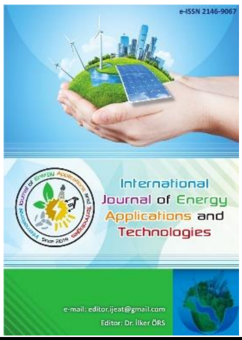
International Journal of Energy Applications and Technologies 8(4) [2021] 169-181

e-ISSN: 2548-060X

International Journal of Energy Applications and Technologies

journal homepage: www.dergipark.gov.tr/ijeat



Original Research Article

As a case study, energy analysis application of a hotel business in private sector

Fatih Aydın[1*], Fatma Nur Günay[2]

[1]*Necmettin Erbakan University, Faculty of Engineering, Department of Energy Systems Engineering, Konya, Türkiye*
[2]*Necmettin Erbakan University, The Graduate School of Natural and Applied Science, Department of Energy Systems Engineering, Konya, Türkiye*

ARTICLE INFO

* Corresponding author
fatihaydin@erbakan.edu.tr

Received July 8, 2021
Accepted October 27, 2021

Published by Editorial Board Members of IJEAT

doi: 10.31593/ijeat.964832

ABSTRACT

In our study, a detailed energy study was carried out in a hotel business, which is a commercial building, energy saving potential was determined, measures that could be taken to increase energy efficiency and reduce energy consumption costs were determined and recommendations were presented. As a result of the measurements of the hot water installation line with the thermal camera, heat losses in the valves and flanges were observed and insulation was recommended. When the investment determined for insulation is made, it is calculated that there will be a decrease of approximately 17% in the annual energy consumption for the water installation. After heating, booster and fire pump motors with efficiency class EFF_2 were replaced with IE_4 efficiency motors, it is seen there is a 6.9% increase in motor efficiency. As a result of replacing the IE_1 class engine used in the cooling system with an IE4 class engine, the engine efficiency is expected to increase by 6.2%. As a result of the replacement of halogen bulbs in the business with LED luminaires, the annual total electricity savings were calculated as approximately 19158.12 kW/year.

Keywords: Energy, Energy Audit, Energy Study, Energy Efficiency, Energy Consumption

1. Introduction

Basically, energy is the ability to do work. It is one of the fundamental dimensions of physics that cannot be measured directly. It can be determined through the work to be done to change the state of a physical system or by different calculations depending on the type of energy. Energy can be used or generated in different ways. It occurs and is used in the form of, heat, mechanical (kinetic and potential), chemical, electrical, nuclear, magnetic energy. The system can use some or all of these energy forms while performing the work [1]. Energy is required to meet our basic needs such as feeding and warming. In addition to meeting our basic needs, it is an important requirement that must be used in industry and production. In other words, it is defined as 'the ability to make a move' as a consumption tool that directly affects economic development [2].

The common unit of energy is "Ton Equivalent Oil". It is a widely used measurement unit that facilitates common production or calculation processes in different energy types. The reason for the widespread use of TEO is that the primary (coal, oil, etc.) and secondary (electricity, gasoline, etc.) energy resources that are calculated have their own measurement units [1].

The development level of the countries is directly proportional to the energy consumption per capita. To meet the energy consumed, it is necessary to have continuous and sufficient energy resources. Fossil fuels are primarily used throughout the world to meet the energy needs. However, the limited fossil fuel reserves and the depletion prediction led to the search for alternative energy resources. These searches could not reach a sufficient level to meet the current energy need. The limited energy production and the regular rise in energy demand increase the importance of energy efficiency [3].

Reducing energy consumption for any need (by isolating houses, increasing engine efficiency, etc.) reduces pollutant emissions automatically and proportionally. Energy efficiency measures are the cheapest way to protect the environment as they are cost-effective and do not require extra costs for environmental protection [4].

Energy saving, on the other hand, refers to the reduction in the amount of energy consumed at each stage to realize a certain amount of production and service as a result of the measures taken by the users in order to make efficient use of energy and energy resources [5].

