

Investigation of the Energy Audit Annual Consumption of 1.000 TOE

Fatih AYDIN*¹ Bekir ÇANKAYA²

¹ Necmettin Erbakan University, Faculty of Engineering, Department of Energy Systems Engineering, Konya, Türkiye, fatihaydin@erbakan.edu.tr,  <https://orcid.org/0000-0003-4828-0649>

² Necmettin Erbakan University, Institute of Science and Technology, Department of Energy Systems Engineering, Konya, Türkiye,  <https://orcid.org/0000-0001-5159-090X>

*Corresponding author

Article Info	ABSTRACT
Article History Received: 26.07.2023 Accepted: 08.12.2023 Published: 29.12.2023 Keywords: Energy, Energy Study, Energy Efficiency, Energy Saving.	Our country provides 70% of its energy use from foreign countries. Our current account deficit is increasing due to energy imports. Therefore, efficient use of energy is of great importance for our country. The energy efficiency potential in the residential and industrial sectors is quite high for our country. In the literature, tons of equivalent petroleum is used as energy units and conversion between energy units is provided. In our country, for industrial enterprises with an annual energy consumption of 1000 tons of equivalent oil, the mandatory duration of energy audit work is four years. In this study, the three-year energy cost and energy consumption of an industrial enterprise with an annual energy consumption of more than one thousand tons of oil equivalent were examined, and suggestions were made to increase energy efficiency and reduce energy costs. The study company operates in the food industry. As a result of the study, it has been determined that 128 tons of equivalent petroleum energy savings can be achieved on a yearly basis, thanks to the proposal to the industrial enterprise.

Enerji Etüdü Yıllık 1,000 TEP Tüketiminin İncelenmesi

Makale Bilgileri	ÖZ
Makale Geçmişi Geliş: 26.07.2023 Kabul: 08.12.2023 Yayın: 29.12.2023 Anahtar Kelimeler: Enerji, Enerji Etüdü, Enerji Verimliliği, Enerji Tasarrufu.	Ülkemiz enerji kullanımının %70'ini dış ülkelere sağlamaktadır. Enerji ithalatı yüzünden cari açığımız artmaktadır. Bu yüzden enerjinin verimli kullanımı ülkemiz açısından büyük önem arz etmektedir. Konut ve sanayi sektöründe enerji verimliliği potansiyeli ülkemiz açısından oldukça yüksektir. Literatürde enerji birimi olarak ton eşdeğer petrol kullanılmaktadır ve enerji birimleri arasında dönüşüm sağlanmaktadır. Ülkemizde yıllık enerji tüketimi 1000 Ton eşdeğer petrol üstü olan endüstriyel işletmeler için zorunlu olarak enerji etüdü çalışması yapılma süresi dört yıldır. Bu çalışmada yıllık enerji tüketimi bin ton eşdeğer petrol üzeri olan bir endüstriyel işletmenin üç yıllık enerji maliyeti ve enerji tüketimi incelenmiş, enerji verimliliğini artıracak ve enerji maliyetini azaltacak önerilerde bulunulmuştur. Çalışma yapılan işletme gıda sektöründe faaliyet göstermektedir. Yapılan çalışma sonucunda endüstriyel işletmeye önerilen sayesinde yıl bazında 128 ton eşdeğer petrol enerji tasarrufu sağlanabileceği tespit edilmiştir.

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INTRODUCTION

Fundamentally, energy is the ability to do work. It is one of the fundamental quantities of physics that cannot be measured directly. Max Plank defined energy as "the ability of a system to produce activity outside of itself". Energy can occur or be used in different forms. Energy widely; It arises or is used in the form of mechanical (kinetic and potential), electrical, heat, chemical, magnetic and nuclear energy. The system can use some or all of these energy types while doing work. "Tonnes of Oil Equivalent" is the common unit in energy. (Kıyılmaz, 2019). Tons of Oil Equivalent is an important unit that allows energy resources to be expressed in a single unit and is used in energy, production and consumption calculations. TOE defines the energy released by the combustion of one ton of oil. 1 Tons of Oil is equal to 10.000.000.000 cal and approximately 11.630 MWh (Çankaya, 2022).

