirements are considered.

2. Monitoring the implementation of organizational-technical measures. This component focuses on tracking the execution of planned measures, enabling users to monitor their effectiveness and make adjustments as necessary. Continuous monitoring ensures that energy-saving initiatives are implemented as intended and that potential issues are promptly addressed.

The planning of organizational and technical measures follows the algorithm presented in Figure 4.1. In this process, Level III users are responsible for developing specific measures based on the prescribed steps within the algorithm. Once these measures have been developed, they are sent to Level II and Level I users—those with the authority to review and approve such measures.

After review, if the Level I and Level II users approve the proposed organizational and technical measures, a notification is sent back to the Level III user. This notification signifies that the proposed measures have been authorized and can now be implemented [6,7]. By maintaining this hierarchical review process, the platform ensures that energy-saving strategies are thoroughly vetted before implementation, increasing their likelihood of success and compliance. Through this digital platform, organizations can not only ensure a systematic approach to energy conservation but also enhance collaboration among different levels of users, ultimately promoting a more efficient energy management system.

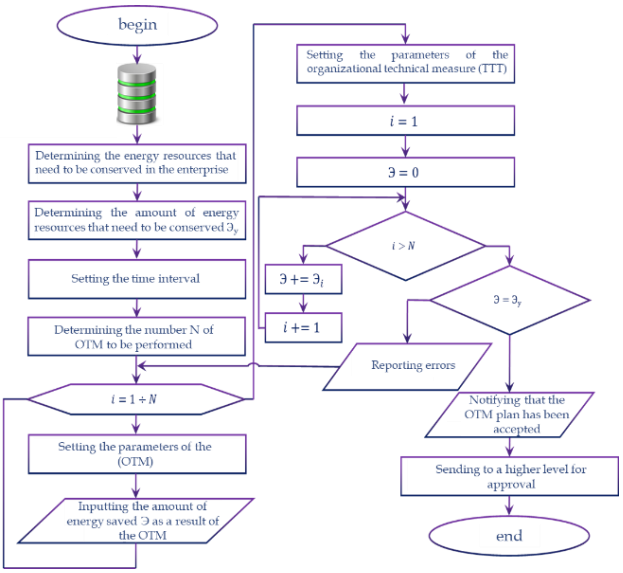

Fig.1. Algorithm for Planning Organizational and Technical Measures

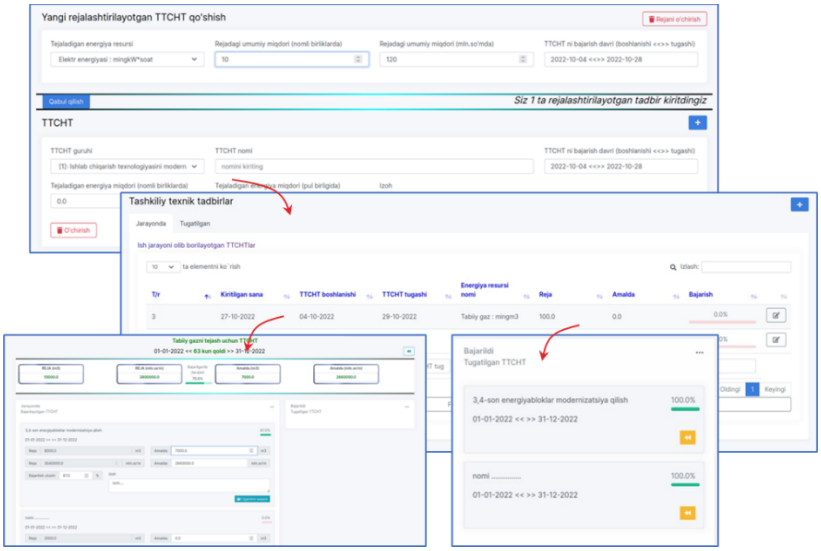

Fig.2. Interface for Planning and Monitoring the Implementation of Organizational and Technical Measures.

After receiving the notification, the Level III user begins implementing the organizational and technical measure. The amount of energy resources saved as a result of this measure is continuously recorded in the monitoring section for the completion of organizational and technical measures.

The monitoring section for the implementation of organizational and technical measures includes the stages shown in Figure 3.

