ENERGY EFFICIENCY AND ENERGY SAVING OPPORTUNITIES IN HYGIENE PRODUCTS MANUFACTURING FACTORY: A CASE STUDY

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ETHICAL DECLARATION

I hereby declare that I am the sole author of this thesis and that I have conducted my work in accordance with academic rules and ethical behaviour at every stage from the planning of the thesis to its defence. I confirm that I have cited all ideas, information and findings that are not specific to my study, as required by the code of ethical behaviour, and that all statements not cited are my own.

Name, Surname:Gamze Filiz Özden

Date:09.10.2023

Signature:

ABSTRACT

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Master's Program in Sustainable Energy

Advisor: Prof. Dr. Muhittin Hakan Demir

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In this study, energy efficiency applications and studies in an industrial facility selected for the study were examined in detail. For this reason, the aim of this thesis is to show energy-saving and energy-efficient applications in production enterprises. Due to the high energy consumption values and energy potential determined as a result of the analyses made, the subject of electricity is taken as a basis. And the amount of energy we saved at the end of the project in the production facility we examined is shown in kWh. In addition, ISO50001 practices in the production facility we examined and information about these practices are explained and the impact of these energy efficiency practices on employees is shown. And it is intended to be an example for future studies.

Keywords: Energy efficiency, energy saving, production facility, electricity,ISO50001, Green Deal

ÖZET

HİJYEN ÜRÜNLERİ ÜRETİM FABRİKASINDA ENERJİ VERİMLİLİĞİ VE ENERJİ TASARRUFU FIRSATLARI: BİR ÖRNEK ÇALIŞMA

Özden, Gamze Filiz

Sürdürülebilir Enerji Yüksek Lisans Programı

Tez Danışmanı: Prof. Dr. Muhittin Hakan Demir

Ekim, 2023

Bu çalışmada, çalışma için seçilen bir endüstriyel tesisteki enerji verimliliği uygulamaları ve çalışmaları detaylı bir şekilde incelenmiştir. Bu nedenle bu tezin amacı, üretim işletmelerinde enerji tasarrufu sağlayan ve enerjiyi verimli kullanan uygulamaları göstermektir. Yapılan analizler sonucunda belirlenen yüksek enerji tüketim değerleri ve enerji potansiyeli nedeniyle elektrik konusu esas alınmaktadır. Ve incelediğimiz üretim tesisinde proje sonunda tasarruf ettiğimiz enerji miktarı kWh cinsinden gösterilmiştir. Ayrıca incelediğimiz üretim tesisindeki ISO50001 uygulamaları ve bu uygulamalar hakkında bilgiler açıklanmakta ve bu enerji verimliliği uygulamalarının çalışanlar üzerindeki etkisi gösterilmektedir ve bundan sonraki çalışmalara örnek olması amaçlanmıştır.

Anahtar Kelimeler: Enerji verimliliği, enerji tasarrufu, üretim tesisi, elektrik, ISO50001,Yeşil Mutabakat

Dedicated to My Family,

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My esteemed thesis advisor, always guided and helped me throughout my graduate education, Thank you very much Prof. Dr. Muhittin Hakan Demir.

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July 2023

Gamze Filiz Özden , Industrial Engineer

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LIST OF ABBREVIATIONS

CAPA: Corrective And Preventive Action

CBAM: Carbon Border Adjustment Mechanism

CO2: Carbon Dioxide

EGD: European Green Deal

EnMs. Energy Management System

EU ETS: Emissions Trading System

EU: European Union

IEA: International Energy Agency

IEM: Industry Energy Manager

ISO: International Organization for

Standardization KVKK: Personal Data Protection

Authority kWh: Kilowatt-hour LED: Light-

Emitting Diode

LISREL: Linear Structural Relations

OIZ: Organized Industrial Zone

PDCA: Plan Do Check Act

SEC: Specific Energy Consumption

SPSS: Statistical Package for the Social Science

T.R.: Republic of Türkiye

TEP: Ton Equivalent Petroleum

TL: Turkish Liras

WTO: World Trade Organization

YEGM: General Directorate of Renewable Energy

YEKDEM: Turkish Renewable Energy Resources Support Mechanism

CHAPTER 1: INTRODUCTION

In this thesis, the use of energy in the production facility and the study of using energy efficiently by conservation the energy used are examined. Energy is very important for the development of countries. Today, energy has become even more important with the decrease in fossil fuel reserves and its effect on global warming.

At this time when the importance of energy and its resources is increasing day by day, it has become a necessity that energy should be used economically and efficiently.

Energy saving can be achieved through studies aimed at preventing current energy losses and increasing energy efficiency. While it provides financial gain in the company where energy saving is applied, it also makes a great contribution to the welfare of the country.

Türkiye, a country trading with the European Union (EU), must also comply with the Green Deal. The relationship between International Organization for Standardization (ISO)50001 and the Green Deal in Türkiye lies in the country's efforts to adopt sustainable energy practices and reduce its carbon footprint within the scope of compliance with EU standards and policies. The thesis also examined ISO 50001, which is a tool for improving energy management systems in the factory, the thesis examined and contributed to national and international sustainability goals compatible with the Green Deal principles.

In addition, we demonstrated with our applications how the target of minimizing energy losses in industry can be achieved according to the Industrial Development Bank of Turkey (2021).

The case study analysed in this thesis focuses on a company producing hygienic products in Türkiye energy efficiency and saving studies at the facility are examined. It is aimed to increase the competitive power of the company by reducing energy costs.

Together with the energy management system Energy Management System (EnMS) team, action plans were created:

- Establishment and Publication of Energy Policy
- Establishment of Energy Planning Procedure
- Creation of Energy Management Systems Purpose and Targets Table
- Extraction of Energy Maps
- Preparation of the Table of Variables Affecting Significant Energy Use and Consumption
- Creation of Management Review Report by adding EnMS items to Management Review Records
- Creation of EnMS Process Cards
- Creation of Nonconformity and Action Follow-up Table after Internal Audit
- Ensuring that the CAPAs are closed by notifying the relevant personnel of the CAPAs that are the result of the internal audit (corrective and preventive action)
- Awareness and competency trainings (Energy efficiency awareness training continues to be given to all our employees. It is planned to provide competency training for our employees in important energy usage areas. Internal auditor trainings were held.)
- Establishment of a predictive maintenance team (The predictive maintenance team will check the related business once a week. If there is unnecessary use of air, electricity, etc. in the business, their opinions will be shared).

The research in this thesis examines the applications made in the factory producing Hygienic Products from the perspective of energy efficiency. Specifically, the energy losses determined as a result of the energy law applications, ISO50001 and the analyzes made in the production factory, and the amount of energy saved as a result of the improvement studies are shown as kWh. In this context, the positive effect of ISO50001 practices has been investigated in terms of the production facility. The prevention of costly energy losses such as air leaks in the production sector we have examined has been examined. Finally, the effect of the improvement works, and energy efficiency practices carried out within the scope of ISO50001 practices on the employees are explained both in the factory where they work and their reflections on their daily lives.

The following basic research questions are explored in this study:

- What are the aspects to be considered in order to conduct an energy efficiency study in a production company?
- What kind of applications can be made for energy efficiency in the production company?
- What are the short, medium and long-term action plans to ensure the continuity of energy efficiency practices?
- What are the effects of energy efficiency practices on employees?
- How can energy efficiency practices, one of the green deal practices of a factory, be implemented with ISO 50001?

CHAPTER 2: LITERATURE REVIEW

Energy saving is crucial for industrial facilities to meet sustainability goals and remain competitive. Even factories producing hygiene products are taking steps to save energy. Research highlights that energy efficiency measures can significantly reduce energy consumption in factories.

Studies in the literature have investigated the energy efficiency of various types of factories and revealed significant energy saving potential in different industrial sectors. Examining the literature, it becomes clear that there is a lack of specific research on energy consumption in the manufacture of hygiene products. However, general principles and measures regarding energy efficiency that apply to all sectors may also apply to the production of hygiene products.

In this thesis, limited information is available about the energy saving potential in hygiene products factories and the specific measures that can be applied in this context. However, general principles of industrial energy management and energy efficiency best practices can offer valuable information and guidance for improving energy efficiency in the production of hygiene products. Therefore, researchers examined studies conducted on other types of factories in the literature to evaluate their energy saving potential and apply the relevant knowledge to the hygiene products manufacturing sector.

The study conducted by Acar (2012) examined a facility with high energy consumption and focused on increasing energy efficiency without compromising quality and efficiency in the Ankara Turkish Tractor Factory. Many energy-intensive systems were examined, cost analyzes were made and energy efficiency projects were developed. These projects include using inverters to optimize compressor operations, preventing air leaks in the production shop, using economizers to heat boiler return water, and using energy-saving lighting. In addition, since the factory's use of renewable energy is quite low; A solar collector system was designed to meet the constant need for hot water in the factory through renewable energy. Although the initial investment costs of these projects are relatively modest, the potential annual energy savings are quite high and provide a rapid return on investment. It has been

announced that the implementation of these projects will provide significant economic benefits to the factory, as well as reducing energy consumption.

The study by Yargı (2010), focused on energy saving efforts through the development of a smart building management system and additional projects in an industrial facility. Since energy consumption is high, air conditioning has been the most emphasized issue of the project. In the study, especially the energy use of air conditioners has been integrated with smart building management software. And a lifetime cost analysis was made. As a result of these analyses, it was found that the use of speed control devices was the best approach in operating synchronous motors in the units. After the project implementation, the thesis analyzed the performance in terms of cost savings and improvements in air handling units.
The energy saving percentage was shown and the project amortized itself in 4 months. And the thinned building moved from the high consumption group to the medium consumption group. In addition, the reduction in CO2 emissions obtained with these studies was calculated and at the end of the thesis, suggestions were made to make the studies more effective, and also recommendations were made on what could be researched and developed in future theses.

According to Şenol (2016), in his study, the Energy Efficiency Law has led to regulations aimed at promoting energy efficiency in Turkey. Despite this, organizations in Turkey need greater awareness and understanding of energy efficiency regulations. It is emphasized that since energy is used intensively in industry, the issue of energy efficiency practices and effective use of energy should be addressed in industry. In the study, the development of a theoretical model to determine these factors based on data obtained from Structural Equation Model tests and surveys of industrial companies is discussed. In this context, the data are taken from the survey. was obtained by the method. The data obtained were analyzed with SPSS and LISREL package programs. Both direct and indirect factors affecting energy efficiency were identified. There is a need for more awareness and understanding about energy efficiency regulations and strategies in Turkey.

According to Çankaya's (2022) research, the main reason why Turkey is foreign-dependent in its energy needs is due to the high share of our trade deficit in terms of energy imports. In the thesis, an energy audit was carried out in an industrial facility with annual energy consumption over 1000 TEP. A comprehensive analysis of the three-year power consumption and energy cost of the facility was carried out in order to determine the potential for energy efficiency improvement and to make recommendations to increase energy efficiency and reduce energy costs. Energy consumptions and costs in the facility were examined. The relationship between them was examined in detail and regression analysis was used and energy costs were analyzed. equations have been extracted. Specific energy consumption for 3 years has been calculated. A waste heat recovery system has been proposed. It has been calculated that thermal insulation should be applied to uninsulated pipes and if this is done, the resulting annual natural gas savings, financial savings and CO2 emissions will be prevented. In addition, it has been revealed that the lights should be replaced with LED. It has been shown that if the suggested steps are done, energy savings of 128 TEP and around 128 TEP and cost savings of 2,135,000 TL can be achieved in the enterprise. Additionally, it has been shown that thanks to these recommendations for efficiency-enhancing projects, 175.52 tons of CO2 emissions will be prevented annually.

According to the research conducted by Güvenç (2017), the increasing energy demand is due to increasing urbanization as well as industry in Turkey. This thesis focuses on increasing energy efficiency in a factory producing frit. The compressed air system in production, measurements made in furnaces and cooling towers, and energy efficiency practices are explained in detail. Reducing compressor set pressures, which is achieved by reducing compressed air leaks, replacing existing compressors with more efficient ones, placing an additional recuperator at the kiln outlet, using waste heat from enamel and ceramic kilns, The kWh gain, financial savings and payback periods of the project to be achieved by performing thermal insulation on the furnace surfaces, replacing the existing cooling tower with a more efficient one as it is found inadequate by measurements, and reducing the set pressure of the compressors are calculated and shown one by one. He also pointed out that there will be CO2 emission reductions that can be achieved with these energy efficiency practices.