According to the statistical data of the General Directorate of Energy Affairs (EIGM); The highest energy consumption in Türkiye is in the industrial sector with 32%. The industry sector is followed by transportation with 24%, housing with 23%, trade and service sectors with 10%. Energy efficiency studies in the industrial sector, which has the largest share in energy consumption, will make a significant contribution to energy efficiency in Türkiye (Figure 1) (Anonymous, 2022). According to 2022 data, the energy consumption of the agricultural sector is 4%.

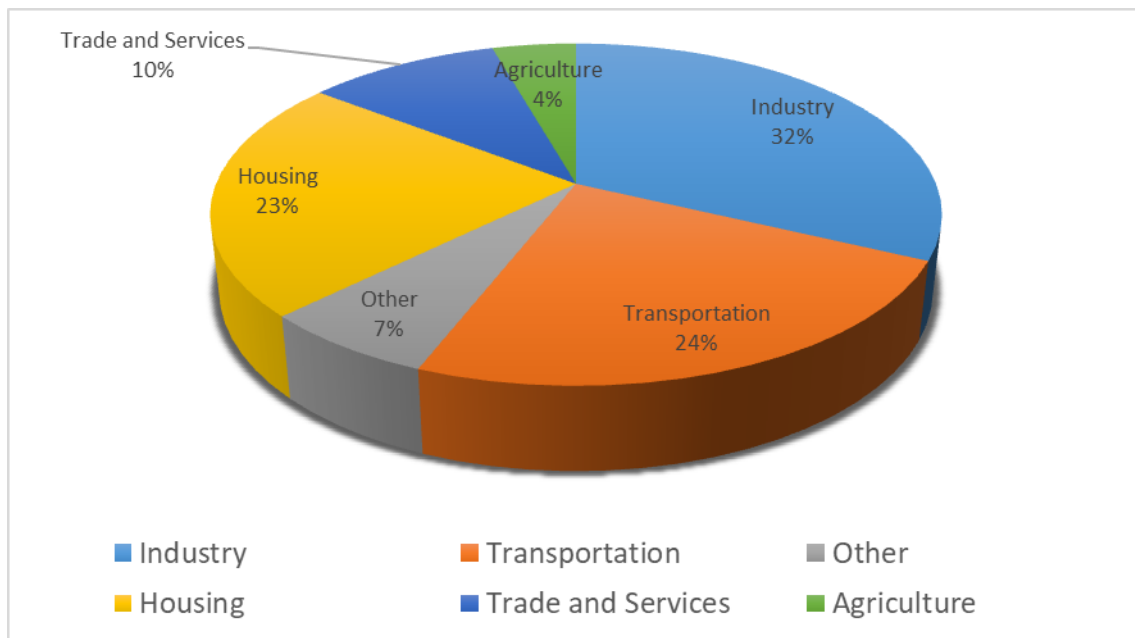


Figure 1. National Energy Balance (Anonymous, 2022)

Energy; It has a very important role in industry, transportation, mining and commercial buildings (Sitorus *et al.*, 2020). Obtaining energy in a quality, safe, continuous and environmentally friendly manner will increase people's well-being and living standards. In order for countries to grow economically, they need to produce continuously and continuously. For this reason, energy, which is an important requirement for production, must be cheap and provided safely (Haydaroğlu, 2006). Along with the developing technology in recent years, our lifestyle and habits have also changed (Uzun *et al.*, 2022). In today's global competitive environment, providing competitive advantage in every field has become one of the main goals of enterprises (Kaya and Alaykiran, 2019). In developed and developing countries, there is a continuous increase in energy consumption due to population growth, economic growth, increase in living standards and time spent inside buildings. According to the International Energy Agency (IEA); By 2040, global energy demand will increase by 30% and global electricity demand by 60% compared to current consumption, and the total population will exceed 9 billion (Al Badi and Al Sadi, 2020). Therefore, it is very important to use energy effectively and to give importance to energy saving for future generations (Balan and Yashvanth, 2020). Today, the