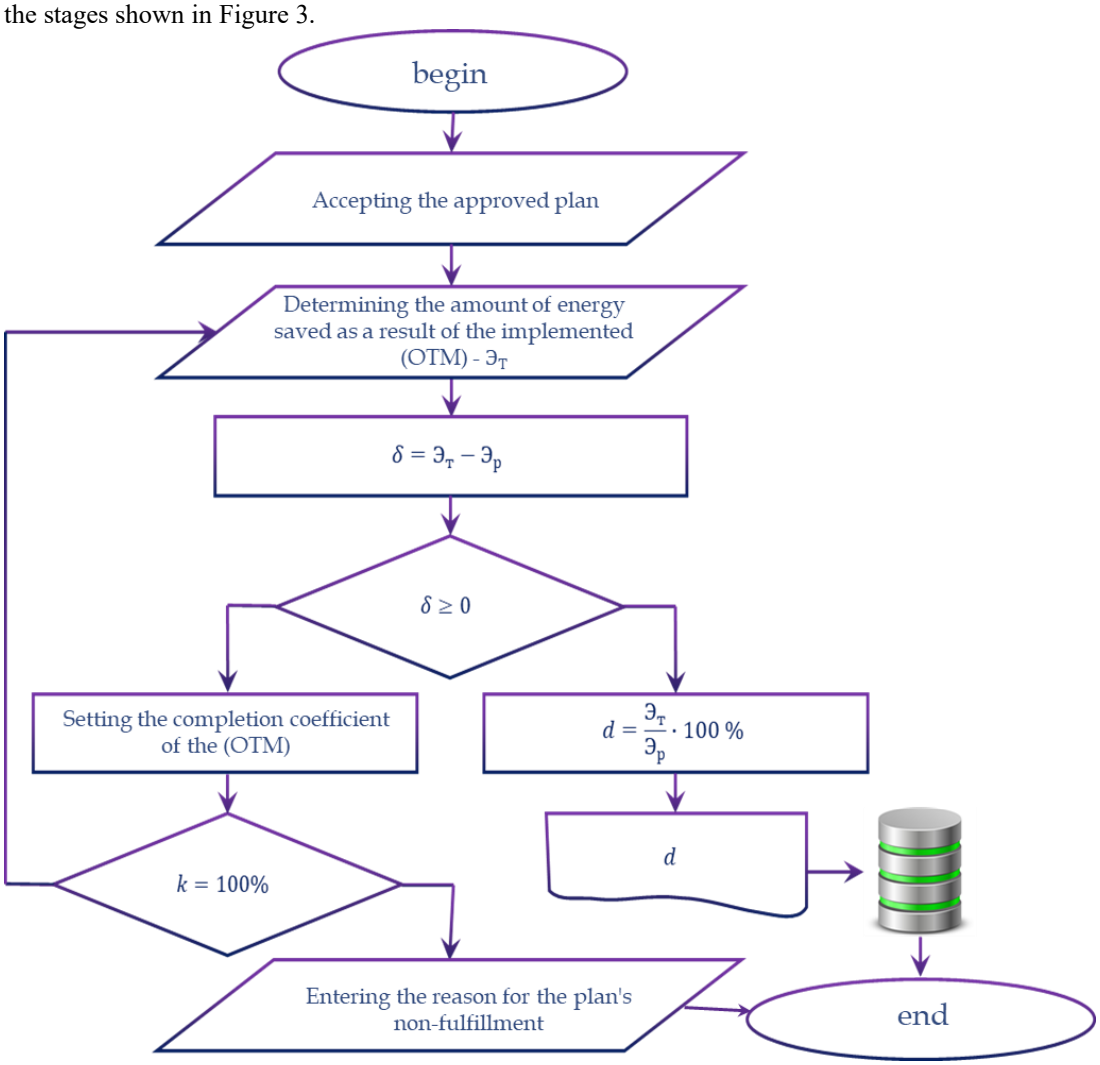

Fig.3. Algorithm for Proposing Organizational and Technical Measures and Evaluating Their Suitability

Alongside the acceptance and monitoring of organizational and technical measures within the digital platform's database, a mechanism has been developed to propose these measures based on the value of the energy intensity indicator.

This digital platform not only allows for the structured recording and supervision of organizational and technical measures but also introduces a data-driven recommendation system. By evaluating the energy intensity indicator—a key metric representing the energy consumption per unit of output—the platform can suggest targeted measures to optimize energy use. This mechanism enables organizations to prioritize actions that are most likely to yield significant energy savings, helping them to efficiently allocate resources toward energy conservation efforts. Such an approach ensures that the proposed measures align with the organization's energy efficiency goals, encouraging continuous improvement in operational processes. The integration of this recommendation system within the digital platform provides a proactive framework, allowing users to make informed decisions based on real-time data analysis and to implement energy-saving measures tailored to their specific operational needs.

Accordingly, organizational and technical measures are initially implemented based on templates of organizational and technical measures developed within the system. The suitability of the proposed organizational and technical measure is determined by the level of technological compliance using the following expression:

$$m = \frac{n}{15} \cdot 100\% \quad (1)$$

where, n-energy consumption refers to the level of installation of technical accounting devices.

