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Analysis Of Increasing Energy Efficiency Through The Use Of IoT Technologies In Food Production

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Abstract
Rising energy demand and prices are significant challenges for the energy-intensive food sector throughout the supply chain. Thus, improving energy efficiency has become an important priority for the food sector. However, most food businesses have limited awareness of the latest technological advances in real-time energy monitoring. The concept of "Internet of Things" (IoT) is used in production enterprises of developed countries around the world to obtain energy data in real time. The Internet of Things has been explored to increase visibility, transparency and awareness of different levels of energy use. This article provides analysis and suggestions for achieving energy efficiency through real-time data collection in food production and processing enterprises. An example of a beverage plant in food processing and processing enterprises is given, where energy consumption reduction measures have been developed by introducing sensor technology that supports the Internet of Things, based on the product energy model.
Key words. Food production, energy efficiency, energy saving, real time, intelligent devices, efficient lighting solutions, heating and cooling, energy saving, energy used per unit of product, improving the efficiency of equipment use, reducing waste.

Introduction. Today, the need for energy is determined by three main factors: 1) Population growth, 2) Economic development of society, 3) Scientific and technical level of production in technological processes. In the world, these needs are increasing year by year and by 2022 will exceed 10 billion tons of oil equivalent per year. Along with the increase in the world's population, the volume of food production and processing is also constantly growing. According to statistical data, in the last hundred years, the population of the earth has increased by 4 times, and the annual energy production has increased by 21 times. This, in turn, requires a sharp increase in the volume of food production and processing. Recent studies show that the world's food production systems - from the farms where food is grown to the processing and marketing chain - consume 30% of all available energy. Rising energy demand and prices are a pressing issue for the food sector, which consumes large amounts of energy throughout the energy supply chain. Thus, improving energy efficiency has become an important priority for the food sector.

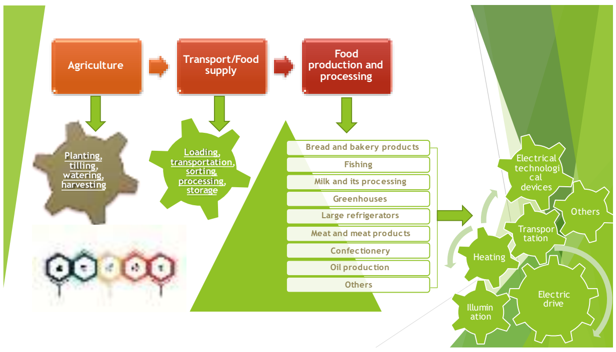

Figure 1. Energy system of food production from production to processing.

The availability of uninterrupted energy supply in the future is a cause for concern due to the depletion of fossil fuel resources and the increasing world population. According to UNESCO's 2022 report, the food production and supply chain accounts for 30% of global energy consumption, and this is mainly in four food-related activities: agriculture, transport, processing and food processing as shown in Figure 1. The threat

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of energy shortages and high energy costs is already approaching the food sector, and they need to address it urgently.

As a result of the research, the amount of energy consumed per kilogram of several food products was analyzed. In this case, the average amount of electricity and fuel energy used for processing milk and dairy products, fruits and vegetables was expressed in MJ/kg.