İsçan's work (2019) examined Metro İstanbul AŞ. In this business, energy management practices were modeled according to ISO 50001 standards. The energy policy was created, so that EnMS was notified from the top management to the suppliers. Documentaries have been created to achieve energy targets. It has been determined that the operation uses electricity and natural gas energy. Energy data for 2016 and 2017 were examined. As a result of all examinations, an energy baseline chart was created. As a result of such investigations, it has been revealed that EnMs should be established in urban electric thai transportation systems in accordance with the ISO 50001 standard and the data should be constantly analyzed, thus energy efficiency will be ensured.

The study by Kaya (2012) focuses on energy efficiency projects in Turkey and the world, especially compressed air systems. According to the author, compressed air systems are generally inefficient and costly, leading to high energy costs. This thesis was studied by examining three different factories. The consumption values of the compressors were measured and these data revealed the annual energy consumption. And efforts have been made to increase the efficiency of air systems, to prevent wasted air losses, and to benefit from the resulting waste heat energy. Possible energy savings as a result of the improvements made are explained with examples.

Uylukçuoğlu's (2009) thesis study, the importance of maintaining production quality and capacity while increasing industrial energy efficiency was mentioned. In the thesis, energy efficiency applications that may occur in the automobile factory are explained. Thermal energy and electrical energy are examined. It examines the automotive sector, the production phase, and the electricity costs incurred in product production in detail and explains the energy-saving heating opportunities in the automotive sector. The gain to be obtained is shown as annual fuel gain and annual TL gain. In the thesis, it is stated that 427,212.05 m3 of gas consumption was achieved by saving on annual gas consumption by improving combustion efficiency, reducing heat losses, solving the insulation problem and using energy from excess heat. It shows that 8,124,197.58 kWh of energy is saved annually by effective engine use, speed control devices, compressor air suction controls and replacement of lighting systems in accordance with standards.

The studies have shown a wide range of energy efficiency measures and practices that could be implemented in different sectors. Structural improvements, technological developments, policy support, method for integrating processes, standardisation and information technologies are also part of these measures. Moreover, important roles are also played in matters such as energy management, efficiency analysis, the potential for reducing energy consumption and effective production planning.

The studies also assessed potential reductions of CO2 emissions and the achievement of sustainability targets, with a view to energy savings gained through implementation of energy efficiency measures. The importance of the interaction between energy efficiency and environmental impact is emphasised in this context. Furthermore, it is possible to summarise the conclusions drawn from literature studies as follows:

Industrial sectors have a lot of opportunities for energy efficiency. The research shows that various energy saving measures and improvements in sustainable production practices can be implemented.

For the purpose of increasing energy efficiency, process integration methods may be an effective approach. It is possible to improve energy efficiency by optimising the interactions of different processes and systems.

The evaluation of energy efficiency scores and potential energy savings can be carried out using analytical methods such as data envelopment analysis in energy efficiency studies. In the area of energy consumption, these analyses can be applied to identify effective and ineffective areas.

Energy efficiency studies can play an important role in achieving sustainability goals by addressing environmental impacts. The relationship between energy efficiency and sustainability of the environment has been highlighted in studies aimed at reducing greenhouse gas emissions, as well as minimising impacts on the environment.

In order to identify areas where further research can be pursued, identifying existing knowledge gaps in the field of energy efficiency is important. These studies have identified priority topics of the forthcoming research and areas in which new discoveries can be explored.

CHAPTER 3: METHODOLOGY

Research methodologies are case studies, and interviews. According to Crowe, Cresswell, Robertson, Huby, Avery, Sheikh (2011), case study is a research technique used to achieve a thorough and in-depth grasp of a complicated issue as it occurs in a real-world context. This method is widely embraced across numerous fields, especially in the social sciences. At its core, a case study involves a comprehensive examination of an event or phenomenon within its natural surroundings. It's often described as a "naturalistic" approach, differing from experimental research where researchers seek to control and alter variables.

There are several categories of case study. First of all, exploratory case studies are designed to look for anything interesting in data that interest the researcher. proposal of research questions and hypotheses, a preliminary or small-scale survey can be carried out.

Among the elements of the case study in the hygiene sector, data collection from the factory we examined, making energy measurements, energy audit, evaluation of compliance with ISO50001, development and implementation of energy saving opportunities and examined. First of all, while designing a case study, focusing on ISO 50001 standards in order to do the research; A case study was conducted to explore energy efficiency and energy saving possibilities and practices.

The case study methodology was chosen because we could explain the subject better and handle the data directly when we did a literature review. Data; obtained by on-site observation. Field visits are made by observing the processes made and ongoing with energy, the systems used and the tools (equipment). Detailed notes are taken to describe energy consumption patterns and potential improvement areas. Since only electricity is used as energy in the factory we examined, the historical electrical energy consumption data of the factory we examined are kept from the factory records. With these data, the energy performance of the factory, areas where energy saving and energy efficiency can be made are determined.

A total of two years energy consumption evaluation is made by taking measurements according to the months of the factory, and a detailed energy audit is carried out to determine the energy saving and efficiency applications that can be made together with this evaluation. This energy control is done with energy measurements. Buying a device to investigate the pressure upper limit of the devices using air. Energy measurements provide a detailed understanding of energy use in processes with various equipment.

Survey research is a versatile method used to collect data from individuals and groups. Quantitative techniques such as rating scales surveys, qualitative methods with open ended questions or a combination of both can be used. In the area of human behaviour studies, such a methodology is widely applied in fields like sociology and psychology.

Given this diversity in survey research, it is important that consumers and readers of these surveys are informed about possible biases and proven techniques to minimise them so as to be able to draw correct conclusions from the information provided Ponto (2015).

Structured interviews is a method in which researchers ask participants a set of predetermined questions in a specific order and limit response options. The questions are standardised, like an interview for a new job; provide consistency and allow easy comparison of responses. The introduction of study, order of question and wording must be strictly controlled by the interviewer. They must not allow any other person to give his or her answers on behalf of the participant, influence replies, clarify questions and improvise. Structured interviews are commonly used, in particular for the purpose of conducting research surveys, and help to obtain more standardised data from a greater number of participants. Stuckey (2013).

By examining the findings obtained through the energy audit and ISO 50001 conformity assessment, energy saving practices will be developed together with the factory's management and energy efficiency team. These practices include awareness and competency training, technological improvements, and other relevant measures. The identified practices examine their gradual implementation.

Energy efficiency applications in previous studies were examined. While primary data are provided when collecting data from the factory through literature reviews and surveys, surveys will be supportive resources to get employee suggestions for energy efficiency practices made. While the survey questions were being created, they were examined in the literature review, no suitable survey was found in the theses, and a survey was prepared with question examples from Google scholar and science direct. The survey was conducted with five people in the company, and these people were selected from departments at all levels from the organization chart of the factory's energy efficiency application. These selected people were selected from the general manager, energy engineer, energy director, operations coordinator, and line leader. Talking to the employees of each department helps to better understand the effects of the work on the employees. The survey first starts with the approval of the KVKK text.

Thanks to this questionnaire, a questionnaire and an interview were conducted to find out whether the employees found the energy efficiency practices implemented in the company I was examining sufficient, whether they received sufficient training on energy efficiency, whether they talked to their colleagues about energy efficiency, and whether they used what they learned with energy efficiency in their daily lives. The survey part was sent with Google Survey. The data were obtained with the answers they gave to this application. The interview part was made over the phone and e-mail.

Thanks to the interviews and surveys, if there are suggestions for energy efficiency and saving practices that can be made in their own departments, it enables them to learn these suggestions in detail. These recommendations will be illuminating to analyse how much energy efficiency practices in the factory are understood by the employees.

3.1. Survey and interview results

This survey and interview were conducted with the participants who participated in the energy efficiency practices in the factory we examined, and as a result of the survey, we saw that the employees saw their perspectives on energy efficiency practices and gained awareness of the areas they use in daily life and energy efficiency practices.

In the first question, we learned about his department. All participants were from other departments. Then, we learned about their duties in the department, the duties of the participants, Energy manager, Factory Manager, Energy Director, Line leader, Operations Coordinator. With this information, we made sure that we had participants from every department in the business.

In the third question, we asked whether he had worked at the factory for less or more than 5 years.

In the fourth question, we aimed to find out whether there was energy training in the factory, and we concluded that there was training.

In the fifth question, we asked whether they turned off the lights in the place they left and they all said they did, so we got information about their energy efficiency awareness. It was to find out if they talked about energy efficiency practices and we obtained the information that all employees who participated in the survey talked about energy efficiency.

With the seventh and eighth questions, we learned that the employees are aware that energy efficiency practices contribute to the company and state budget. We asked if they had any awareness of the issue, and 60% of the participants answered yes and 40% answered no.

In the ninth question, we asked the participants what the best way is to save energy in the factory, and among the options, the use of energy-saving lamps, the prevention of unnecessary use of electrical appliances, thermal insulation, loss of energy. avoid the air, we have put all and other options. While 60% of the participants marked all of them, 40% said that the measure of lost air is the most appropriate way to save energy in the factory.

With the tenth question, “Do you find the energy efficiency practices applied in your factory sufficient?” the participants were asked, if no, they were asked to explain the reason, 80% of the participants said yes while 20% said no.

In the eleventh question, we reached the participants by phone and asked, “After the energy saving awareness trainings you received in your factory, what are the practices related to energy saving that you have not done before in your private life and after the training?” The question was asked, and they were asked to explain in detail. Particularly, when buying electrical appliances at home, they prefer energy efficient devices, pay attention to buy equipment with high energy class, pay attention to the use of energy-saving lamps, do not leave appliances such as chargers in sockets after they are finished, do not run the dishwasher before it is full, and turn off the excess lamps.

Replies were received, replacing the bulbs in the house with LED lamps, reducing the cooling temperature of the refrigerator to meet the need.

With these answers, we understand that the participants both became conscious thanks to the training they received by the factory and also became conscious consumers in their own lives. The question was made over the phone on twelve occasions and “Can you tell us about at least 4 of the energy efficiency applications taken in your factory?”

It was asked, and the participants were asked to automatically turn on and off unnecessary lighting in the machines, connecting a driver to the motors running at maximum speed without a driver in the machine and operating them at low speed. synchronous operation on the conveyors at the machine exits in the direction of working when the machine is running and stopping when the machine is stopped, efficient motor use, led lighting conversion, driver application and frequency drop research, making constantly burning lamps with sensors, reducing engine speeds without harming quality, interior lighting lamps while the machine is running.

The answers were received as applications such as providing automatic extinguishing, reducing the number of overworked glue tanks, as a result of common use, investigating the upper pressure limit of the devices using air and purchasing the device, reducing the amount of air consumption by monitoring the consumptions from the air main inlet line of the machines and giving a warning alarm when it goes out of the limit. are the applications mostly applied in the field of production, according to the departments of the participants in the factory, and the energy efficiency

applications in the factory are the applications that provide the highest return in kWh and TL. If the question is thirteen, it was asked if you could give at least four suggestions that could save energy in your factory. The answers given by the participants were that the energy used in cooling can be saved by taking the units that cause a negative increase in the ambient air temperature. It can be used to heat the water with the heat exchanger at the outlet of the compressors and to heat both the preheating units and the desired environments.

The machine interior lighting can be made automatically, and savings can be achieved. In long stops, the energy in the heating system, which is wasted by taking automatic standby, can be saved, automatic shutdown of the machine lighting, purchase of leakage air detection measuring device, online measurement of the energy efficiency of the machines, reducing the burning time of the lights by making more use of daylight, idling conveyor belts etc. synchronizing, using by reducing the lighting lamps, operating the heat-operated systems with minimum heat so as not to decrease the quality.

Energy saving should be considered in the purchased devices, energy awareness should be increased with the award method in the personnel, a team should be formed to determine and report for energy efficiency control. A system should be established in which the air consumption can be monitored daily on a machine basis. It is planned to operate the electric motors with frequency converter/inverters with motor speed control, which will enable the electric motors to absorb enough energy to meet the machine process need, and to plan to replace them with energy class motors.

As a result of the feedback, we received from people who saw them in production in life, we concluded that they found energy efficiency applications mostly sufficient, but that there were aspects that needed improvement and that energy efficiency applications were important.

CHAPTER 4: EUROPEAN GREEN DEAL AND TÜRKİYE

The European Green Development Strategy launched in 2019 aims to make the EU climate neutral by 2050 through a modernisation of its economy and more efficient use of resources. It will cover a range of sectors, with particular regard to resource intensive fields such as energy and minerals.

The "Package for 55," released in 2021, outlines actions to reduce greenhouse gas emissions by 55%, including reforms within the Eıropean Union Emissions Trading System (EU-ETS) and regulations for non-ETS sectors like agriculture and energy efficiency. The Carbon Border Adjustment Mechanism (CBAM) is a crucial part of these regulations, aiming to prevent carbon leakage and reduce emissions from third countries.