Energy efficiency is a concept that complements national strategic objectives such as ensuring security of supply in energy, reducing risks arising from external dependency, making energy costs sustainable, protecting the environment and combating climate change [6, 7].

The oil crisis has led to the emergence of economic crisis and energy bottleneck all over the world. Countries have started to give importance to the efficient use of energy and the research and development of new energy resources to eliminate the negative effects of this energy crisis on their economies [8].

Focus should be on buildings in an effective strategy to reduce global energy consumption [9]. It is essential to increase the energy efficiency of the building stock for sustainability goals worldwide [10].

Building audits are conducted in many commercial buildings to identify opportunities to reduce energy costs and improve building management. As inspections often require considerable effort by civil engineers to obtain building details, they are often economical for larger commercial building owners [11, 12].

Hwang et al. 2019 [13], aimed to find out in their study how significant energy performance reflecting good energy management and energy saving measures (ECM) can be operated for complex buildings with different systems and for hospital buildings, which is a category that covers large gaps in between. In the end, they concluded that the energy saving of the hospital building is largely required to determine the energy utilization standard of the target facility system and to find the energy saving operating factor according to the characteristics of the medical facility through smart energy analysis of the hospital building.

Balan and Yashvanth 2020 [14], worked on energy auditing in residential buildings. According to the research team's recommendations, a small number of split air conditioning systems were replaced with a central air conditioning unit. In new buildings, the application was easier and the calculations were made at an affordable cost in existing buildings considering the building expenses, and payback period was determined as 4 years with the total implementation cost. Cooling load calculation was made by duct losses with 20% loss for a central air conditioner. They found that the replacement cost of the new system was much lower than the overall operating cost of existing conventional systems.

This study sets an example for improving efficiency in commercial buildings, which covers an important part of energy efficiency.

2. Material and Methods

Our study, under the subject of energy efficiency in buildings which covers a significant part of energy efficiency, includes the examination of the energy consumption and energy management system of the facility, the investigation of the efficiency of existing luminaires, building envelope, heating and cooling systems, air handling units and aspirator units, belt and pulley systems, fan and pump systems, flue gas measurement in boilers, boiler body thermal measurement and calculation of boiler. In the energy studies, the devices calibrated and labeled by accredited national or international organizations were used. Fluke brand Ti 27 model device with 11090481 serial number was used to determine the heat losses in the hotel where the energy audit was performed. The device measures in the standards of AB-0155-K and TS EN ISO / IEC 17025.

Table 1. Technical specifications of thermal imaging device [15]

Property	Unit	Value
Temperature	Operating (^{0}C)	-10 to 50
	Storage (^{0}C)	-20 to 50
	Charge (^{0}C)	0 to 40
Relative Humidity	%	10 to 95
Screen	Backlight (inches)	3.7
	LCD (mm)	640x480
Software	Smart View	
Battery Charge Time	Hour	2.5
Size	H x W x L (cm)	27.7x12.2x17
Weight	kg	1.05
Accuracy	25 ^{0}C nominal value	± 2 ^{0}C or %2
Frequency	Hz	9 to 60
Sensor Type	Pixel	240x180
Heat Sensitivity	30 ^{0}C target temperature	<0.05
Infrared Spectrum Band	μm	8 to 14
Minimum Focus Distance	cm	46

Fig. 1. Thermal imaging device

Fig. 2. Three phase portable energy analyzer

Fig. 3. Gas analyzer

Fig. 4. Pressure differential measurement device

Chauvin Arnoux brand Energy Analyzer with serial number 140563JDH was used in the measurement of motor powers in order to calculate the energy consumption of the hotel where energy audit was conducted. The device measures in the standards of AB-0155-K and TS EN ISO / IEC 17025.

For the flue gas analysis measurements in the hotel where the energy audit was carried out, measurements were made with the Madur brand, GA-21 PLUS model device with serial number 21294081. The device measures in accordance with TS EN ISOIEC 17025-2012 standards.