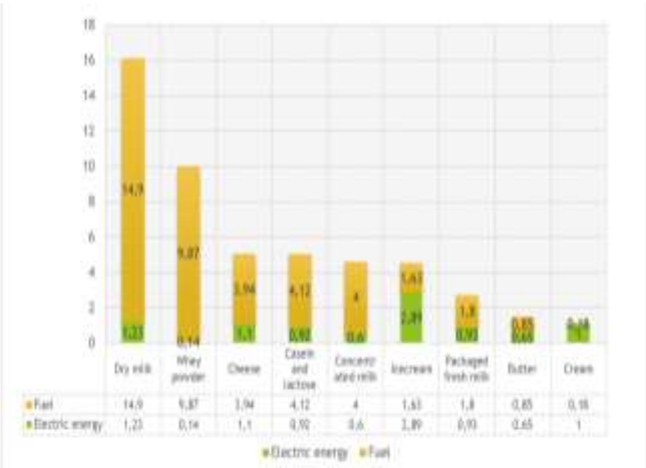


Figure 2: Average final electrical and fuel energy used for dairy production

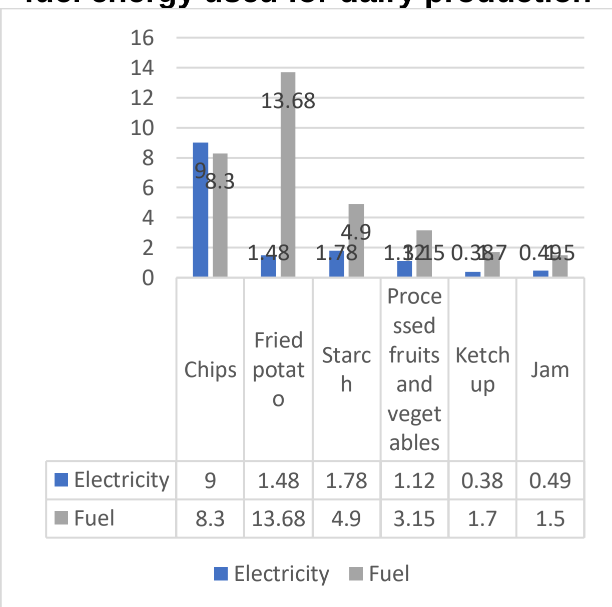


Figure 3: Average final electrical and fuel energy used for fruit and vegetable processing (MJ/kg product)

Some options to reduce the amount of energy used in the above food products are to reduce energy-intensive activities without affecting the profitability of the producer, or to better manage energy and recover energy. Energy management systems (EMS's) are widely implemented in the food production sector to achieve and sustain improvements in energy use. EMS is complex with various parameters such as energy production, energy import/export, energy storage, energy conversion, energy transmission and energy consumption. This situation can be further complicated by other uncertain parameters (ie, interval, probability, and probability distribution). Thus, in order to improve energy efficiency, there is a need for a system that provides a detailed breakdown of the energy consumption of their production facilities in real time.

Methods. Energy smart meters based on the Internet of Things (IoT) network of intelligent devices can provide visibility and reliability on energy consumption efficiency and productivity. It provides management with critical information on the energy consumption levels of various manufacturing facilities, thereby enabling them to make better decisions in real time to reduce overall energy consumption. This paper aims to demonstrate the application of an IoT-based smart energy system in reducing energy wastage in a beverage company. The article provides a brief overview of the technologies adopted to optimize energy consumption in food production enterprises, as well as the basis for measuring the energy of food products. The last sections present a case study of how a food manufacturing company implemented a smart energy metering system connected to an IoT system based on a product energy model to reduce annual energy consumption and thereby increase its profit margin.

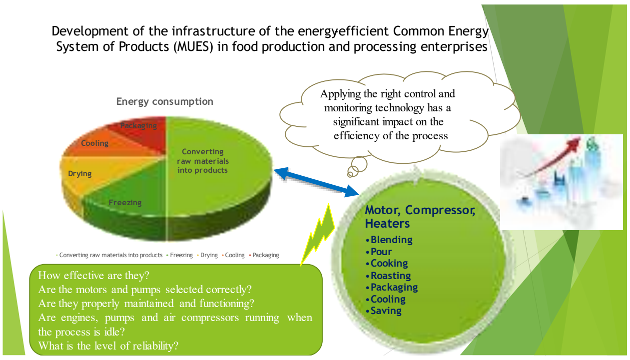


Figure 2. Infrastructure of the total energy system of energy-efficient products in food production and processing enterprises

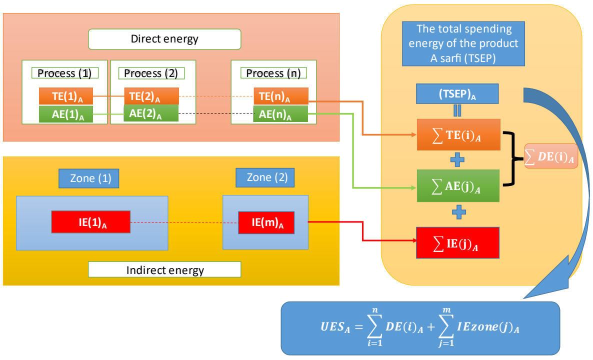


Figure 3. Total energy consumption of food products.

