



Energy Efficiency in the Production Process of the Modern Food Industry

Gabriela Vanesa Mutiarani^{1*}, Karina Indah Risjana²

^{1*}Global Scholarly Research Institute, Indonesia

²Universitas Hasanuddin

*Correspondence author: Vanesamutiarani533@gmail.com

Abstract

Energy efficiency in the production process of the modern food industry is an important aspect in supporting industrial sustainability and increasing product competitiveness. The food industry has high energy needs, especially in the process of heating, cooling, drying, and storage. Therefore, the application of energy-saving technologies such as production system automation, renewable energy utilization, and production system integration is a strategic solution to reduce energy consumption and operational costs. In addition, the development of digital technology such as the Internet of Things (IoT) allows for real time monitoring of energy use so that it can identify potential energy waste in the production process. The application of modern technology such as non-thermal processes and heat recovery systems has been proven to be able to increase energy efficiency without reducing the quality of food products. Energy efficiency efforts not only provide economic benefits for the industry, but also contribute to reducing greenhouse gas emissions and supporting the development of environmentally friendly industries. Collaboration between governments, researchers, and industry players is needed to encourage more efficient and sustainable technological innovation in facing future energy demand challenges.

Keywords: Energy Efficiency, Food Industry, Production Technology

1. Introduction

The modern food industry is one of the industrial sectors that has an important role in meeting people's food needs while supporting economic growth. Along with the increasing demand for food products, the production process is also experiencing increasingly complex developments and requires large energy consumption. High energy consumption mainly occurs in the process of heating, cooling, drying, and storing foodstuffs. This condition requires the industry to implement more efficient production technology in order to reduce operational costs and reduce negative impacts on the environment. Therefore, energy efficiency is one of the main aspects in the sustainable development of the food industry [1].

2. Materials and Methods

In the context of energy efficiency in the modern food industry, "material" refers to

equipment and systems used in the production process, such as heating machines, coolers, dryers, food processors, and energy monitoring equipment. In addition, the energy sources used, both electricity, gas, and renewable energy, are an important part of this material concept. The selection of energy-efficient materials and equipment can directly affect energy consumption at every stage of production and play a role in maintaining the quality of food products.

The methods applied to improve energy efficiency generally include a variety of modern strategies and technologies. Some key approaches include the automation of production processes to reduce excess energy use, the implementation of heat recovery systems to harness residual energy, and the use of digital technologies such as the Internet of Things (IoT) to monitor and regulate energy consumption in real time. In addition, optimizing production schedules and designing efficient workflows is also an important method in reducing energy waste, while supporting sustainability and operational cost savings in the modern food industry [2].

3. Results

The application of energy efficiency in the modern food industry has a significant impact on energy use at various stages of production. The heating, cooling, drying, and storage processes are the most energy-consuming parts, so focusing on managing this stage can reduce overall energy use. The use of automation technology and digital monitoring systems allows for precise equipment setup, so that energy is not wasted on inefficient operations. The results of the application of this method show a significant reduction in energy consumption compared to conventional production processes.

In addition, the application of heat recovery systems and non-thermal processing technology also improves energy efficiency. The energy generated from the previous heating or drying process can be reused for other stages of production, so that the total energy load is reduced. This not only reduces operational costs, but also lowers environmental impact, including greenhouse gas emissions generated during the production process. Thus, this strategy supports more environmentally friendly and sustainable production practices [3].

Overall, the application of energy efficiency in the modern food industry provides dual benefits, namely from the economic and environmental sides. The industry is able to reduce energy costs without sacrificing product quality, while the negative impact on the environment can be minimized. In addition, the use of modern technologies such as sensors, IoT, and automation systems opens up opportunities for the development of more innovative and sustainable production processes. With this approach, the food industry can increase competitiveness while supporting sustainable development goals [4].

3.1 Analysis of Energy Use in the Production Process of the Food Industry

The use of energy in the modern food industry is divided into several main stages, namely heating, cooling, drying, processing, and storage. Each stage has different energy needs depending on the type of product, production capacity, and technology used. The heating and drying stage is usually the largest energy consumer because it requires high temperatures to ensure product quality and shelf life. By understanding the energy distribution at each stage, the industry can determine the right efficiency strategies, such as the use of automation systems, non-thermal technologies, or heat recovery systems [5].