The Circular Economy Action Plan, approved in 2021 by the European Parliament, is a key element of the EU's transformation program. In promoting a circular economy, where resources are more effectively utilised and waste is reduced, the Circular Economy Action Plan shall include specific laws, regulations, strategies and measures in each of the sectors concerned. As the EU seeks to align its decarbonisation objectives with Europe's, these initiatives will have an impact on Türkiye and its industry (Türkiye Industrial Development Bank ,2021).

Figure 1. EGD's Main Policy Areas (Source:Türkiye Industrial Development Bank,2021)

4.1 Green Deal and Türkiye's Actions

The Paris Agreement entered into force on November 10, 2021, following Türkiye's approval of the agreement on climate change on October 6, 2021. The European Green Deal, launched by the EU in 2019, is a key driver of climate-related changes in policies across various sectors.

The "more mitigation" scenario has set a target of 41% reduction in emissions by 2030, which is relevant given that the extent to which we can meet our climate change targets and actions will have an impact on access to International Financing for Climate Change.

Türkiye closely follows EU legislation, including the Border Carbon Regulatory Mechanism, to align its regulations with EU regulations and ensure that its exports are not negatively affected. In order to deal with the impact of the EU Green Deal, Türkiye has set up a number of specialised task forces including those related to carbon regulation, circular economy, green funding and more.

In essence, Türkiye has made significant steps towards meeting its international climate targets and adapting to the evolving regulatory environment that is brought about by the EU's Green Deal. Efforts to ensure sustainability and combat climate change are part of these efforts, including legislative changes, financing initiatives and international cooperation (Ministry of Trade Republic of Türkiye).

4.2. Energy Efficiency in the Green Transformation of Industry

Green Transformation of Turkish Industry, a key focus is on optimizing energy efficiency in both transmission and distribution networks to make the consumption of electricity more efficient. This effort aligns with the goal of transitioning to a lowcarbon energy system, which involves increasing the proportion of renewable energy sources used for generating electricity, decreasing the reliance on fossil fuels, and minimizing energy losses. (Turkish Industrial Development Bank, 2021).

4.2.1. Türkiye's Carbon Border Adjustment Mechanism

The Carbon Border Adjustment Mechanism (CBAM) is a part of the European Green Deal (EGD) designed to boost climate efforts and encourage other countries to combat climate change. It connects economic transformation with competitiveness, shaping future regulations and industrial policies in line with environmental goals.

Türkiye is highlighted as one of the countries that will be significantly affected by CBAM. CBAM aims to impose financial liability on imported products based on their carbon footprint to mitigate carbon leakage risks, impacting industries like iron and steel, cement, aluminium, fertilizer, and electricity.

The regulation proposes a transition period from 2023 to 2025, during which importers report emissions, and the financial burden of CBAM begins in 2026, indexed to EU carbon prices. There is a gradual exit from free allowances within the EU-ETS, coordinated with CBAM until 2035.

Concerns include potential legal issues at the World Trade Organization (WTO) and the allocation of revenues from CBAM to the EU budget, with uncertainty about how the funds will be used for combating climate change.

CHAPTER 5: ENERGY AND ENERGY SOURCES IN TÜRKİYE

5.1. Energy and Energy Sources

There are many definitions of energy in different sources, but the definition that fits best with our research is that it can be defined as the capacity to do work or produce heat. The demand for energy increased rapidly with the industrialization that occurred as a result of the Industrial Revolution. This increase in demand; It has been formed as a result of factors such as increasing industrialization, population and human needs (Eskin,2018).

In the literature, energy sources have been classified in many different ways. As can be seen in the table below, energy resources are divided into two main headings, and they are classified according to their use and recyclability. First of all, there are two of the sub-titles of energy sources that can be converted, the first of which is primary energy sources are found in nature and can produce energy from their current state. However, secondary resources are formed by processing only primary energy resources. In another distinction, energy resources are separated according to their use. While non-renewable energy sources expire, renewable energy sources are selfrenewable and sustainable (Eskin,2018).

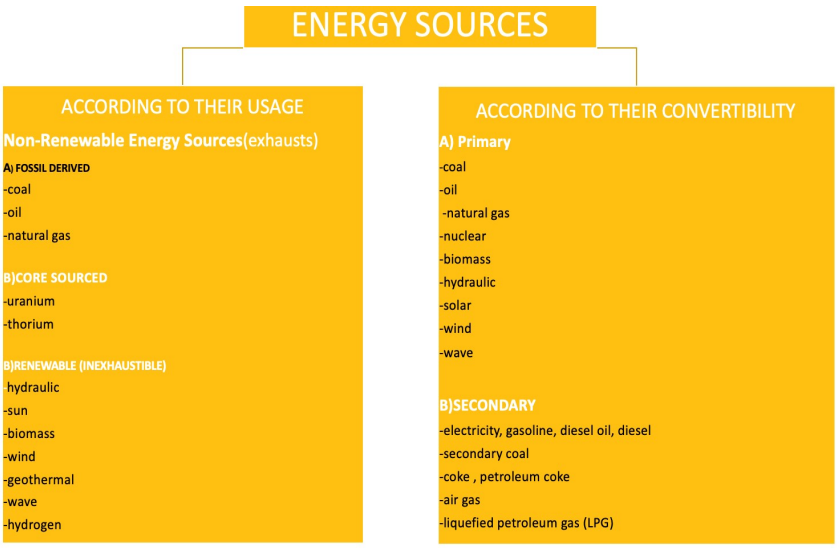

Figure 2 . Energy Sources (Source: Koç E. and Şenel M.c.2013)

5.2. Non-Renewable Energy Sources

Non-renewable energy resources are energy resources whose resources decrease as they are used, cannot renew themselves and whose stocks are variable. These energy resources are resources that have limited reserves and have the potential to be depleted (Eskin,2018).

Nuclear Energy

Nuclear energy is a safe and sustainable energy source that can be used for the environment and climate, as it does not emit carbon. Nuclear power plants produce electricity day and night without being affected by climatic conditions. It helps to reduce carbon emissions. Since the installation area of the nuclear power plant is smaller than other power plants, its impact on the surrounding agriculture, settlement, plants and animals is less than other power plants (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

Coal

Coal is a fuel that has a great importance in people's lives and energy resources. The fact that it is found in large quantities and can be used widely throughout the world indicates that coal has a great reserve potential. Coal is a fossil fuel that can be used safely, is easily produced and is economical (Eskin,2018).

5.3. Renewable Energy

It is a self-renewing resource whose reserves do not decrease as it is used. Other names are clean energy, green energy or environmentally friendly energy. They include energy types such as solar, wind, geothermal, hydrogen and biomass. Renewable energy sources do not harm nature or the environment. Therefore, the production and use of renewable energy sources is of great importance for the future of humanity and nature. They are clean energies that do not or minimally emit greenhouse gases to the environment, maintain the ecological balance. Renewable energy is a sustainable energy source compared to fossil fuels. Unlike fossil fuels, renewable energy sources

are energy sources that are infinitely renewable and can be used by future generations. Renewable energy plays a fundamental role for a sustainable energy future by addressing important issues such as energy security, environmental protection and climate change (Eskin, 2018).

5.4. Electricity Generation with Renewable Energy Resources in Türkiye

Solar Energy

The sun is basically a renewable energy source, which is the main source of all energy sources, including fossil and hydraulic energy, and heats our planet. The sun is a sustainable, unlimited source of energy as it will continue to exist in the coming years. The sun is the core of all energy sources in the world (Eskin, 2018).

Recently, the studies carried out by our ministry of energy for the use of solar energy, which is a sustainable energy source, have gained momentum. In order to prevent the damages of non-renewable energy, countries care about renewable energy sources and have started to work on these energy sources more and support them (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

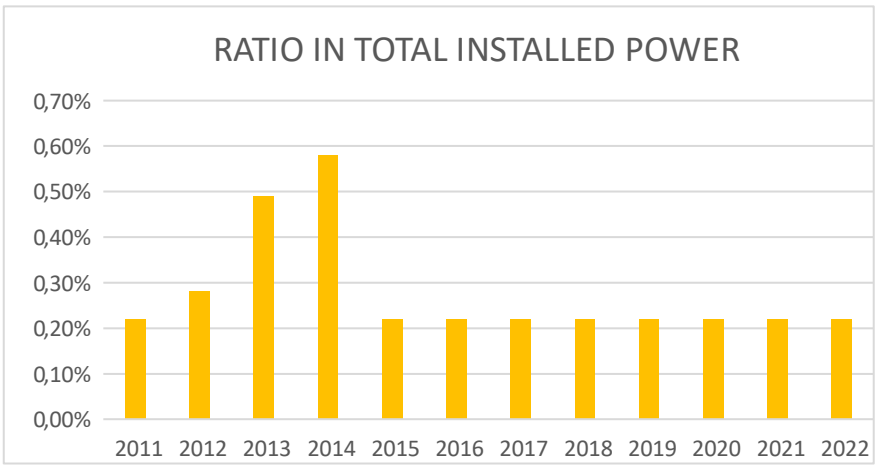

Figure 3. Ratıo in Total Installed Power For Solar Enegy (Source: Republic of Türkiye Ministry of Energy and Natural Resources,2022)

As can be seen in the chart below, the total installed capacity of solar energy has increased each year. In June 2022, the highest installed power ratio was reached. It showed an increase of 0.52 compared to 2021. These installed power rates prove the importance given to renewable energy sources by our ministry, which I mentioned above (Republic of Türkiye Ministry of Energy and Natural Resources,2022).

Wind Energy

Wind energy is an energy source that occurs as a result of the sun's different heating of the earth's surface and causes the movement of air. Wind is characterized by local geographic differences and variability resulting from heterogeneous warming of the earth. Wind energy is a renewable and clean energy source. It is also a reliable option as there is no risk of exhaustion. Wind energy has costs that can compete with power plants today, and its maintenance and operating costs are low. Wind turbines are the main structural elements that convert the kinetic energy of the moving air into mechanical and electrical energy (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

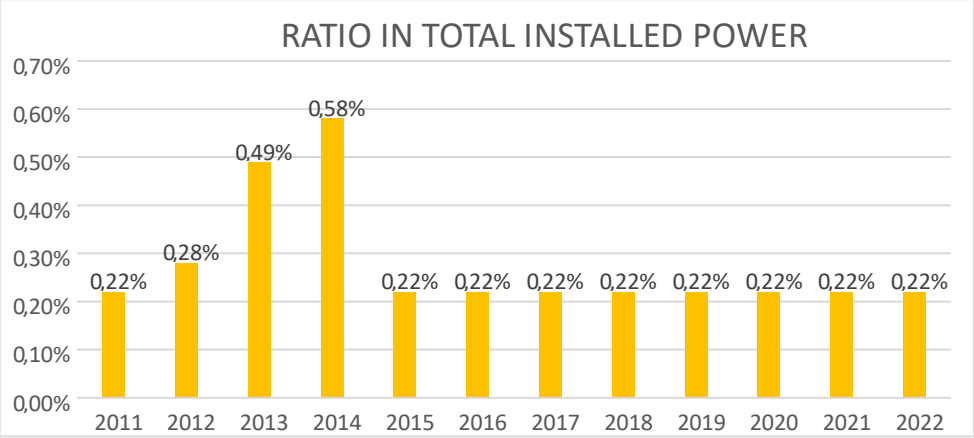

Figure 4. Ratio in Total Installed Power for wind (Source: Republic of Türkiye Ministry of Energy and Natural Resources, 2022)

The figure below shows the installed power development based on wind energy. The growth rate is only 0.18% compared to the previous year (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

Hydraulic Energy

Hydroelectric power plants are a preferred source because they do not harm the environment and the possibility of any potential hazard is low. These sources are highly efficient, sustainable energy sources that do not cost fuel to use (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

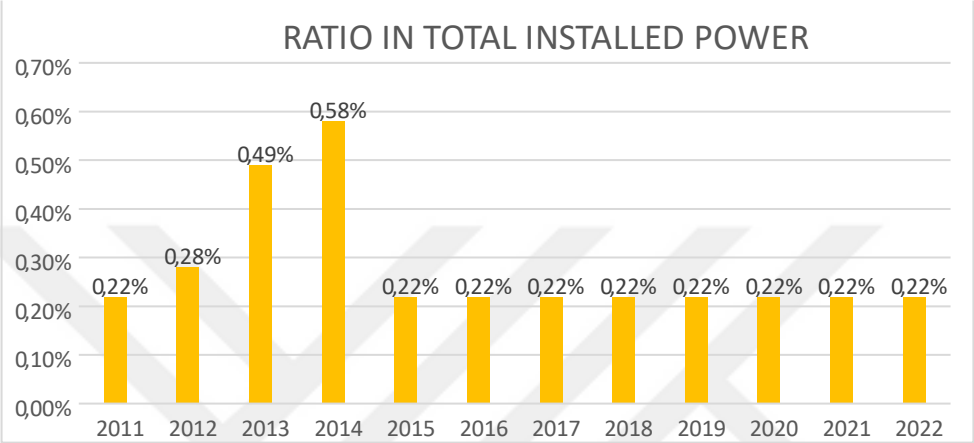

Figure 5. .Ratio in Total Installed Power for Hydraulic Energy (Source :Republic of Türkiye Ministry of Energy and Natural Resources, 2022)

As can be seen in the chart below, the installed power ratio has not increased continuously like the energy resources we have examined before. While the percentage of total installed power was at its highest in 2015, this ratio continued to decrease in the following years. experienced a decrease in power.