Advantages of real-time energy data collection:

1. Cost savings: By monitoring energy consumption in real time, businesses can identify areas of excessive energy consumption and implement targeted energy conservation measures. This can result in significant cost savings in terms of reduced energy bills.

2. Improve energy efficiency: Real-time data allows businesses to understand how energy is being used in their operations. This allows them to optimize energy consumption and identify areas where efficiency can be improved. By making decisions based on real-time data, businesses can reduce waste and improve overall energy efficiency.

3. Demand Management: Real-time data helps businesses better manage energy demand. By identifying peak usage periods and load patterns, businesses can schedule energy-intensive activities during off-peak hours to avoid costly demand charges or power outages.

4. Risk Reduction: Real-time data collection allows businesses to identify anomalies or deviations from normal energy consumption patterns. This helps identify equipment malfunctions, leaks, or other problems that could lead to costly downtime or safety hazards. By addressing these issues promptly, businesses can avoid potential risks and minimize downtime.

5. Sustainability and environmental benefits: Real-time energy data collection promotes sustainability by enabling businesses to monitor their carbon footprint and take proactive steps to reduce it. By identifying energy-intensive processes or equipment, businesses can implement energy-saving technologies or renewable energy sources to reduce environmental impact.

6. Regulatory Compliance: Real-time energy data collection provides businesses with accurate and up-to-date information on energy usage. This helps ensure compliance with energy reporting and auditing requirements imposed by regulatory bodies or industry standards.

We developed a general model of food production and processing enterprises based on the "Internet of Intelligent Devices" (Internet of Things) as a result of many analyzes during the research. In the utility model we have developed, the issue of achieving efficiency through comprehensive control and management as well as real-time data management throughout the entire production and processing network is the main essence of the utility model. With the help of the "Internet of intelligent devices" (Internet of things), in-depth analysis of data in real time, development of methods of reducing total energy consumption, development of energy-saving measures in energy supply of technological processes, improvement of energy efficiency in consumption a model of the improvement system and a detailed classification of the data of the General Energy System of Products (GESP) have been developed. In this, through modern technologies ("Internet of things", artificial intelligence devices, digital technologies), real-time control of the total energy data spent on the entire system of food products, from planting to the finished product, and management, and through this, it is possible to make decisions aimed at efficiency.

Today, one of the main issues is the collection of data, control and application of energy-efficient technologies in the production and processing of food products. As energy costs continue to rise, food and beverage manufacturers need to gain more control over these costs to gain a competitive advantage. The key to reducing energy-related costs is to understand where, when and how much is consumed. Armed with this information, companies can proactively manage load demands, improve system performance and reduce costs. That is, it is necessary to fully consider the issues of knowing the total energy consumed per unit product, reducing wastage, and improving the quality of control and management. This, in turn, leads to a reduction in the amount of energy used per unit of production and processing of the product, ensuring quality and safety control, making energy-efficient decisions and reducing the need for human intervention. The main essence of a useful model is that it considers the issue of achieving efficiency through the entire production and processing network, comprehensive control and management, as well as real-time data collection.

A useful model task: The task of the proposed device, unlike the previous devices, is to develop ways to reduce overall energy consumption by analyzing the data using the "Internet of Intelligent Devices", and to provide energy for the technological processes of food production and processing. development of energy-saving measures, development of a system model for increasing energy efficiency in the process of food production and processing, detailed classification of general energy system data of products, development of energy consumption models.