consumption of fossil fuels, which meet most of the energy demands, is increasing rapidly. Countries with fast developing economies have higher fossil fuel consumption demands. However, the reserves of fossil fuels do not increase at the same rate. Even if the demand for energy remains stable, it is predicted that it will be depleted in the near future, as fossil fuel reserves are limited (Yıldız *et al.*, 2018). The importance of energy efficiency in energy production and energy consumption is increasing due to reasons such as the rapid depletion of fossil fuels, our country's dependence on foreign countries at the rate of 70% in the field of energy, greenhouse gas emissions that occur during energy production and consumption, causing climate change and global warming (Karyeyen *et al.*, 2012). Energy efficiency is defined in the Energy Efficiency Law No. 5627 as “Reducing energy consumption per unit or product amount without reducing the standard of living and service quality in buildings and production quality and quantity in industrial enterprises” (Anonymous, 2007).

Energy efficiency in industry is minimizing energy consumption without reducing the production quality and production amount, without hindering the welfare level and economic development (Uzun and Değirmen, 2018). In other words, energy efficiency can be explained as a set of measures that increase efficiency and reduce energy need, such as preventing energy losses in energy uses such as steam, air, heat and gas without reducing production, and recovering various waste energies by using advanced technological equipment (Tekkol, 2019).

Energy efficiency has an important place in the policy of most developed countries. Energy efficiency improves commercial and industrial competitiveness and energy security. It also reduces environmental pollution by reducing CO₂ emissions. Energy efficiency is very important for our country, and it will both ensure the sustainable growth of our economy and increase sectoral competition. The primary energy sources in the world are rapidly depleting and new energy sources are being sought. In this respect, we can consider energy efficiency as an energy source. Studies have shown that there are great energy efficiency potentials in both industry and residence in our country (Yıldız *et al.*, 2018).

In some industrial enterprises, more energy is used than is actually required and some of the energy is wasted. This is due to the use of outdated, inefficient equipment and outdated technologies in the production process. Energy saving and efficient use of energy is very important. The purpose of using efficient equipment is to use all possible energy from the fuel. This leads to higher productivity and not only saves money. It also affects the life and safety of equipment. It reduces environmental pollution. Worldwide, country- and sector-specific analyzes show that there are significant energy efficiency improvement opportunities in the industrial sector. Most of these are low cost (Muhammad *et al.*, 2020). Since the industrial revolution, countries in the world have been competing with each other to have energy resources, as a result of this competition, energy wars are seen in the world. Energy, which has great economic importance, directs world politics. Regions where fossil fuels are found are generally always politically tense regions (Yüksel, 2020).

MATERIALS AND METHODS

In our research on efficiency in industry, that constitutes a significant part of consumption, energy study was conducted in a sample facility. Efficiency potentials were determined at the facility, and the relationship between production and energy consumption was observed (Çankaya, 2022). In the method section, the results obtained by explaining the application are given (Yurdakul and Kalaycı, 2020).

In the industrial facility where the energy survey was conducted, the electricity consumption of the compressors was measured with the Metrel brand MI2492 model energy analyzer. Picture of the energy analyzer and connection diagram of the energy analyzer are given in Figure 2, and technical information of the energy analyzer is given in Table 1.