TESTO brand 510 model device with 38965918 serial number was used for pressure difference measurements in the hotel where energy audit was performed. The device measures in the standards of AB-0113-K and TS EN ISO / IEC 17025-2005.

Table 2. Technical specifications for three phase portable energy analyzer [16]

Property	Unit	Value
Internal Rechargeable Battery	mAh	4000
Full Charge Time	Hour	5
Size	HxWxL (cm)	24x18x5.5
Weight	Gr	1900
Harmonic Measurement	Degree	50
Current, Voltage Measurement	Degree	50
Registration Memory	Gbyte	8
Language Option	Piece	21

Table 3. Technical specifications of gas analyzer specifications [17]

Property	Unit	Value
Size	Y x G x U (cm)	4.6.x2.6x24
Weight	Kg	6.2
Working Conditions	^{0}C	10 to 50
Storage Temperature	^{0}C	0 to 55
Power. Source	VAC	90 to 240
Maximum Power Consumption	W	70
Battery	Type	Lead Acid
	Working Time (hour)	7
	Charging Time (hour)	14
Data Memory	kB	32
	Number of Data Sets	1024

The hotel business, whose energy audit was carried out, was built in 2006 and restoration work was carried out between 2015 and 2017. In the hotel, there are a total of 44 rooms including 20 m^2 standard rooms, 25 m^2 superior rooms, 30 m^2 luxury rooms and 35 m^{2}suite rooms, and there is a lobby, a currency exchange office, a restaurant, a breakfast room, a cafe, a bar, a parking area and a garden.

Table 4. Technical specifications for pressure differential meter [18]

Property	Unit	Value
Measuring Range	hPa	0 to 100
Resolution	hPa	0.01
Dimensions	cm	11.9x4.6x2.5
Operating temperature	^{0}C	0 to 50
Protection Class	IP40	
Maximum Static Pressure	mbar	500
Measuring Speed	s	0.5
Battery	Type	Mikro
	Capacity (AAA)	2
	Life (h)	50
Storage Temperature	^{0}C	-40 to 70

Table 5. Features of the hotel business whose energy audit

Specifications	Unit	Quantity
Closed Volume	m^3	3800
Annual Heating Degree Days	^{0}C/day	1374
Annual Cooling Degree Days	^{0}C/day	349
Heating / Cooling System	Two-Pipe Fan-Coil	
Insulation Condition	Mold mortar-Plaster-Paint	

2.1. Investigation of energy consumption

The monthly electricity consumption values of the hotel, whose energy audit was conducted, were converted from kWh to TEO unit, and the monthly natural gas consumption values were converted from m^3 to TEO.

$$TOE = 0.000086 * kWh \tag{1}$$

$$TOE = 0.000825 * m^3 \tag{2}$$

According to the electricity data obtained, the least electricity consumption is seen in April, as the need for cooling is low due to climate conditions in April. The highest electricity consumption was in August. Considering the general table, it is observed that electricity consumption is higher in the hot summer months than in other months. Looking at the data for natural gas, the highest natural gas consumption was in December. December natural gas consumption is followed by January and February with similar consumption values. The reason is that the heating system is used more in winter than in other months.

Considering the general picture, it is observed that natural gas consumption is higher in the cold winter months than in other months. Natural gas is also used in the restaurant section in the hotel business. Since September coincides with the school opening period, the decrease in the number of customers in the hotel reduces the use of natural gas in the restaurant section. Therefore, the least natural gas consumption in the hotel business is in September.