Geothermal Energy

It is an energy originating from high temperatures caused by heat and pressure accumulating deep in the earth. This energy is above the regional average temperature and comes to the earth with steam, hot water and gases (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

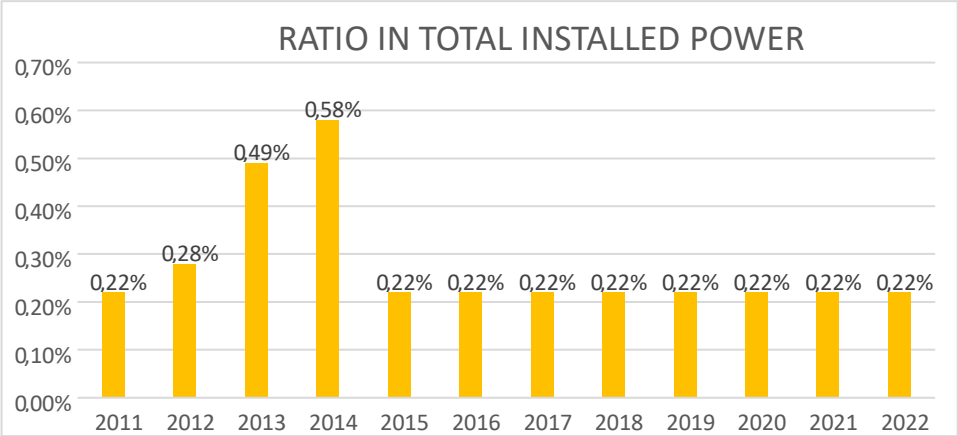

Figure 6.. Ratio in Total Installed Power for geothermal energy (Source :Republic of Türkiye Ministry of Energy and Natural Resources, 2022)

While the total installed power of geothermal energy increased from 2011 to 2019, it remained stable in 2020 and 2021 and experienced a loss of 0.02% in its installed power in 2022 (Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

Electricity produced from sustainable sources is a very important source for energy efficiency applications in our country. To the electricity produced from these sources, we can have a sustainable and less foreign-dependent electrical energy.

Distribution of Renewable Energy Resources in Electricity Generation

The graph above shows the amount of electricity produced from sustainable sources according to the YEKDEM report in Turkey. Electricity produced from sustainable sources is a very important source for energy efficiency applications in our country. Thanks to the electricity produced from these sources, we can have a sustainable and less foreign-dependent electrical energy (EPDK ,2022).

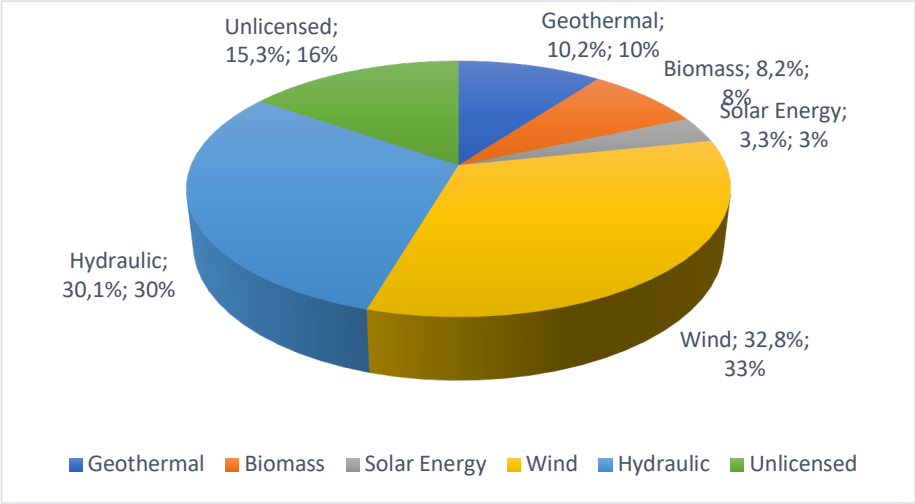

Figure 7 .Distribution Renewable Energy Resources in Electricity Generation (Source:EPDK)

Electricity Consumption in Industry in Türkiye

When the electricity consumption in the image is examined in detail, we see that the electricity consumption in industry is the highest compared to other areas of electricity consumption. This shows that energy efficiency practices are more important in industry than other areas.

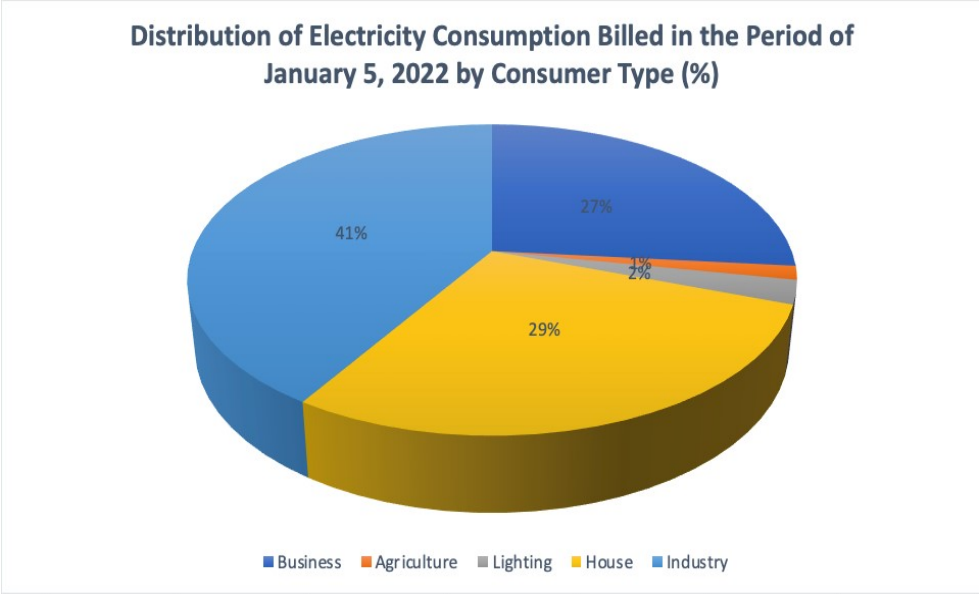

Figure 8. Distribution of Electricity Consumption Billed in the Period of January 5, 2022 by Consumer Type(%) (Source:EPDK)

CHAPTER 6: ENERGY EFFICIENCY AND ENERGY MANAGEMENT SYSTEMS (ENMS)

Another issue as important as obtaining energy is to use the energy we obtain efficiently.

Energy efficiency is an approach that aims to preserve product quality by using energy resources more effectively and efficiently. This approach includes processes such as reducing energy losses, recycling wastes and using less resources more efficiently.

One of the main objectives of energy efficiency is the least possible energy consumption within the determined limits. In addition to providing energy savings, energy efficiency also takes care of balancing these savings with necessary expenditures. In this context, it is important to eliminate the negative effects with energy efficiency practices, to develop energy usage habits, to adopt improvement methods and to use advanced technologies.

While increasing population, industry and technological progress lead to an increase in energy demand, the decrease in energy resources and price fluctuations reveal the necessity of using energy resources more efficiently. With energy efficiency applications, fossil fuel demand can be reduced, energy resources that will be depleted in the future can be protected, the costs of new technologies can be reduced, and the welfare levels of countries can be increased independent of foreign dependency.

6.1. The Relationship of Energy Efficiency and Energy Saving Concepts

Energy saving is to obtain the same product without changing the output and quality of the product by using less energy as a result of the improvements made and the importance taken by the producer, user and distributor of energy in the areas where energy is used.

In short, energy saving is an approach that aims to achieve the same amount of product or service with lower energy consumption. This can be achieved through various measures such as process improvements, use of energy efficient equipment, management strategies and conscious use of energy. Energy saving makes a great contribution to the economy of the country as well as the factory where it is applied.

Energy efficiency is the ability to use energy resources efficiently and effectively, minimizing the amount of energy required for a particular job or service. Basically, energy efficiency aims to provide the same work or service by consuming less energy.

Energy efficiency is also about monitoring, analyzing and optimizing energy use. This may include the use of energy audits and energy management systems. Energy audits are detailed studies to evaluate the energy efficiency of a building or system. These reviews analyze energy consumption, identify inefficiencies and provide recommendations for energy savings. Energy management systems are automatic systems that monitor and control energy consumption. These systems increase energy efficiency by optimizing energy use.

Energy efficiency provides economic and social benefits as well as environmental benefits. More efficient use of energy helps reduce energy costs and increase energy supply security. It also contributes to the fight against climate change by reducing greenhouse gas emissions. Energy efficiency also creates innovation and job opportunities, increases employment and combats energy poverty.

Energy saving and energy efficiency are complementary concepts. While energy saving reduces energy consumption, energy efficiency enables more efficient use of available energy resources. The application of these two concepts together is the key point for the sustainability of energy resources and the energy system (Elsadig, 2005).

6.2. Impact of Energy Emission in Industry on Climate Change

Energy efficiency does not only bring us profit in terms of money. At the same time, it provides great benefits to climate change and the environment by reducing CO2 emissions. In the graphic below from the IEA, we see that in 2022, industrybased CO2 emissions are much higher than in other years. CO2 emissions have increased over time until 2022, due to the end of the pandemic and the return to old consumption and production habits after the Covid-19 pandemic in 2020. And finally, it has reached the highest level until now (IEA, 2022). Proper implementation of energy efficiency will prevent the adverse effects of climate change and increasing CO2 emissions.

6.3. Energy Efficiency and Energy Audits in Industry

A significant part of the energy expenditures in Türkiye takes place in the industrial sector and this sector has a large share in energy use. Therefore, the focus of energy saving efforts is on other sectors, especially the industrial sector. According to statistics, it is seen that energy is not used efficiently in the industrial area in Türkiye. One of the biggest expenses of businesses is energy costs, so energy efficiency has become a priority issue. Improvements in energy efficiency in the industrial sector offer important opportunities such as reducing energy consumption, increasing the efficiency of business processes, supporting technological progress and reducing greenhouse gas emissions.

Energy efficiency projects in industry are projects where measures are taken to reduce energy consumption in industrial enterprises and to make energy use more efficient. These projects analyze the current energy consumption by conducting energy studies, determine the energy saving potential and offer suggestions to increase energy efficiency. An energy audit draws a roadmap for projects by evaluating a business's energy resources, energy distribution, energy losses and other factors related to energy efficiency.

Energy efficiency projects in industry are generally supported by the energy management unit within the enterprise, the energy manager or external Energy Efficiency Consulting (EVD) companies. ESCO companies provide consultancy

services for energy efficiency projects, conduct energy studies, organize trainings and manage the processes from design to implementation of projects. These companies specialize in planning energy efficiency projects, evaluating financing options, determining technical details and successfully implementing projects.

Implementation of energy efficiency projects in industry enables businesses to optimize energy use, reduce energy costs, reduce environmental impacts and gain competitive advantage. With the implementation of these projects, energy intensity decreases, energy savings are achieved, operating costs are reduced, and environmental sustainability is supported. At the same time, energy efficiency projects offer businesses more effective and efficient production processes, encourage efficient use of energy resources and increase energy security by reducing energy dependency (Engin, 2018).

6.4. Energy Management Systems

Energy Management System (EnMS) is a management system that aims to continuously improve energy performance and adopts a systematic approach to increase energy efficiency. This system was created on the basis of the ISO 50001 standard, which includes energy management and sustainability principles. EnMS is used to save energy by effectively managing energy consumption, to continuously increase energy efficiency in enterprises and to create a sustainable energy management culture.

The implementation of the EnMS may vary depending on the size, industry and characteristics of the enterprise. In this process, the commitment of the top management and the support it provides to the energy manager are important. The energy manager assumes a leadership role in energy management and ensures the successful implementation of the EnMS.