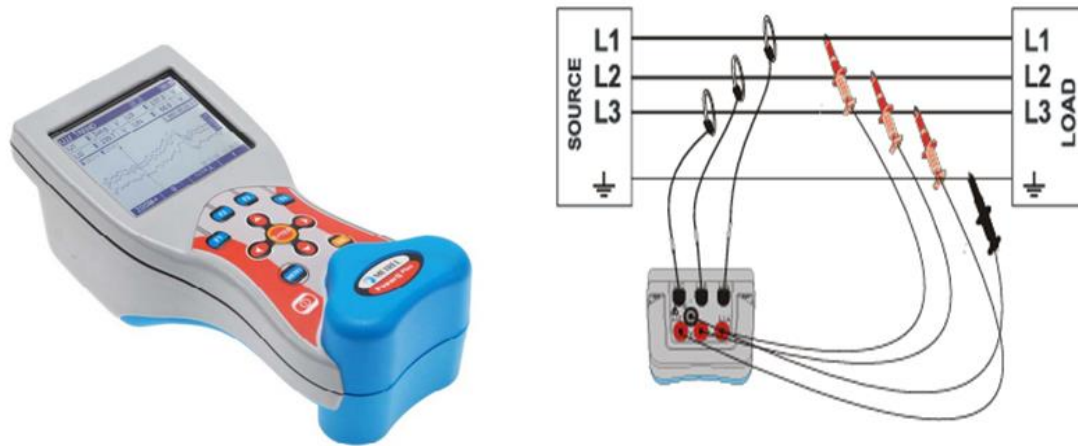


Figure 2. Energy Analyzer and Connection (Çankaya, 2020)

Table 1. Energy Analyzer Technical Information (Metrel, 2013)

Feature	Unit	Value
External DC Supply	Volt	12
	mill ampere	400
Battery Life	Hour	12
Harmonic	Degree	50
Memory	8	MB
Dimension	(mm) G x U x Y	115 x 90 x 220
Weight	g	650
Screen	LCD(160x160)	
Software	QPower	

Testo brand 875-1i model thermal camera was used for heat losses in the industrial facility where energy survey was conducted. Thermal camera is presented in Figure 3 and the technical specifications of the thermal camera are presented in Table 2.



Figure 3. Thermal Camera (Çankaya, 2020)

Table 2. Thermal Camera Technical Information (Testo, 2012 a)

Feature	Unit	Value
Heat	In operation (°C)	-15 / 40
	Storage (°C)	-30 / 60
Moisture	%	20 / 80
Screen	LCD (3.7 ") 320x240 pixel	
Measurement Temperature	°C	-20 with +350
Software	Soft PC (IR)	
Working Time (Battery)	Hour	4
Dimension	(mm) G x U x Y	108 x 262 x 152
Infrared Spectrum Band	µm	8 / 14
Minimum Focus Distance	cm	40

Testo brand 540 Luxmeter was used to measure the illumination intensity of inefficient lighting fixtures throughout the facility in the industrial facility where energy survey was carried out. The technical specifications of the Testo 540 Luxmeter are presented in Figure 4, and the technical specifications of the Luxmeter in Table 3.

**Figure 4.** Luxmeter (Çankaya, 2020)**Table 3.** Luxmetre Technical Information (Testo 20123 b)

Feature	Unit	Value
Heat	Operating temperature (°C)	0 / 50
	Storage (°C)	-40 with 70
Dimension	(mm) G x U x Y	46 x 25 x 133
Battery Life	Hour	200
Measuring speed	Second	0.5
Weight	g	95
Measuring Range	Lux	0 with 100000
Resolution	Lux 1	

RESULTS AND DISCUSSION

Since the annual energy consumption of the energy audited enterprise is above 1000 TOE, it is obligatory to have an energy manager, to establish an ISO 50001 Energy Management System and to have an energy audit every four years (Çankaya, 2022).

The three-year (2018 - 2019 - 2020) energy costs and consumption of the energy surveyed business were examined. Figure 5, the graph of the monthly energy consumption of the enterprise in 2018 is given. It is seen that natural gas consumption is approximately twice as high as electricity consumption in all months.