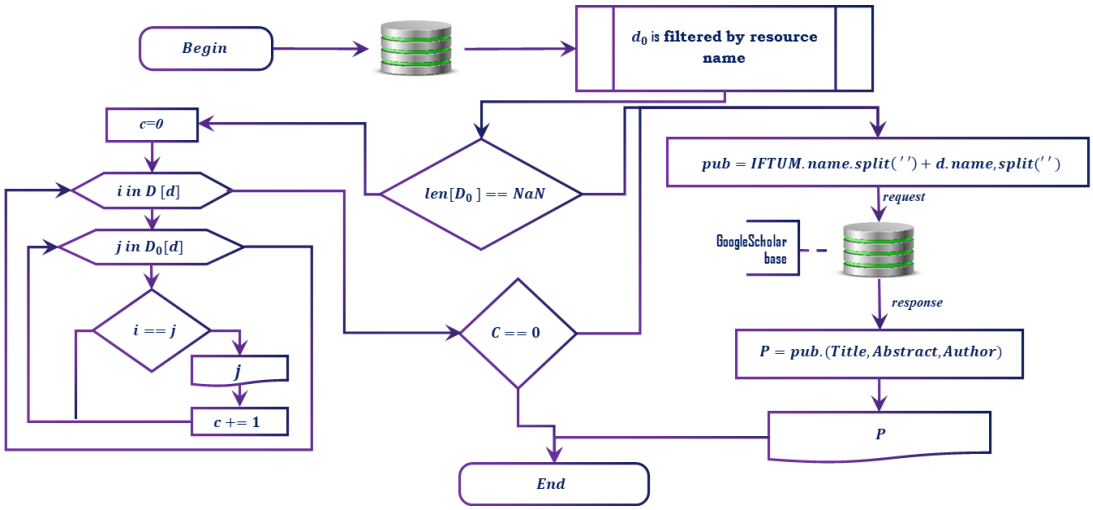

Fig.4. Algorithm for Proposing and Decision-Making of OTM

If no solution is found among the existing templates to address the problem at the specified time, relevant organizational and technical measures are identified from the digital platform database. These measures have been implemented by all enterprises and have demonstrated high effectiveness (over 80%). The degree of relevance of these measures is then evaluated (Figure 4). It is known that when developing organizational and technical measures, all factors contributing to the emerging problem are taken into account and stored in the digital platform database. The degree of relevance is determined by comparing these factors with the causes presented at the proposed time, as expressed by the following equation:

$$m = \frac{\sum_{i=0}^{n_{\max}} k_i}{n_{\max}} \cdot 100\% \tag{2}$$

where, k_i represents the ratio of the values of compatible factors.

$$\begin{cases} \frac{\phi_1}{\phi_2} > 1 \Rightarrow k_i = \frac{\phi_2}{\phi_1} \\ \frac{\phi_1}{\phi_2} < 1 \Rightarrow k_i = \frac{\phi_1}{\phi_2} \end{cases} \tag{3}$$

If no solution is found among the organizational and technical measures stored in the digital platform database, alternative solutions that may address the issue are suggested from global databases (Scopus, Google Scholar). In this case, the relevance degree is not calculated.

For the module responsible for selecting organizational and technical measures, a certificate (DGU №19197) has been obtained from the Intellectual Property Agency of the Republic of Uzbekistan for the OTM_PRO software, which identifies and evaluates the energy efficiency of organizational and technical measures in industrial enterprises [8].

Developing and analyzing the energy balance of an industrial enterprise enables the identification of primary reserves to increase energy consumption efficiency and resource utilization. This also allows for evaluating the rational use of energy resources at consumption points [9; pp. 62-65, 10; pp. 260-263]. The method of forming the energy balance in the digital platform varies depending on the user level. Each user level can create energy balances based on the information they possess within their scope of authority and capabilities [11,12].

For Level III users, the necessary energy resources are selected to form the energy balance, followed by selecting the energy balance period. Instructions for generating the energy balance are provided in Appendix 7. The detailed structure for preparing reports is outlined in Appendix 8.

A significant feature of the DIGITAL PLATFORM is its universal approach to presenting data for report generation, including tables, graphs, and tabular data formats [13,14,15]. According to this principle, DIGITAL PLATFORM users at Levels I, II, and III have the capability to automatically generate all necessary report forms.

4. Conclusion

The integration of intelligent control systems and digital platforms for optimal load management in industrial enterprises presents significant benefits for energy efficiency, cost reduction, and resource conservation. The developed digital platform, with modules for selecting and monitoring organizational and technical measures, enables automation in energy consumption control, planning, and evaluation. By implementing these systems, industrial enterprises can systematically address energy challenges, reduce operational costs, and enhance sustainability. The study emphasizes the importance of a structured approach to energy management, with hierarchical user levels facilitating data input, monitoring, and reporting. This approach allows for flexibility across different organizational roles, enabling each level to contribute to efficient energy management within their scope of authority. The universal presentation formats on the platform—tables, graphs, and charts—support comprehensive reporting and facilitate data-driven decision-making.

Furthermore, the platform's recommendation system provides a proactive mechanism for proposing energy-saving measures based on real-time data and energy intensity indicators. When internal solutions are insufficient, the platform leverages global databases to identify alternative solutions, ensuring that the most effective practices are available to address emerging issues. This adaptability underscores the platform's relevance in the dynamic industrial landscape. In conclusion, the developed digital platform, certified by the Intellectual Property Agency of Uzbekistan for the OTM_PRO software, stands as a critical tool for enhancing energy efficiency in industrial enterprises. By automating energy management processes and enabling informed decision-making, the platform supports Uzbekistan's goals for digital transformation and sustainability, providing a robust framework for enterprises to achieve energy efficiency and contribute to global environmental goals.

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