The benefits of EnMS include improvement in energy efficiency, reduction in energy costs, reduction of carbon footprint, ensuring energy security and gaining competitive advantage. The success of EnMS is ensured by its integration into the energy management culture of the enterprise, its continuous application and the active participation of employees.

By adopting a systematic approach in energy management, EnMS offers businesses an effective tool to achieve their energy efficiency and sustainability goals. In this way, businesses can gain competitive advantage by reducing their energy costs and minimizing their environmental impact (Engin, 2018).

6.5. ISO 50001 Energy Management Standard as Energy Management System

ISO 50001 is a global energy management standard and a globally accepted standard to support energy efficiency. This standard aims to effectively implement energy management systems for businesses, organized industrial zones and residences. ISO 50001 provides a structure that requires the creation of energy management units and the appointment of energy managers.

Industrial enterprises with an annual energy consumption of 1,000 TEP (Ton Equivalent Petroleum) or more, in short, industrial enterprises with high energy consumption, Organized Industrial Zones and enterprises operating in the field of energy management are subject to the obligation to comply with TS ISO 50001 standards. These standards require the establishment and implementation of energy management systems. EnMS is used to improve the energy performance of organizations and to ensure their compliance with established standards.

The benefits of ISO 50001 are:

To support the use of necessary systems, equipment and technologies to increase the energy performance of businesses.
To contribute to the development of appropriate systems for easy monitoring and management of energy use.
To contribute to environmental sustainability by reducing energy consumption and to support the protection of natural resources.
To raise awareness about energy efficiency and to adopt a conscious approach towards energy saving.
To guide the efficient use of energy resources and to make improvements in energy production processes.

Provide a framework for building confidence and identifying risks in energy supply. Helping organizations set their energy targets and manage them effectively.
ISO 50001 is a standard that promotes best practices in energy management and offers businesses benefits such as sustainability, cost savings and reduction of environmental impacts.

EnMS guides businesses through the stages of analyzing their energy performance, optimizing energy use, setting energy targets, creating energy management plans, implementing energy efficiency projects, and continuously monitoring and improving performance. It encourages continuous improvement by adopting a systematic approach such as the Plan - Do - Check - Act (PDCA) cycle (TSE ISO50001, 2018).

"Plan: understanding the general situation of the organization, establishing an energy policy and establishing an energy management team, identifying activities for risks and opportunities and conducting an energy review, identifying significant energy uses (OEK) and energy performance indicators (EnPG), energy reference line/ Determining the objectives and targets of the lines (EnRC) and action plans that will ensure results that improve energy performance in accordance with the energy policy of the organization.

Do: implement operational plans, operation and maintenance controls and communications, ensure competence, and consider energy performance in design and supply.

Check: monitor, measure, analyze, evaluate, audit and conduct management review of energy performance and EnMS.

Act: Take action for unsuitability, energy performance and continuous improvement of the EnMS." (TSE ISO50001, 2018).

CHAPTER 7: CASE STUDY: ENERGY MANAGEMENT IN THE HYGIENE SECTOR

7.1. Hygiene Sector In Türkiye and Its Classification

The hygiene sector in Türkiye covers the production, distribution and consumption of products and services aimed at protecting personal and social health. Hygiene products and services can be classified into various sub-sectors. State Planning Organization (DPT) has classified hygienic products according to their sectors as shown in the table below.

According to this classification, the factory we examined is included in the subsector of the manufacturing industry of other paper-based hygienic products, under the sub-heading of articles made of paper and cardboard, since it produces diapers for children and adults, sanitary napkins, wet wipes, bed covers.

Figure 9. Hygiene Sector in Türkiye and It's Classification (Source:Ertuğrul,2003)

7.2. Energy Management in the Factory

In this section, the energy efficiency studies applied in the researched factory for energy efficiency applications are shown.

The company we are examining is a hygiene company. It started the production of underpads in 2013 and women's pads in 2017. The company is one of the leading companies in the sector with a production capacity of 220 million diapers, 10 million adult diapers, 10 million wet towels, 10 million mattress protectors, 11 million pocket wipes in a month. In 2019, it started to produce 85% of its own raw materials for sanitary pads, baby diapers, wet towels, diapers, adult diapers and mattress protectors. It exports to more than 100 countries around the world and has a widespread domestic sales structure. Only electrical energy is consumed in the enterprise. All the energy used is outsourced.

One of the most important actions taken was the creation of the organization chart, in which there were people from every department. The representations in this diagram start from the top manager, this is the general manager, there is the assistant general manager and just below him, the energy manager. Other departments; all people such as business coordinator, maintenance chief, human resources specialist, planning manager, energy manager, assistant general manager and general manager. it depends. Since energy management is an issue that needs to be addressed as a whole in the factory, it is very important to have participation from every department.

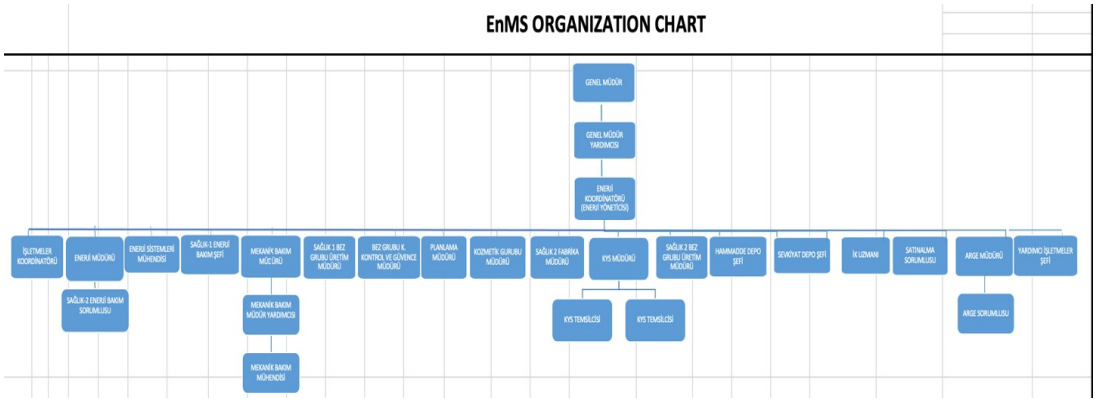

Figure 10. Organization Chart of the Company (Source: Case study data from the company)

Together with the team formed, energy analyses were made and energy efficiency applications were planned, and a detailed study was carried out for the production factory examined:

Meetings were held with EnMS teams on the same day and time every week.
The road map to be followed was determined in the meetings held with the EnMS teams.
The roles and responsibilities of the members of the team were determined.
Documentation documents to be used by EnMS teams have been prepared.
Awareness training was given to all business employees.
Bring energy efficiency and savings to places that all business employees can see.
The amount of energy use was determined.
In which areas energy savings can be made were discussed.
By evaluating the suggestions received from the EnMS team and the employees of the enterprise, action plans were prepared by determining the subjects that would make maximum savings with minimum expenditure.
Colourful posters in A3 size were hung to raise awareness. Examples are shown below:

Figure 11. Poster for awareness (Source:Case study data from the company)

7.3. Energy Management System Policy Established at the Factory

The factory which produces hygiene products, is aware that one of the most important elements of being able to compete in developing technology and changing market conditions is to use energy efficiently. For this reason, it is in an effort to use energy efficiently and reduce natural resource consumption together with all our related parties, especially the employees in this factory.

In the factory that makes hygiene products, it will reduce specific energy (kWh/ton or kWh/1000 units of product) consumption and energy costs, and promote economic and environmental sustainability in their activities, so they have created their own energy management system policies:

It will reduce the specific energy consumption of the facility by 2% in three years,
It will ensure continuous improvement of energy performance,
Will use the necessary information and resources to achieve the goals and objectives,
To comply with the legal and other requirements related to energy,
Consider energy performance during the design and improvement of facilities, equipment, systems and processes,
It will use technology that improves energy performance,
It will supply energy efficient products and services,
It aims and undertakes to cooperate with suppliers on energy efficiency.

7.4. Energy Consumption and Monitoring in The Factory

First of all, the energy used in production was determined and the table below shows the energy used in the production of 1000 hygienic products in each factory we examined on a monthly basis.

The following formula was used to make this determination.

$$\text{• Amount of Energy} = \frac{\text{Energy We Consume (kWh)}}{\text{Amount of Product We Produce (1000 PED)}}$$

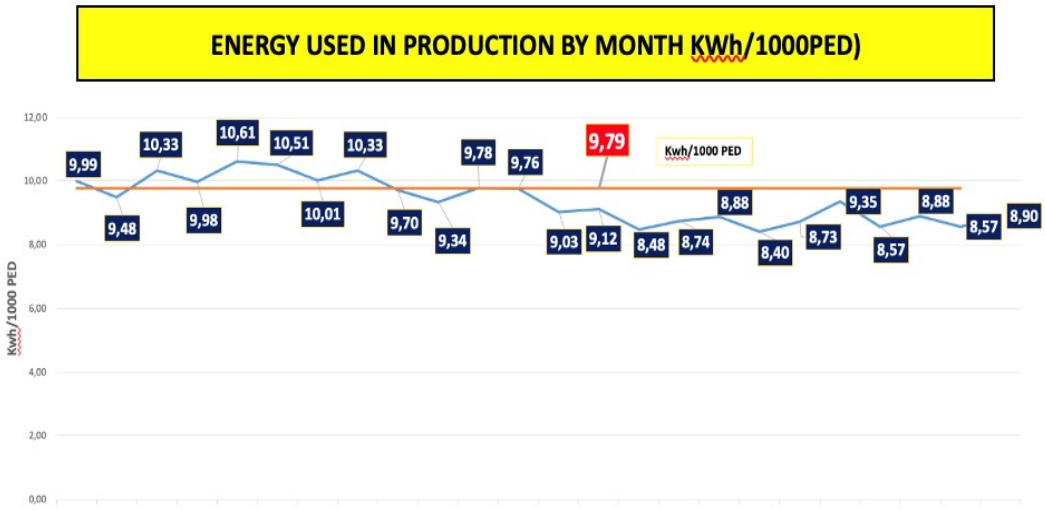

Figure 12. Energy Consumption Graph (Source: Case study data from the company)

Energy Consumed in the Factory

The area shown in red as 9.79 in this table is the average of the energy used in the production of each 1000 pads over 24 months (2 years).

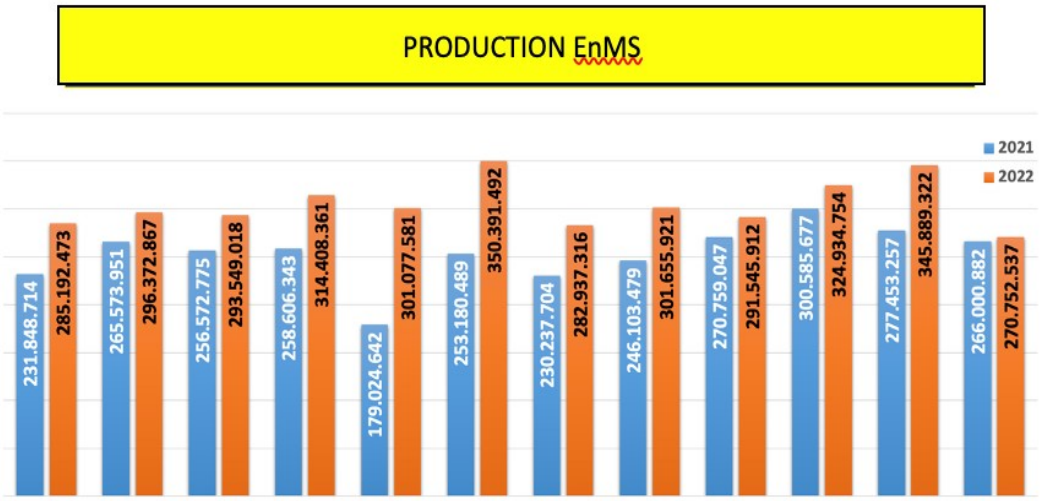

Figure 13. Number of Product Production (Source: Case study data from the company)

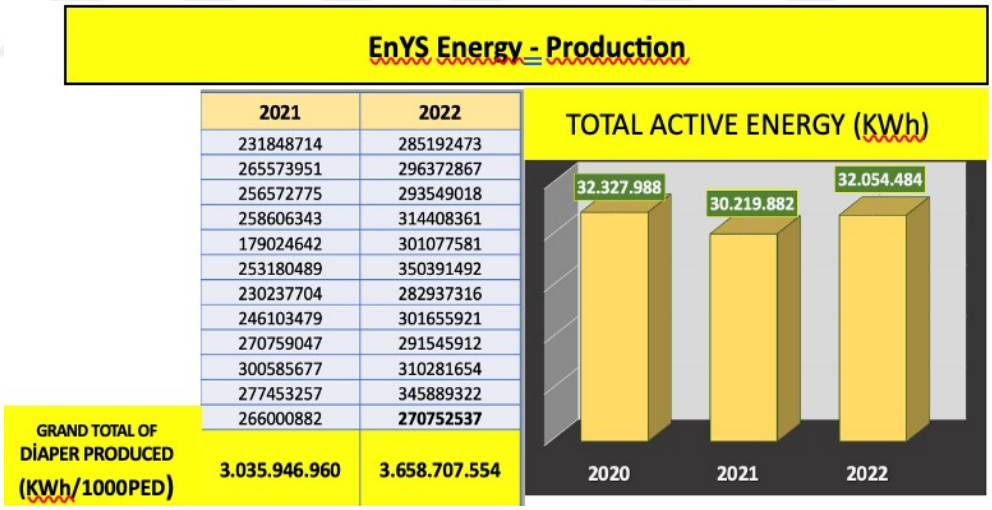

Figure 14. EnMS Energy Production List (Soırce:Case study data from the company)

$$\frac{\text{Total consumption energy(kwh) in 2022}}{\text{Total number of pads produced in 2022}} = \frac{32.054.484 \text{ kWh}}{3.658.707.554 \text{ pads}}$$

= 0.008 kWh/pad (kWh spent per pad)

= 0.008 x 1000 pad = 8.76 kWh/ 1000pads

The application of energy management must be observed and measured accurately in order to get the desired result. Reporting the measured energies is also one of the most important steps. Following the reporting at the meetings is one of the most important duties of the energy manager.