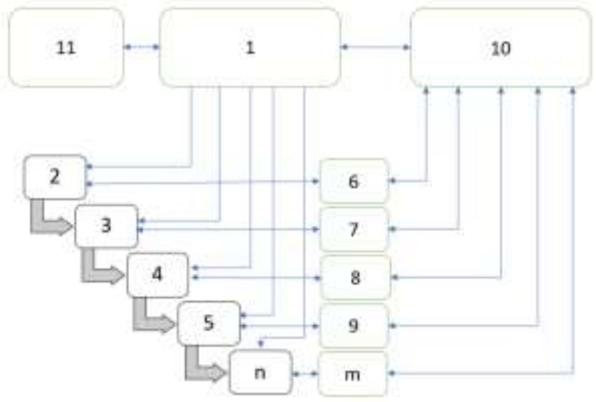
Fulfillment of the task: The implementation of the task in the proposed model is carried out by receiving energy data in real time in enterprises based on the "Internet of Intelligent Devices" (Internet of Things) used in it. Through the use of such a model, food production and processing enterprises will have the ability to predict energy consumption, quality, control indicators, future production and failures in each section at the same time. Energy management system (EMS) is a complex structure consisting of various parameters such as energy production, energy import/export, energy storage, energy conversion, energy transmission and energy consumption. This situation can be further complicated by other uncertain parameters (ie, interval, probability, and probability distribution). Thus, in order to improve energy efficiency, there is a need for a system that provides a detailed breakdown of the energy consumption of their production facilities in real time.

The importance of real-time data collection: Ensuring quality and safety control (For example, during the storage of products), Preventing failures (For example, monitoring the status of engines in the process at the same time and eliminating if there is a failure), Fast, energy making and managing cost-saving decisions (obtaining information about each energy user), (possibility of obtaining permanent energy audit data, determination of energy consumption, quality indicators, and energy waste values for each site), Accurate and reliable forecasting (estimation of productivity by monitoring the light, temperature, humidity and soil moisture of cultivated areas), Reducing the need for human intervention (Remote control, if sensors detect that workers are working in the enterprise, turn on the air conditioner, lighting devices, or if, if not, delete) it is possible to perform actual tasks.

Important features that characterize a useful model: Key features of the utility model are the interconnection of energy-consuming devices in enterprises using different types of sensors, such as radio frequency identification, and actuators that work together to sense, collect and transmit, and physical and digital using utility technologies. refers to the connection between the world. Using this model, producers can track their production from the farm to the end user, which can improve food safety and can be used to collect information related to production processes, and this information can be manipulated to make better decisions about the business process model.

In our model, energy management practices focus on improving energy efficiency. Collecting and analyzing data in the model facilitates investment in technology, and through continuous operation, it can also identify inefficiencies, malfunctioning equipment, optimize the energy system and evaluate the effectiveness of technologies.

The proposed model works as follows: In food production and processing enterprises or other industrial enterprises, all energy-consuming devices are registered and divided into plots. Before that, intelligent devices performing various tasks are installed on the plots in a suitable manner and the program is installed. In this case, there is no resistance to the operation and structure of the company's devices, that is, efficiency is achieved through existing devices. Installed intelligent devices are interconnected with the Internet network, and information about each energy-consuming device (its energy parameters, quality indicators, safety and control indicators, malfunctions and operating status) is obtained. . On the basis of the collected data, optimal and cost-effective operating modes for devices are developed, workflow control schemes are created, faults are identified and methods of their elimination are shown. In this model, future plans for enterprises are developed: production forecast indicators in accordance with the level of consumption, possible failures and methods of their elimination, and several other efficiency-oriented activities. A schematic view of this process is shown in Scheme 1.



Scheme 1. General model of food production and processing enterprises based on "Internet of intelligent devices" (Internet of Things).

It can be seen from the given scheme 1 that energy comes to food production and processing enterprises in different forms from electric energy producers (11), the main reducing substation of the enterprise and a set of general energy distribution devices (1). Energy is distributed from it to all sections (2, 3, 4, 5, n).