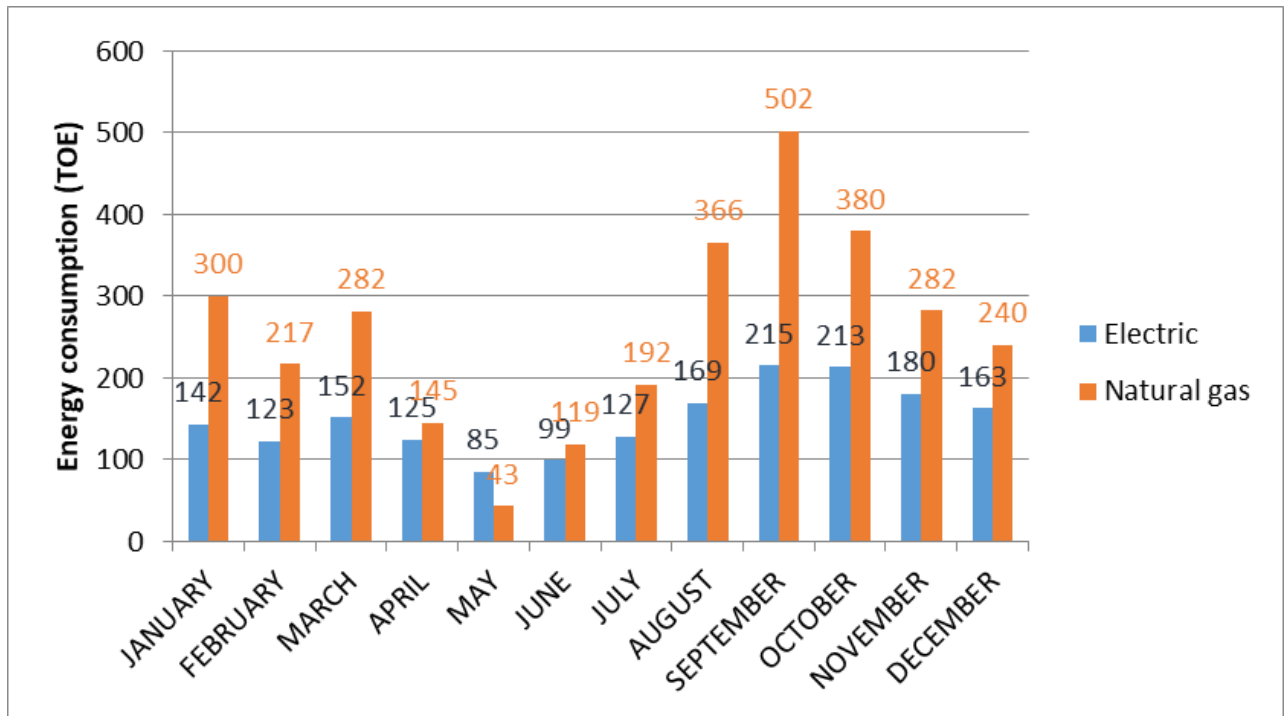


Figure 5. Monthly Energy Consumption of Industrial Enterprises in 2018

In Table 4, the annual energy consumption and costs information of the enterprise for 2018 are given. In 2018, a total of 4.858 TOE energy consumption was realized in the enterprise. While 63% of the energy consumption was natural gas, 37% was electrical energy. Although natural gas consumption is higher, 35% of the energy cost is natural gas and 65% is electricity. The reason for this is that the unit energy cost of electricity (₺/TOE) is higher than the unit energy cost of natural gas.

Table 4. Annual Energy Consumption and Cost Information in 2018

Energy Type	Consumption				Cost		The unit cost
	Quantity	Unit	TOE	% Total	₺	% Total	₺/ TOE
Electric	20.849,077	kWh	1.793	37	8.819,256	65	4.919
Natural gas	3.715,486	Sm ³	3.065	63	4.724,847	35	1.541
Total	-	-	4.858	100	13.544,104	100	-

In Figure 6, the graph of the monthly energy consumption of the enterprise in 2019 is given. Natural gas consumption is higher than electricity consumption in all months.