Table 6. Monthly electricity consumption and natural gas energy costs of the hotel management, who’s energy audit

Months	Electricity			Natural gas		
	Consumption		Cost (TL)	Consumption		Cost (TL)
	Purchased		Total	Purchased		Total
	kWh	TOE		m^3	TOE	
January	52674.42	4.53	24230.23	12230.30	10.09	14676.36
February	55581.39	4.78	25567.43	12460.60	10.28	14952.72
March	51162.79	4.40	23534.88	10933.33	9.02	13119.99
April	40000	3.44	18400.00	10024.24	8.27	12029.08
May	50930.23	4.38	23427.90	5660.60	4.67	6792.72
June	90000	7.74	41400.00	3878.78	3.20	4654.53
July	75813.95	6.52	34874.41	3709.09	3.06	4450.90
August	92325.58	7.94	42469.76	3612.12	2.98	4334.54
September	68139.53	5.86	31344.18	3490.90	2.88	4189.08
October	57325.58	4.93	26369.76	6193.93	5.11	7432.71
November	46511.62	4.00	21395.34	10193.93	8.41	12232.71
December	48139.53	4.14	22144.18	12836.36	10.59	15403.63
Total	728604.7	62.66	335158.13	95224.24	78.56	114269.08

Table 7. Monthly energy consumption and costs of the hotel management for which an energy audit was performed in 2019

Total Energy Consumption				
Months	**Electricity Purchased TOE**	**Natural gas Purchased TOE**	**Total TOE**	**Total Cost TL**
January	4.53	10.09	14.62	38906.59
February	4.78	10.28	15.06	40520.15
March	4.40	9.02	13.42	36654.87
April	3.44	8.27	11.71	30429.08
May	4.38	4.67	9.05	30220.62
June	7.74	3.20	10.94	46054.53
July	6.52	3.06	9.58	39325.32
August	7.94	2.98	10.92	46804.31
September	5.86	2.88	8.74	35533.26
October	4.93	5.11	10.04	33802.48
November	4.00	8.41	12.41	33628.061
December	4.14	10.59	14.73	37547.81
Total	62.66	78.56	141.22	449427.22

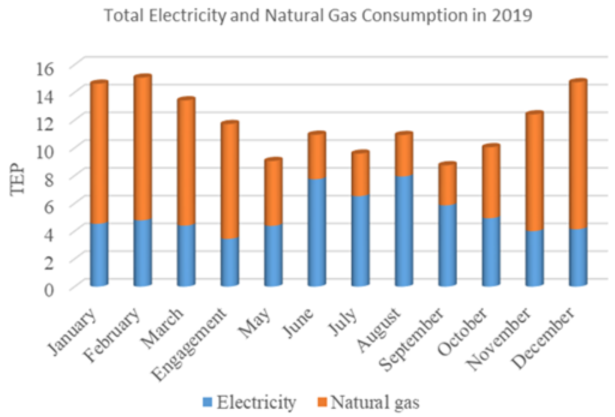


Fig. 5. Monthly electricity, natural gas and total energy consumption of the hotel management of which energy audit was made in 2019

Research Findings and Discussion

The hotel business, whose energy study is carried out, is a reinforced concrete building. The building consists of a ground floor, four mezzanines and a terrace. Reinforced concrete and aluminum joinery double glazing is used on the facade of the building. Large part of the building structure consists of glass areas. Polyvinyl Chloride (PVC) double glazing is used in the building structure. Heat losses of the building surface were measured with a thermal imager. Values between +6.3 ^{0}C and +22.6 ^{0}C were obtained on the building surface. There is more temperature transmission on the window sills compared to other surfaces.

3.1. Heating system

There are 1 floor type hot water boiler and 2 wall mounted condensing boilers in the hotel where the energy audit is carried out. Wall-mounted boilers are activated when the ambient air temperature drops below 0. Boilers are operated to meet the hot water need of the air handling unit, Fan-Coil units and domestic water. Surface insulation and flue gas analysis measurements were made in the boilers.