The purpose of this system is to measure energy consumption, to control whether the kwH gain calculated for the end of the year will be achieved and to understand whether it meets the necessary conditions specified in ISO50001.

Energy consumption is reported on a daily, monthly and annual basis according to the division and requirements in kWH.

7.5. Measurements and Analysis

7.5.1. Energy Efficiency in Compressed Air Systems

The fact that air losses cause great electricity consumption and financial losses to the factories shows the importance of using the air correctly and effectively. Compressed air is produced with compressors. And compressors consume a large amount of energy to produce the air, which is a serious amount for the energy used in the business. Because of this energy consumption size, the improvement applications to be made in the compressors are of great importance for the factory to reach the EnMS target (C. Beals, J. Ghislain, H. Kemp et al., 2003). Electronic device used to detect air leaks. It can also be called an air leak detector with a camera.

Figure 15. Air Leak Detector (Source: Case study data from the company)

Measurements are made with a thermal imager.

Points where air leakage is detected with this device are shown in the pictures below:

Figure 16. Point of Air Leakage Detected (Source: Case Study Data From The Comapany)

Leakage: 14 L /min

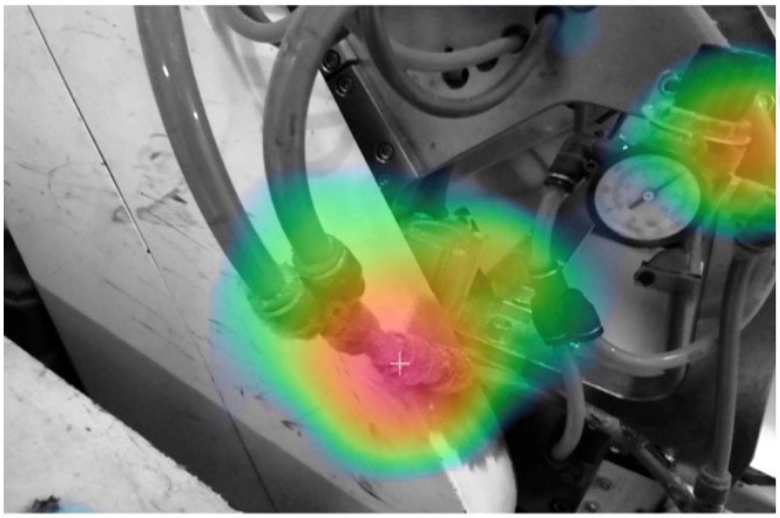

Figure 17. Point of Air Leakage Detected (Source: Case Study Data From The Company)

Leakage: 45 L /min

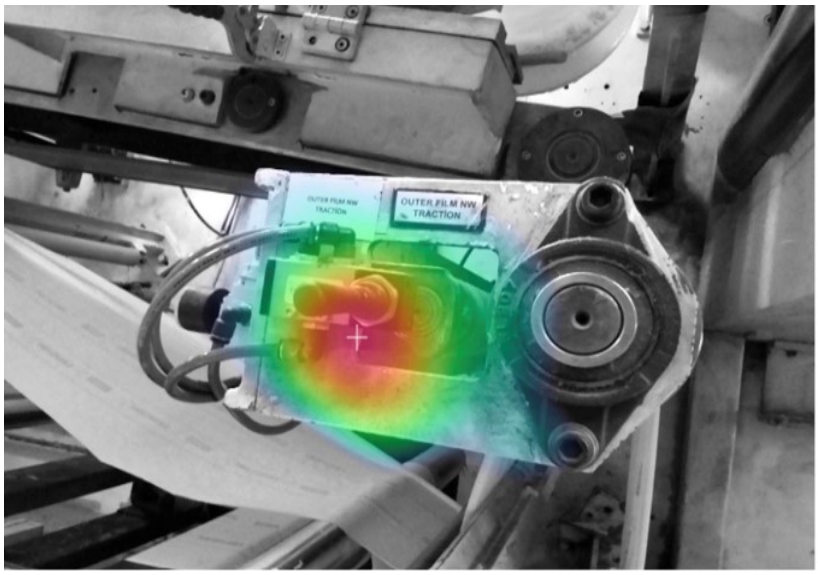

Figure 18 . Point Of Air Leakage Detected (Source: Case Study From The Company)

Leakage: 35 L/ min

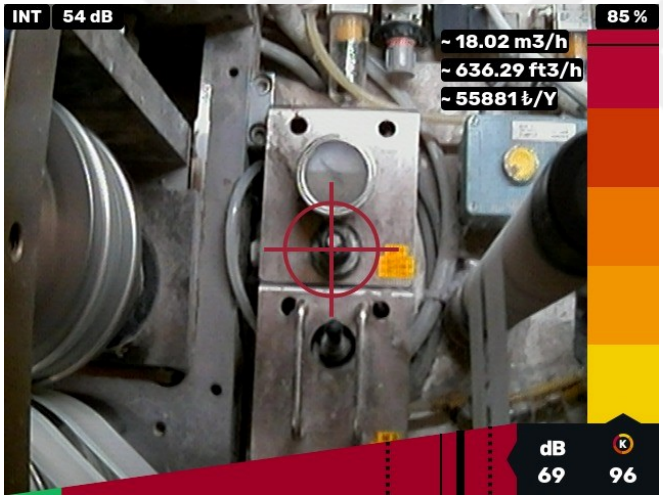

Figure 19. Point of Air Leakage Detected(Soırce: Case Study Data From the Company)

The amount of air leakage in 1 hour: 18.02 m^3/h

The amount of air leakage in 1 hour: 636.28 ft^3/h

Energy cost of air leakage at this point in 1 year: 55881 TL

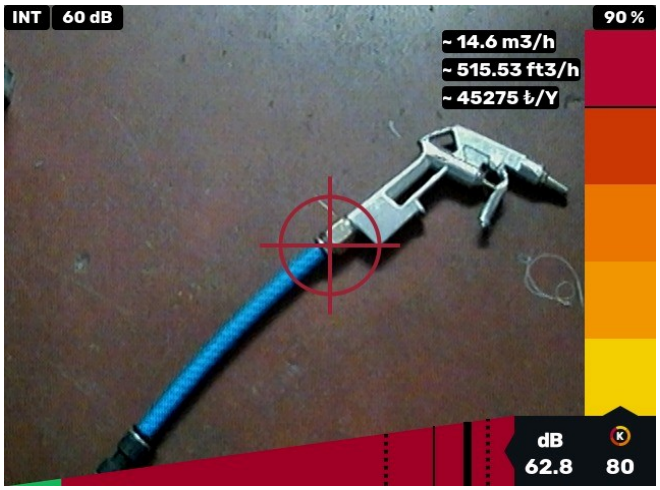

Figure 20. Point of Air Leakage Detected(Source: Case Study Data From the Company)

The amount of air leakage in 1 hour: 14.6 m^3/h

The amount of air leakage in 1 hour: 515.53 ft^3/h

Energy cost of air leakage at this point in 1 year: 45275 TL

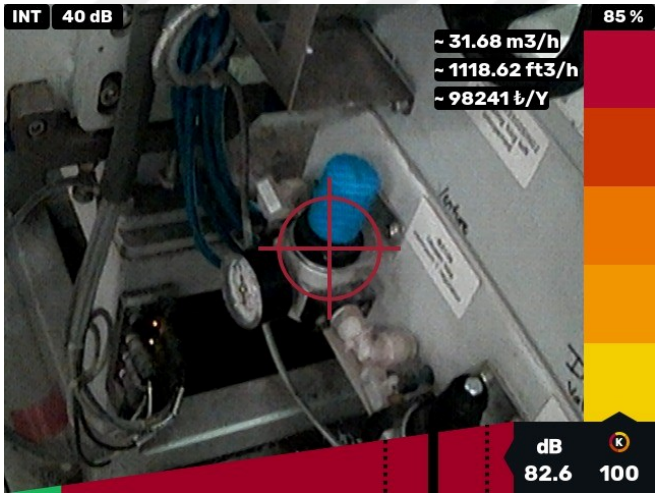

Figure 21. Point of Air Leakage Detected(Source: Case Study Data From the Company)

The amount of air leakage in 1 hour: 31.68 m^3/h

The amount of air leakage in 1 hour: 1118.62 ft^3/h

Energy cost of air leakage at this point in 1 year: 98241 TL

Calculations are made as a result of these air leak detections:

Before the application, measurements were made with the necessary tools and hourly consumption values were found, kwh and TL gain was achieved by optimizing these values as follows:

Measured compressor output set at 6.5 Bar at end points; It is obtained as a result that it varies between 6.3-6.4 Bar.

Hourly energy consumption at 7 Bar 422,34 kWh

Hourly energy consumption at 6.5 Bar 425.499 kWh

Hourly energy consumption at 5.9 Bar 388,221 kWh

-- 6.5 bar difference from 7 bar is added as 350500 kWh.

Expected/Actual Gain kwH Calculation: 10 kw saved in an hour x working time of the machine

= 10 x24 x 350

= 84,000kWh

Expected/Actual Gain TL= Expected/Actual Gain kwh x current price for 1 kwh

= 84,000kwh x 4

= 336,000TL

7.5.2. Energy Efficiency by Automatic Shutdown of Conveyors Metal Detectors

For the automatic shutdown of metal detectors of the exit conveyors of 4 machines for you and during maintenance failures has been implemented. The calculation of Kwh and TL gained after this application is shown below:

Expected/Actual Gain kWH Calculation:

= 0,37x 24x 10

= 88.80 kwH

Expected/Actual Profit (TL) = Expected/Actual Gain kwH Calculation x 1 kwh current date price

= 88.80 kwH x 4 = 355.20 TL

For the automatic shutdown of metal detectors of the exit conveyors of 12 machines for you and during maintenance failures has been implemented. The calculation of Kwh and TL gained after this application is shown below:

Expected/Actual Gain kWH Calculation:

= 0,37 x 24 x 10 x 2

=177.60 kwH

Expected/Actual Profit (TL) = Expected/Actual Gain kwH Calculation x 1 kwh current date price

=177.60 kwH x 4 = 710.40 TL

For the automatic shutdown of metal detectors of the exit conveyors of 2 machines for you and during maintenance failures has been implemented. The calculation of Kwh and TL gained after this application is shown below:

Expected/Actual Gain kWH Calculation:

= 0,37 x 24 x 10 x 4
= 355.20 kwH
Expected/Actual Profit TL = Expected/Actual Gain kwH Calculation x 1 kwh current date price

=.355.20 kwH x 4 = 1.420.80 TL

For the automatic shutdown of metal detectors of the exit conveyors of 1 machine has been applied to you and during maintenance failures. The calculation of Kwh and TL gained after this application is shown below:

Expected/Actual Gain kWH Calculation:
=0,37x 24x 10 x 3

=266.40 kwH

Expected/Actual Profit TL = Expected/Actual Gain kwH Calculation x 1 kwh current date price

=.266.40 kwH x 4 = 1.065.60 TL

For the automatic shutdown of metal detectors of the exit conveyors of 1 machine has been applied to you and during maintenance failures. The calculation of Kwh and TL gained after this is shown below:

Expected/Actual Gain kWH Calculation:

=0,37x 24x 10 x 2

=177.60 kwH

Expected/Actual Profit TL = Expected/Actual Gain kwH Calculation x 1 kwh current date price

=177.60 kwH x 4 = 710.40 TL

For the automatic shutdown of metal detectors of the exit conveyors of 8 machines for you and during maintenance failures has been implemented. The calculation of Kwh and TL gained after this application is shown below:

Expected/Actual Gain kWH Calculation:

=0,37x 24x 10

=88.80 kwH

Expected/Actual Profit TL = Expected/Actual Gain kwH Calculation x 1 kwh current date price

=88.80 kwH x 4 = 355.20 TL

Investment Cost of the Project = 350 TL

For the automatic shutdown of metal detectors of the exit conveyors of 5 machines for you and during maintenance failures has been implemented. The calculation of Kwh and TL gained after this application is shown below:

Expected/Actual Gain kWH Calculation:

= (0,37x 24x 350) - (0.37 x 18 x 350)

= 777.00 kwH

Expected/Actual Profit TL = Expected/Actual Gain kwH Calculation x 1 kwh current date price

= 777.80 kwH x 4 = 3.108.00TL

Investment Cost of the Project = 350 TL

This process has been done and completed for all machines.