A useful model is to increase energy efficiency through a high level of energy resource management system. In the center, there are at least two identical software and hardware systems for data processing and IoT management, each of which includes a web server and an application server, and the server has a message line, communication using IoT protocols. There is a data collection and transmission unit. Each server block is networked to each other, storage and file server, there is also an analytical block, a control block, a central data balancing block, and a message queuing control block.

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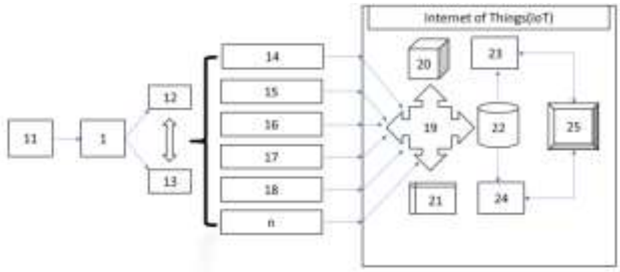

Scheme 2. The structural system of the general model of food production and processing enterprises based on the "Internet of Things".

An energy calculation system is implemented in the complex of accounting for all energy consumption values, i.e. Intellectual structures (6, 7, 8, 9, m), data is managed through the 10th data management device. Figure 2 shows the main processes. Direct(12) and indirect(13) energy users are connected to the data collection device(19) using the Internet. The Internet of Things section of intelligent devices includes the Internet (20), sensor (21), data storage (22), data processing (23), data control and management (24), and computer (25).) are involved. Power monitoring, water monitoring, gas monitoring, shutdown operations, energy monitoring (Short-term, periodic, continuous modes), monitoring (Demand management, Emergency load shutdown, Compressed air management and optimization, Pump optimization solutions, Steam gas consumption reduction, waste detection) are performed. A global control center for the consumption of energy resources based on IoT technology, which includes at least two identical software and hardware systems for data processing and IoT management, data collection and storage that can scale internal data storage segments , a server designed to store data in the form of files, a data balancing unit and a message queue control unit designed for indirect information interaction of energy resource consumption management systems of complexes with intelligent devices, each The complex includes a web server and an application server connected to it, which in turn includes a message bus, a block for collection and transmission. Analytical block configured to implement the function of processing and analyzing data, energy resource consumption indicators and generating control commands through protocols of intelligent devices, control block configured to implement scenarios for control, program launch logic i, IoT request timing, interaction with databases, as well as data encryption and protection, there are blocks of each server.

Smart meters of energy in each department of production enterprises and some machines measure the corresponding energy consumption. This enabled daily real-time monitoring of direct and indirect energy use and efficiency of each facility based on the GESP model. To measure energy consumption in enterprises, smart energy meters are installed for each technological and energy-intensive equipment, such as energy consumers, heating and cooling devices, and engines. The indirect and direct energy data collected by these smart meters based on the GESP model are transmitted wirelessly to a central database, where they are stored and analyzed to obtain meaningful and actionable information. Real-time, actionable energy data is made available to all energy-related personnel in a user-friendly dashboard.

The savings interface row on the sensors in the model shows how much electricity is saved or lost for each month. This provides a high level of energy awareness that enables decision makers to make sound energy use decisions.

Furthermore, it shows how IoT-enabled energy monitoring solutions based on the GESP model are important for the food sector and should be included in plant energy management initiatives. At the same time, during the implementation of the case study, it became clear that problems such as food production stoppages, product wastage and contamination risks can be eliminated by installing IoT devices.