3.1.1 Distribution of Energy Consumption in the Food Production Process

In the modern food industry, energy consumption is spread across several major stages of



production, each of which has a different role and contribution to the total energy used. Based on a general analysis, the distribution of energy in the food production process can be explained as follows:



- Heating (40%)

The heating stage is the stage that consumes the most energy. This process includes boiling, pasteurization, or pre-cooking of the product to ensure food safety and quality. High temperatures and long heating times cause the energy used to be relatively large.
- Drying (25%)

Drying is done to reduce the moisture content in the product so that it is more durable. This process uses a significant amount of heat, either through ovens, hot air dryers, or industrial dryers.
- Refrigeration (15%)

Refrigeration is used to store raw materials and finished products. Although less than heating, the energy used is still important because it must maintain a stable temperature during the storage and distribution process.
- Processing (10%)

This stage includes mixing, grinding, cutting, or other mechanical processes. The machine used requires electrical energy, but it is relatively smaller than heating or drying.
- Storage (10%)

Energy is also used to store products, especially in warehouses or cold storage. Storage requires temperature and humidity regulation to maintain product quality until distribution.

By understanding this distribution of energy consumption, the food industry can focus energy efficiency strategies on the most energy-intensive stages, such as heating and drying. The application of energy-saving technology, automation, and heat recovery can significantly lower energy consumption and operational costs.

3.1.2 Optimizing Energy Consumption in the Food Production Process

Optimizing energy consumption in the modern food industry aims to reduce energy waste, reduce operational costs, and support sustainable industrial practices. Based on the distribution of energy consumption, the heating and drying stages are the top priorities for the implementation of efficiency strategies. Some common methods used include:

- Production Process Automation

The use of temperature, pressure, and energy flow sensors allows equipment to operate optimally as needed. The automation system can shut down or adjust the operation of the machine in real time to avoid excessive energy consumption.
- Heat Recovery



The heat energy generated from the heating or drying process can be reused for other stages, such as the initial heating of the product or the subsequent drying of the batch. This strategy reduces the need for additional energy from external sources.

- The use of technologies such as ultrasonics, microwaves, or adiabatic cooling can replace some conventional processes that require high energy. This method still maintains product quality while saving energy.
- Digital Monitoring (IoT)

Digital-based monitoring systems allow for real-time evaluation of energy consumption. The data obtained can be used to improve production schedules, optimize equipment usage, and identify energy waste points.

With the implementation of these strategies, the food industry can increase energy efficiency by up to 20-30% without degrading product quality. In addition to the economic benefits, this step also supports the reduction of greenhouse gas emissions and environmental sustainability.

4. Discussion

The application of energy efficiency in the production process of the modern food industry shows that the heating and drying stage is the main focus because it is the largest energy consumer. Strategies such as process automation, IoT-based digital monitoring, and heat recovery have proven effective in reducing energy consumption without degrading product quality. This is in line with modern food industry practices that emphasize sustainability, cost efficiency, and reduced environmental impact. By utilizing energy-saving technology, companies can not only reduce operational costs, but also increase product competitiveness through more environmentally friendly production [6].

In addition, optimizing energy consumption has a long-term positive impact on the environment and the sustainability of the food industry. Reducing excess energy use at critical stages reduces greenhouse gas emissions and the risk of wasting resources. Collaboration between technological innovation, workforce training, and efficient production process management is the key to the successful implementation of energy efficiency. With this holistic approach, the food industry can achieve a balance between productivity, product quality, and environmental responsibility, thereby supporting the development of a sustainable and future-oriented industry [7].

5. Conclusion

Energy efficiency is a crucial aspect in the modern food industry because it can reduce operational costs while supporting environmental sustainability. Analysis of the distribution of energy consumption shows that the heating and drying stages are the largest energy users, so efficiency strategies should be focused on these stages. The application of modern technologies such as process automation, IoT-based energy monitoring systems, and heat recovery has proven to be effective in reducing energy consumption without sacrificing product quality.

In addition to the economic benefits, the implementation of energy efficiency also has a positive impact on the environment, including reducing greenhouse gas emissions and saving resources. Optimizing production processes through energy-saving technology, processing method innovation, and real-time monitoring allows the food industry to achieve a balance between productivity, product quality, and environmental responsibility. Thus, energy efficiency strategies are key to supporting the sustainable and highly competitive growth of the food industry in the future.



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