7.5.3. Energy Efficiency by Adjusting Pressure Upper Limits of Air Devices

By determining the pressure requirement according to the manufacturer's values on the basis of the machine, the operation and determining the air consumption need are made; by recording and controlling the instant, hourly, 24-hour, monthly, annual consumption of the machine, the electronic flowmeter device was mounted to the main air inlet of the machines as seen in the photos below and commissioned.

Flowmeter device was integrated with the computer of process engineers. The upper limits of the air consumption of the machine were determined; When the air consumption reaches the upper limits, it gives a warning to the process engineers. Process engineers get the 24-hour air consumption reports of each machine from the integrated computers and share this information with the production manager if the machine has consumed more than the required 24-hour air consumption, and the cause of unnecessary air consumption is investigated and eliminated. In conclusion, with this flow meter, it is possible to detect the air consumption outside the target consumption values of the machine and take action. Thus, the wasted use of energy caused by air leaks is prevented.

Figure 22. Flowmeters (Source: Case Study Data From the Company)

In machine analysis, vibration frequency is very important. The operation of each part creates characteristic vibration frequencies that are effective on the system. As a result of a malfunction, it produces a different frequency than the normal operation of the machine. It is tried to be detected and it helps to identify and intervene the malfunctions.

Since there will be heating in the vibrating electric motor and fans, this will cause unnecessary energy consumption in the heating. With these measurements, unnecessary energy consumption will be prevented by intervening on vibration motors in a timely manner.

We used Cf+ (Crest Factor) Fluke brand for Bearing vibrations while we were measuring in the factory and their values and equivalents are shown below.

1 – 5: “Good”
6 – 10: “Sufficient”
11-15: “Insufficient”
16 or more: “Unacceptable”

In general vibration values, 7.1 mm/s vibration value is our threshold value for the factory we examined. Above this value, it has been determined that there is more vibration and strain in the engine than normal. It is known that the engine works better as this value approaches zero.

Values according to the class of the motors as temperature - They are classified as A, B, F, and H.
The highest temperature class is H.
They can work up to 105, 130, 155 and 180 degrees Celsius, depending on their class.

These values are calculated by assuming that the environment is according to 40 degrees. In the factory we examined, we took care not to exceed 80 degrees. And using this information, the table below shows the calculated analyses for each machine.

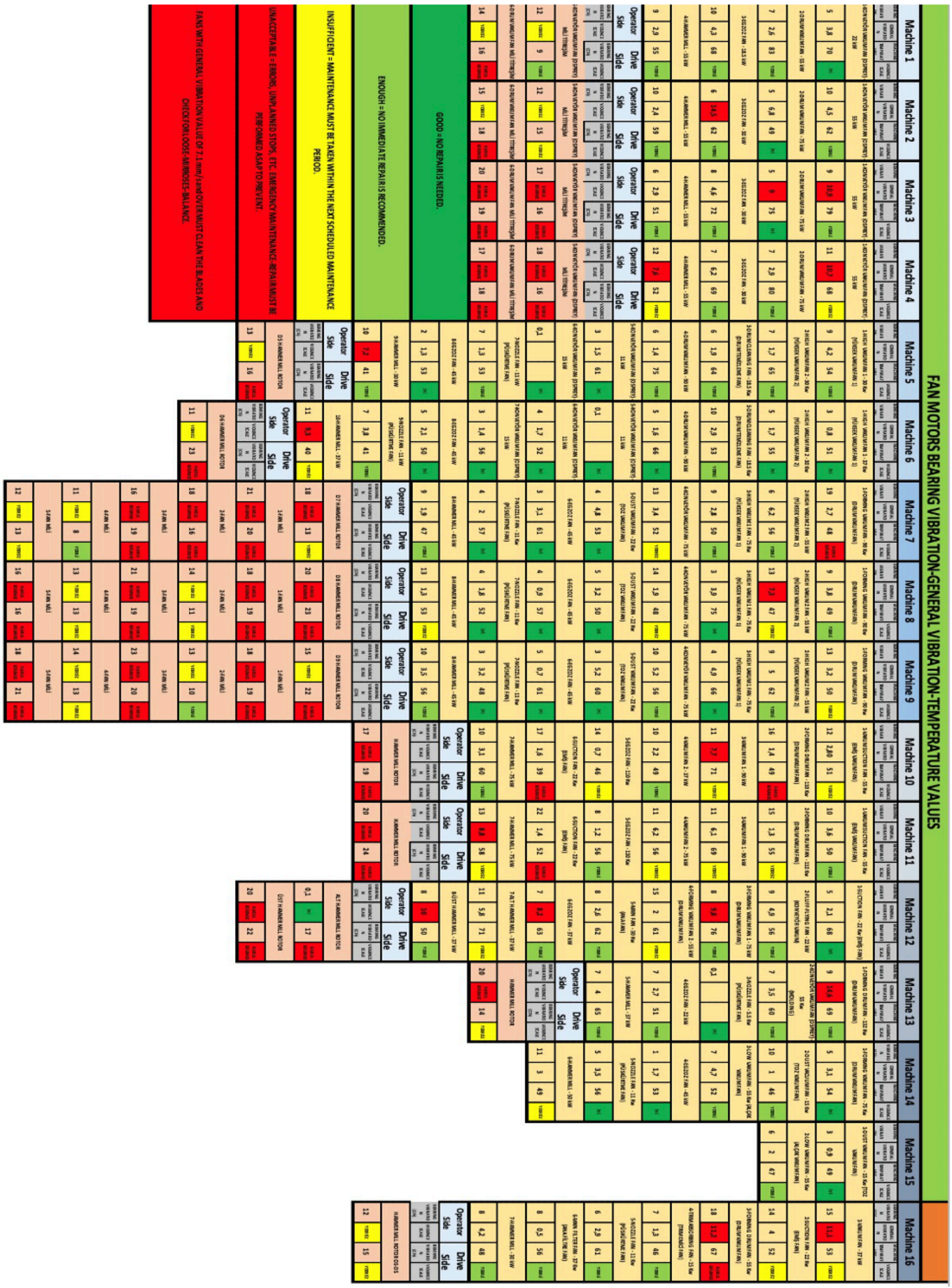

Figure 23. Calculated Vibration Frequencies (Source: Case Study Data From the Company)

Working with the optimum frequency value will be ensured in the fan motors working with the drive in the machine, together with the process and production departments. Intervented machines will be monitored for 10 days, after which the lower and upper limits will be determined, and the processors will be asked to inform the line leader when they are outside the limit. It is a continuous practice.

Expected/Actual Gain (kWH):

= 40x24x300=288,000kWH

Expected/Actual Gain TL= Expected/Actual Gain kwh x 1 kwh how many current date price:

= 288,000kwh x 4 = 1.152,000TL

The profit rate here is calculated annually and is written in the table for calculating the targeted kwh and TL gain.

7.5.4. Energy Efficiency by Temperature Measurement using Thermal Camera

With the help of a thermal camera, infrared radiations are detected and displayed. The temperature of the measured surface is determined accordingly.

The temperature measurements of the machines working with the thermal camera and the temperature measurement system were made, the places where it was determined that the motors were overheating than the normal value were determined, and the necessary interventions were made, thus preventing the waste of energy. The measuring device is shown below:

Figure 24. Thermal Camera (Source: Case Study Data From the Company)

The root cause of the warming will be investigated. Engine that uses air for cooling, etc. For all the machines for which the equipment list will be created. As long as you are in the machines, the problems in the engines will be eliminated.

Expected/Actual Gain (kWH):

= 1x24x350

= 8,400kWH

The calculation for the units cooled by chillers is as follows:

Expected/Actual Gain (kWH):

= 0,5 x10 x 24 x 200

= 24.000.00kWH

Expected/Actual Gain TL = Expected/Actual Gain kwH x 1 kwh current date price

= 24.000.00kwh x 4 = 96.000.000TL

For the similar improvement made in another line

Expected/Actual Gain (kWH):

= 0,5 x 2 x 24 x 200

= 4.800.00kWH

Expected/Actual Gain TL = Expected/Actual Gain (kwH) x 1 kwh current date price

= 4.800.00kwh x 4 = 19.200.000TL

This application has been completed once and is not an application that should be done continuously.

7.5.5. Energy Efficiency by Taking Machines to Standby

It is to shut down the vacuum motors and take the glues to the standby in case of downtimes such as maintenance and malfunctions in the machines. It is a continuous application, so there is no specific deadline.

Expected/Actual Gain (kWH)

= [motor KWH x machine downtime for maintenance x number of maintenance days per year x number of fan motors)

= 100 x 4 x 80 x 2

= 64000kwH

Expected/Actual Gain (TL)= Expected/Actual Gain kwh x 1 kwh current date price

= 64000kwh x 4

= 256,000TL

By putting the glue tanks into standby and turning off the vacuum motors, energy savings were achieved in kWh and current electricity prices in TL. The rates in this calculation are calculated for one year, they are annual savings.

7.5.6. Energy Efficiency by Replacement of Outdoor Lighting Projectors with Led Projectors

Exterior lightings will be turned on with a photocell from being constantly on,

Expected/Actual Gain (kWH):

= 115/1000 x 9 x 24 x 350 - 115/1000x9x4x350

= 7.275.00Kwh

Expected/Actual Earning (TL)= Expected/Actual Earnings kwh x 1 kwh current date price

7.275.00kwh x 0.22706
= 1.645.05TL

Expected/realized earnings (TL) = 1019,99 TL

$$\text{Project payback period (months)} = \frac{\text{investment amount of the project (TL)}}{\text{expected/realized earnings per month (TL/month)}}$$

= 1019,99 / 1645,05 x 12

= 7,44 months

For making all machine interior lights LED and keyed, with photocell. This efficiency study has been done on 4 machines. They have been installed inside the

machines, but they have not been automated yet. The calculation for a machine is shown in this state.

Expected/Actual Gain (TL):

= 0.12 x 24 x 350 x 4

= 4.032.00 TL

The same process was implemented for 2 other machines. When the machine is running, it is ensured that it is turned off and buttons are placed. Thanks to the buttons, it can be opened when needed and texts are written on the buttons.

Expected/Actual Gain (TL):

= 0.32 x 24 x 350 x 4

= 10.752.00 TL

The same efficiency study was carried out on 3 other machines. When the machine is running, it is ensured that it is turned off and buttons are placed. Thanks to the buttons, it can be opened when needed and texts are written on the buttons.

Expected/Actual Gain (TL):

= 0.24 x 24 x 350 x 4

= 8.064.00 TL

Automatic shutdown of machine interior lights. All of them will be LED and keyed and will be made Photocell. This efficiency study was carried out on 2 machines. When the machine is running, it is ensured that it is turned off and buttons are placed. Thanks to the buttons, it can be opened when needed and texts are written on the buttons.

Expected/Actual Gain (TL)
= 0.32 x 24 x 350 x 4

= 10.752.00 TL

Automatic shutdown of machine interior lights. All of them will be LED and keyed and will be made Photocell. This efficiency study was carried out on 4 machines. When the machine is running, it is ensured that it is turned off and buttons are placed. Thanks to the buttons, it can be opened when needed and texts are written on the buttons. It was deemed sufficient for the existing 12 lamps in the machine to operate as 6, and 6 lamps were permanently turned off.