Fig. 7. Hot water boiler

Table 8. Thermal images of boiler surface at the hotel facility energy audit

Measured	Unit	Quantity
CO	ppm	8
O_2	%	3.1
T	ºC	107
CO_2	%	3.05

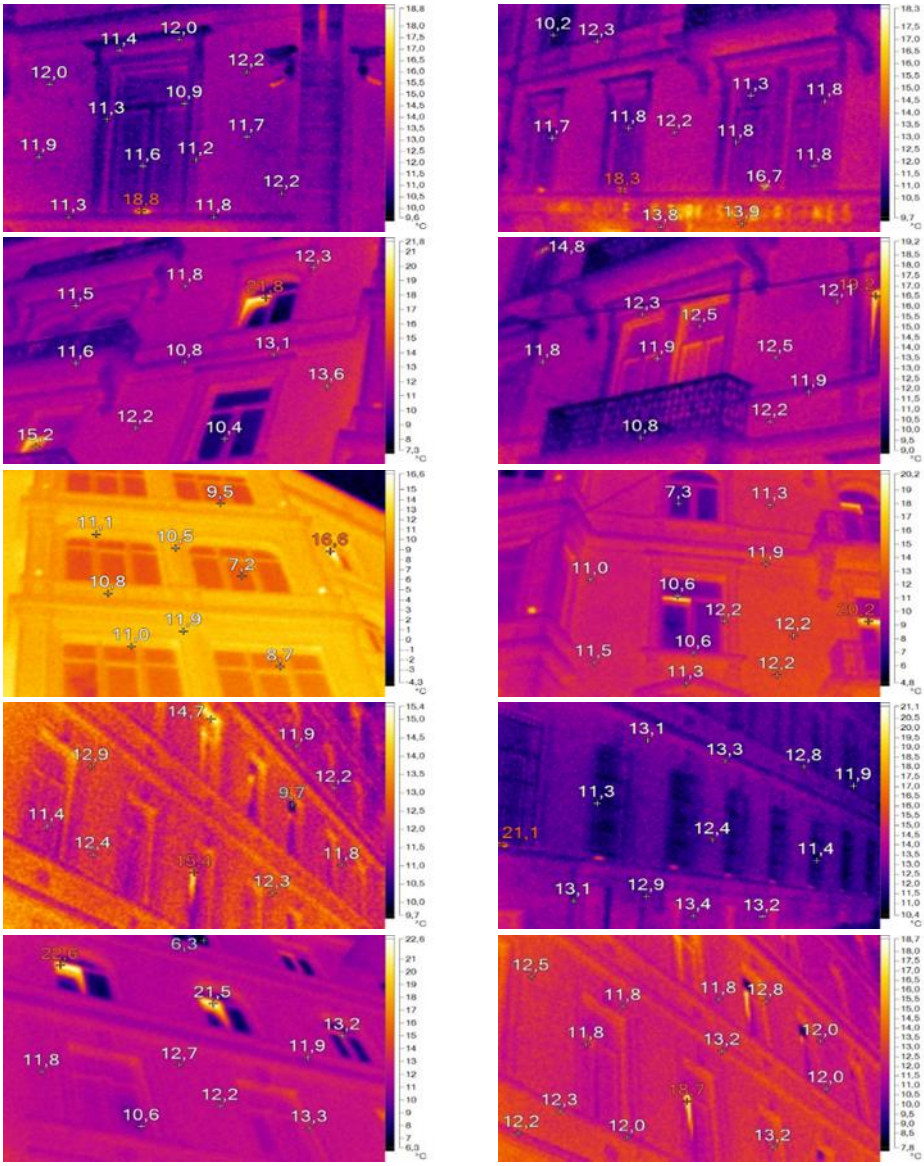


Fig. 6. Thermal images of the hotel management energy audit

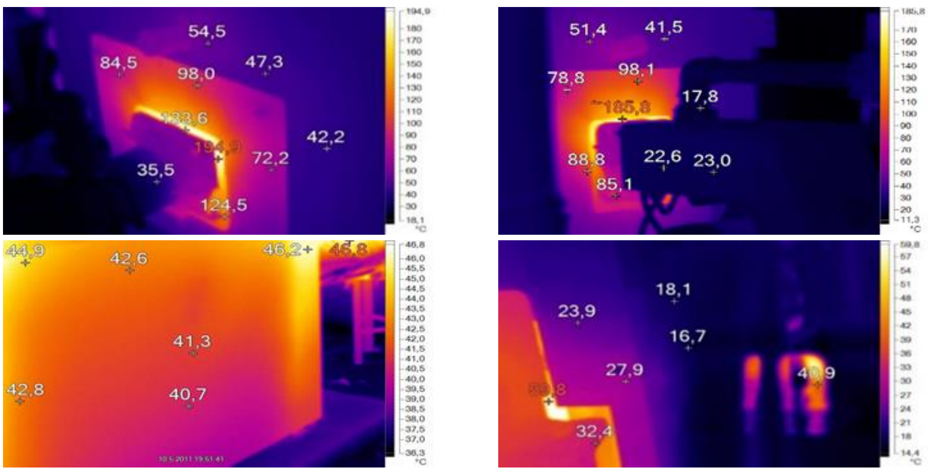


Fig. 8. Thermal images of boiler surface at the hotel facility energy audit

3.2. Air conditioning and ventilation systems

There is 1 air handling unit and 1 exhaust aspirator as a ventilation system in the hotel where an energy study is conducted. In air conditioning, while the lobby is made with a variable refrigerant flow (VRF) system, the other floors and rooms are made with a Fan-Coil system. Fan-Coil units have two pipes.

Fig. 9. Hotel enterprise ventilation and air conditioning units with energy audit

The motors used in the ventilation system have EEF_2 efficiency. If motors with IE_4 efficiency are used in this system, 15% energy efficiency is achieved.

3.3. Cooling system