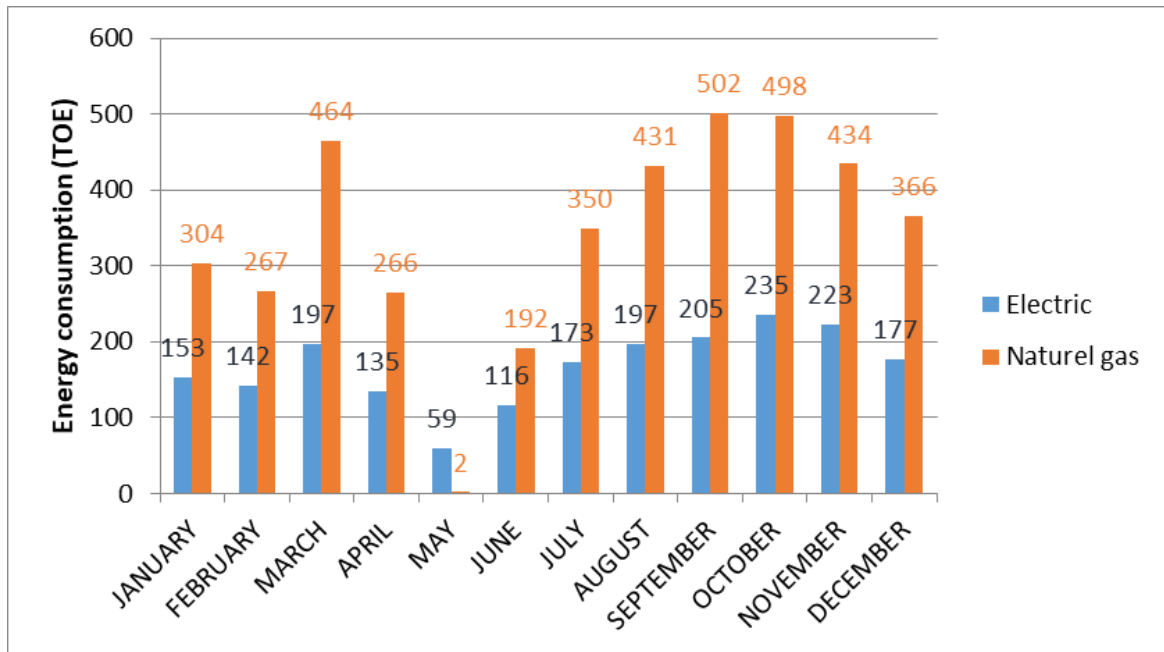


Figure 6. Monthly Energy Consumption of Industrial Enterprises in 2019

In Table 5, the annual energy consumption and cost information of the enterprise for 2019 are given. In 2019, a total of 6.089 TOE energy consumption was realized in the enterprise. Energy consumption increased by 25% in 2019 compared to 2018. While 67% of the energy consumption in 2019 was natural gas, 33% was electrical energy. Although natural gas consumption is higher, 40% of the energy cost is natural gas and 60% is electricity.

Table 5. Annual Energy Consumption and Cost Information in 2019

Energy Type	Consumption				Cost		The unit cost
	Quantity	Unit	TOE	% Total	₺	% Total	₺/TOE
Electric	23.413,776	kWh	2.014	33	12.859,739	60	6.386
Natural gas	4.940,311	Sm ³	4.076	67	8.646,482	40	2.121
Total	-	-	6.089	100	21.506,220	100	-

In Figure 7, the graph of the monthly energy consumption of the enterprise for the year 2020 is given. Natural gas consumption is higher than electricity consumption in all months.

In Table 6, the annual energy consumption and cost information of the enterprise for the year 2020 are given. In 2020, a total of 5,351 TOE energy consumption was realized in the enterprise. Energy consumption in 2020 increased by 14% compared to 2018 and decreased by 17% compared to 2019. While 65% of the energy consumption was natural gas, 35% was electrical energy. Although natural gas consumption is higher, 35% of the energy cost is natural gas and 65% is electricity. The reason for this is that the unit energy cost of electricity (₺/TOE) is higher than the unit energy cost of natural gas.