Conclusion. Overall, real-time energy data collection enables businesses to make data-driven decisions, improve operational efficiency, reduce costs, mitigate risks, and contribute to sustainability goals. Rising energy demand and prices are a pressing issue for the food sector, which consumes large amounts of energy throughout the energy supply chain. Thus, improving energy efficiency has become an important priority for the food sector. The Internet of Things (IoT) has been explored to increase visibility, transparency and awareness of different levels of energy use while collecting real-time data. The proposed "General Model of Food Production and Processing Enterprises based on the Internet of Things" is mainly energy-using devices (Engines, heating, cooling, freezing devices, electrotechnological devices, lighting, storage , transport devices, etc.), consists of intelligent devices (microcontroller, sensor, smart devices and automation devices, intelligent monitoring boxes, relays, etc.), and differs from its close analogue in that it uses separate intelligent modern devices and with their help, information on energy consumption, management, control is obtained in real time.

Above, the model we have developed is the infrastructure of energy-efficient Product Common Energy System (GESP) in food production and processing enterprises. It describes the energy consumption in the departments and devices until the food products are ready. Converting raw materials to products (ie, motors, compressors, and heaters) consumes the most energy. In the above sections, the use of the right management and control technologies to reduce and optimize energy consumption has a significant impact on the energy efficiency of the process.

References:

Accorsi, R., Bortolini, M., Baruffaldi, G., Pilati, F., & Ferrari, E. (2017). Internet-of-things paradigm in food supply chains control and management. ProcediaManufacturing,11, 889–895. https://doi.org/10.1016/j.promfg.2017.07.192

Cai, Y., Huang, G., Yang, Z., & Tan, Q. (2009). Identification of optimal strategies for energy management systems planning under multiple uncertainties. Applied Energy, 86(4), 480–495. https://doi.org/10.1016/j.apenergy.2008.09.025

Arshad, R., Zahoor, S., Shah, M. A., Wahid, A., & Yu, H. (2017). Green IoT: An investigation on energy saving practices for 2020 and beyond. IEEE Access, 5, 15667–15681. https://doi.org/10.1109/ACCESS.2017.2686092

Backlund, S., Thollander, P., Palm, J., & Ottosson, M. (2012). Extending the energy efficiency gap. Energy Policy, 392–396. https://doi.org/10.1016/j.enpol.2012.08.042

Baysan, S., Kabadurmus, O., Cevikcan, E., Satoglu, S. I., & Durmusoglu, M. B. (2019). A simulation-based methodology for the analysis of the effect of lean tools on energy efficiency: An application in power distribution industry. Journal of Cleaner Production, 211, 895–908. https://doi.org/10.1016/j.jclepro.2018.11.217

K. E. Khujamatov, D. T. Khasanov and E. N. Reypnazarov, "Modeling and Research of Automatic Sun Tracking System on the bases of IoT and Arduino UNO," 2019 International Conference on Information Science and Communications Technologies (ICISCT), 2019, pp. 1-5, doi: 10.1109/ICISCT47635.2019.9011913.

A. Kabulov, I. Saymanov, I. Yarashov and F. Muxammadiev, "Algorithmic method of security of the Internet of Things based on steganographic coding," 2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS), 2021, pp. 1-5, doi: 10.1109/IEMTRONICS52119.2021.9422588.

Khujamatov, H., Reypnazarov, E., Khasanov, D., Akhmedov, N. (2021). IoT, IIoT, and Cyber-Physical Systems Integration. In: Singh, K.K., Nayyar, A., Tanwar, S., Abouhawwash, M. (eds) Emergence of Cyber Physical System and IoT in Smart Automation and Robotics. Advances in Science, Technology & Innovation. Springer, Cham. https://doi.org/10.1007/978-3-030-66222-6_3.

I. Siddikov, K. Khujamatov, E. Reypnazarov and D. Khasanov, "CRN and 5G based IoT: Applications, Challenges and Opportunities," 2021 International Conference on Information Science and Communications Technologies (ICISCT), 2021, pp. 1-5, doi: 10.1109/ICISCT52966.2021.9670105

Pulatov.Sh.U, Aliev.U.T.Isroilov.J.D.. Energy harvesters wireless charging technology // International Conference on Information Science and Communications Technologies (ICISCT) Applications, Trends and Opportunities, 2nd, 3rd and 4th of November 2017, Tashkent, Uzbekistan. DOI: 10.1109/ICISCT.2017.8188566+