Expected/Actual Gain (kWH):

= (0.031 x 12 x 24 x 350) – (0.031 x 6 x 24 x 350)

=1.562.40 kWh

Expected/Actual Gain (TL) = Expected/Actual Gain (kwH) x 1 kwh current date price

= 1.562.40kwh x 4 = 6.249.60TL

7.5.7. Energy Efficiency by Automatic Shutdown of Manual Welders

When manual welding machines are not working, they are automatically shut down after the specified time. The factory we examined determined this time as the first 10 minutes. And the welding machine turns off after the first 10 minutes of nonuse.

Expected/Actual Gain (kWH):

= [(1,1 x 24 x 100 x 6) – [1,1 x 2 x 100 x 6)] + [(1.1 x 24 x 100 x 4) – (1.1 x 2 x 100 x 4)]

= 24.200.00kwH

Expected/Actual Gain TL = Expected/Actual Gain (kwH) x 1 kwh current date price
= 24.200.00 kwH x 4

= 96.800.00TL

Investment Cost of the Project = 2000 TL

This application has been completed once and is not an application that should be done continuously.

7.5.8. Energy Efficiency by Using Hummer Shaft Lights with Sensors

Expected/Actual Gain (kWH):

= [(0,08 x 24 x 350) – [(0,08 x 2 x 350)]

=616.00kwH

Expected/Actual Gain TL = Expected/Actual Gain (kwH) x 1 kwh current date price

= 616.00 kwH x 4

= 2.464.00TL

Investment Cost of the Project = 625TL

This application has been completed once and is not an application that should be done continuously.

7.5.9. Energy Efficiency by Reducing the Frequency of Vacuum Motors

Frequency reduction is achieved by attaching drivers to machine vacuum motors

Expected/Actual Gain (kWH)

= [(10 x 20 x 350) - (7 x 20 x 350)]

=21.000.00kwH

Expected/Actual Gain (TL) = Expected/Actual Gain (kwH) x 1 kwh current date price
=21.000.00 kwH x 4= 84.000.00TL

CHAPTER 8: CONCLUSION AND SUGGESTIONS

Studies and measurements of energy-based application areas in a hygiene products factory, these determinations and result applications were made.In the study, production processes were examined, and energy studies were carried out in production. With these studies, areas that use energy intensively and where energy losses are detected were determined.

As a result of the analyses made, the characteristics of all energy losses are very important, and the pictures made are very important. However, as a result of the structuring, the operation where the correct operation of the air is very important and in case of air leaks, very large units of kWh and TL reduction for the factory will cause losses.

Result of the analyses made in production, it was aimed to reduce the energy consumed in the factory, which we examined with the energy analysis and interventions, which are the most used areas of electricity at the right time.

As a result of the improvements made in the hygiene products factory we examined, it was concluded that 650.485 kWh of electrical energy was saved, and after the investment cost of 15.519.99 TL, 4.118.856.62 TL was saved. The payback period of this project is foreseen as 7.44 months. And thanks to these improvements, it has been awarded the ISO50001 certificate. and as a result of these improvements, it can be an example of the energy improvements that Türkiye, which trades with Europe, needs to make in order to be in compliance with the green deal, and it is shown how much energy efficiency has increased after this example.

In addition, as a result of the survey and interview conducted with the employees involved in the energy efficiency application in the factory and the management, they made very important suggestions that the employees were generally conscious of energy efficiency and that additional management should be considered in the applications made in their own departments. and suggestions have been made to increase energy efficiency.

The kwh and TL display we expect as a result of the applications we made in the factory are shown below:

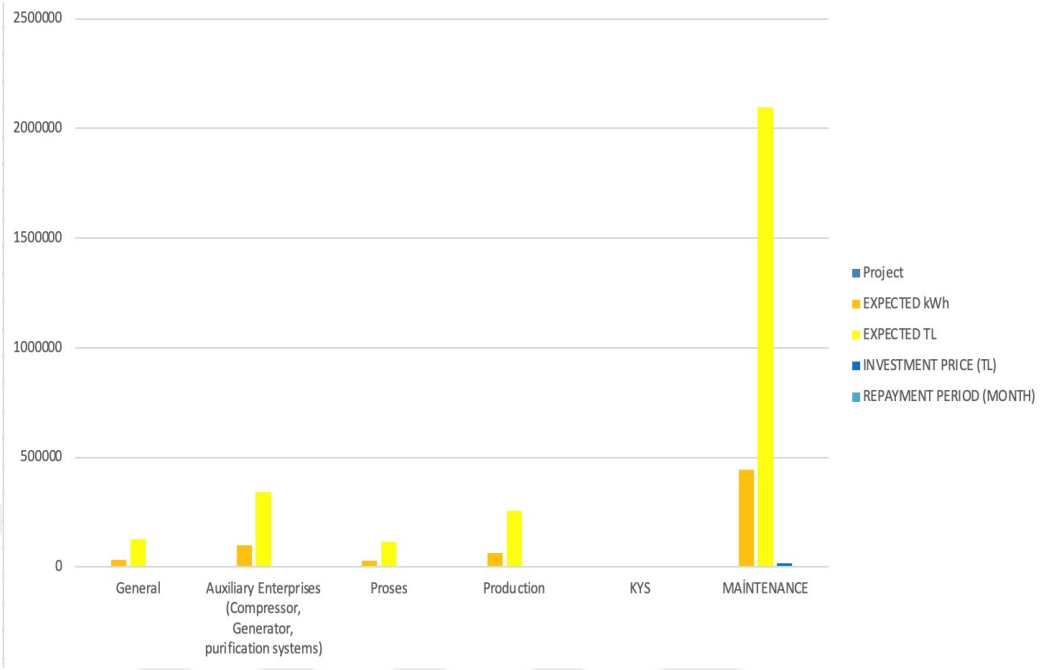

Figure 25. Expected kWh and TL gain graph (Source: Case Study Data From the Company)

Departments	Project	EXPECTED kWh	EXPECTED TL	INVESTMENT PRICE (TL)	REPAYMENT PERIOD (MONTH)
General	8	33.562	128.000,00		
Auxiliary Enterprises (Compressor, Generator, purification systems)	9	100.000	339.632,96		
Proses	2	28.800	115.200,00		
Production	3	64.000	256.000,00		
KYS	14				
MAİNTENANCE	148	444.422	2.096.927,66	15519,99	7,44
Grand Total	184	670.785	2.935.760,62	15519,99	7,44

Figure 26. Expected Gain of Project (Source: Case Study Data From the Company)

All these results show that many applications can be made to reduce the energy used in the hygiene sector and efficient results can be obtained from them. These applications are very important for the energy to be more sustainable. Therefore, energy efficiency applications are of great importance in the industrial area where a large part of the energy is spent. For this reason, studies and investigations for energy efficiency should be continued and followed continuously.

For the most efficient use of energy, the energy applications made in the factory should be supported by the managers, employees, and the state. And all employees should be conscious about this. Measures such as wasted energy and air leaks should be taken continuously. ISO50001 Energy management standard should be taken and

applied by factories. For this reason, it is very important to listen to the suggestions of the employees in an energy efficient factory, such as the suggestions we received in the survey we made.

The energy efficiency we achieved with ISO50001, which we implemented in the company, also affects Turkey, which trades with the EU, and is a very important example for the actions taken by Turkey to use the energy efficiently for the industry in order to comply with the Green Deal, and as a result of our study, it is seen that it is an application suitable for the target of using this energy efficiently.

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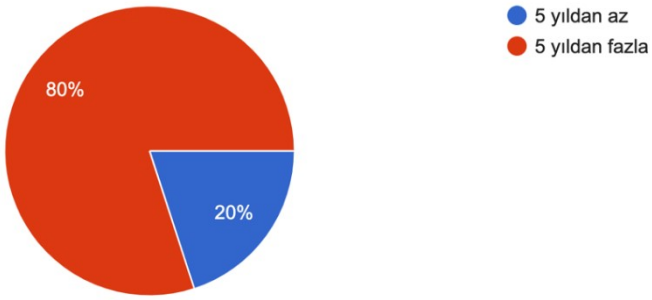
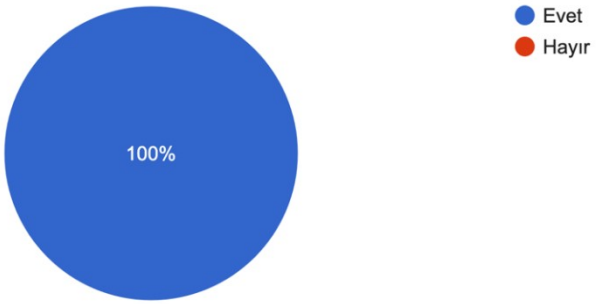
APPENDICES

Appendix A - Survey Questions and Results

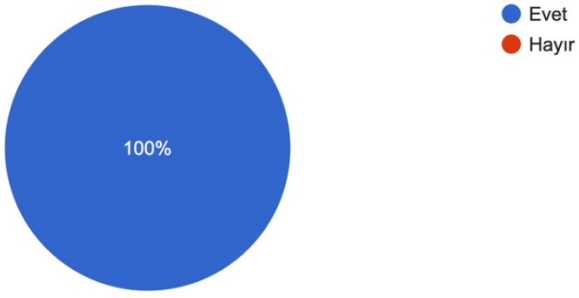
Kaç yıldır bu fabrikada çalışıyorsunuz?
5 yanıt



İş arkadaşlarınızla enerji verimliliği ile ilgili üzerine konuşmalar yapıyor musunuz?
5 yanıt

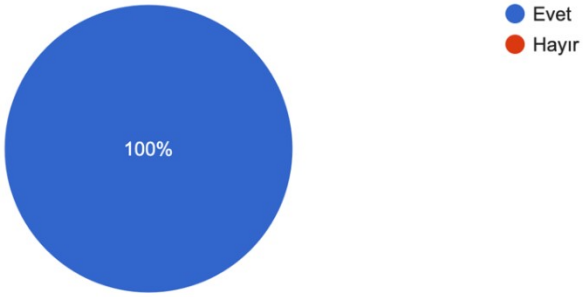


Enerji tasarrufu yaparak fabrika ve devlet bütçesine katkı sağlayacağınıza inanıyor musunuz?
5 yanıt



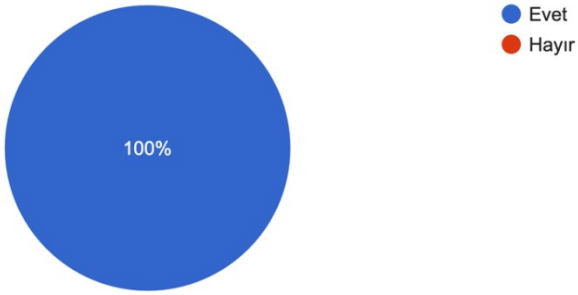
Yöneticileriniz enerji verimliliği önerilerinizi destekliyor mu?

5 yanıt



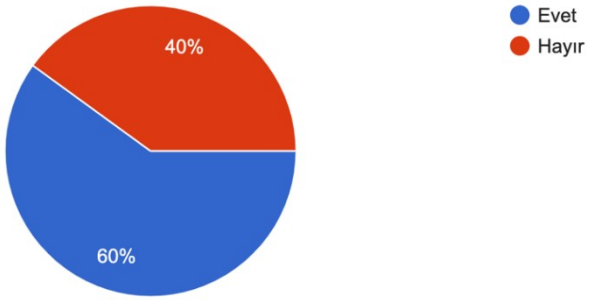
Fabrikadaki odadan ve tuvaletten ayrılırken ışık otomatik kapanmıyorsa, siz kapatmaya dikkat ediyor musunuz?

5 yanıt



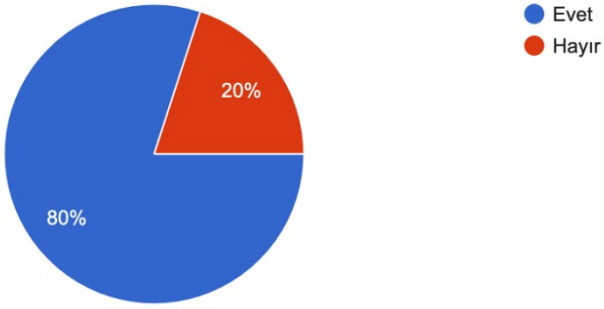
Fabrikanızda enerji verimliliği ile ilgili yeterli bilinç var mı?

5 yanıt



Fabrikanızda uygulanan Enerji Verimliliği uygulamalarını yeterli buluyor musunuz?

5 yanıt



Fabrikanızdaki enerji tasarrufu yapmanın en iyi yolu sizce aşağıdakilerden hangisidir?

5 yanıt