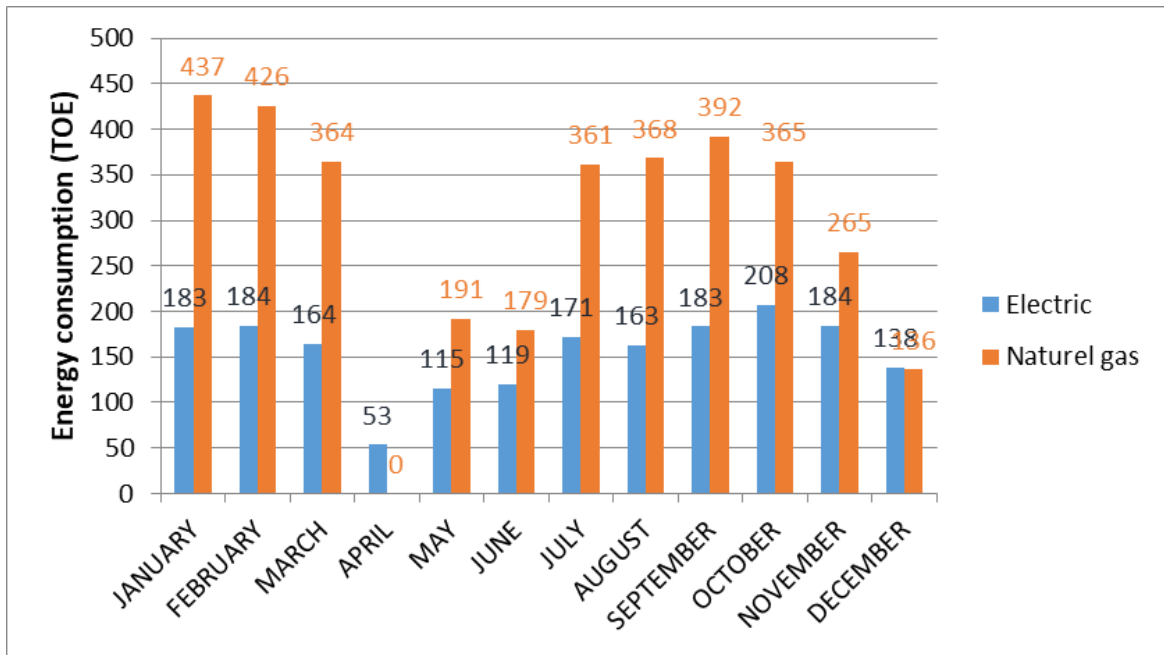


Figure 7. Monthly Energy Consumption of Industrial Enterprises in 2020

Table 6. Annual Energy Consumption and Cost Information in 2020

Energy Type	Consumption				Cost		The unit cost
	Quantity	Unit	TOE	% Total	₺	% Total	₺/TOE
Electric	21.709,140	kWh	1.867	35	11.546,805	65	6.185
Natural gas	4.223,514	Sm ³	3.484	65	6.286,904	35	1.804
Total	-	-	5.351	100	17.833,709	100	-

CONCLUSIONS

In this study, the three-year energy cost and energy consumption of an industrial enterprise operating in the food sector, whose annual energy consumption is over one thousand tons of oil equivalent, has been examined, and suggestions have been made to increase energy efficiency and reduce energy costs.

- The energy costs and consumption of the enterprise in 2018 – 2019 and 2020 were examined in detail.
- There are two screw compressors in the facility to produce compressed air. Screw compressors throw 95% of the energy they consume into the atmosphere as waste heat due to the friction of the screw group. It is possible to recover this waste heat. A waste heat recovery system is recommended for both compressors. With the waste heat recovery system for a compressor, 52.800 m³ of natural gas is saved annually.
- Non-insulated valves and pipes were detected in the facility. When heat insulation is applied to non-insulated pipes and valves, an annual gas saving of 20.759 m³ will be achieved. If the project is implemented, 4.46 Tons of CO₂ emissions per year will be prevented.
- By replacing inefficient lighting systems with LEDs, annual electricity saving of 277.300 kWh will be achieved. In addition, as a result of LED conversion, annual 148 Tons of CO₂ emission will be prevented.
- With the improvement projects proposed to the enterprise as a result of the energy survey, an annual energy saving of 128 TOE will be achieved.

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