There is one air cooled chiller with in the hotel business where energy study is carried out. Copper pipes with high heat conduction are called condensers. Air cooled chillers are devices that cool with the air in the condenser. With the fans on it, it cools the refrigerant flowing through the condenser.

Fig. 10. Hotel facility chiller unit with an energy audit

3.4. Installation

During the survey, the uninsulated valves and equipment in the hot water transmission lines are generally in good condition. However, uninsulated valves and equipment have been found in some areas. An analysis was made for the insulation of the valves and flashes on the hot water line in the business.

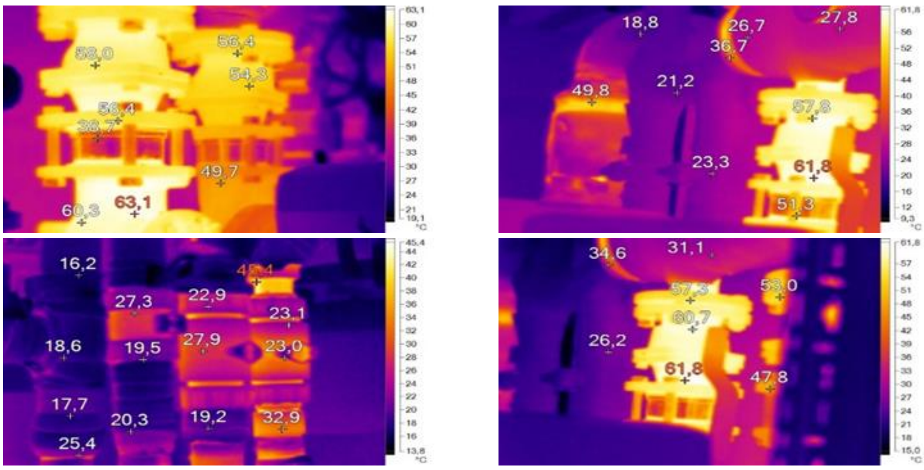


Fig. 11. Thermal views of non-insulated valves and equipment in a hotel facility energy audit

Example calculation for Line 1 in Table 9;

$$U_c = 1{,}15 \text{ x } (T_s - T_a/d_1)^{0.25} = 1{,}15 \text{ x } ((65-10)/0.1)^{0.25} = 5{,}569 W/m^2K \quad (3)$$

$$U_r = 5{,}67 \text{ x } 10^{-8} \text{ x E x } (T_s^2 + T_a^2)\, x\, (T_s + T_a) = 5{,}67 \text{ x } 10^{-8} \text{ x } 353{,}41 \text{ x } (65^2 + 10^2)\, x\, (65+10) = 6{,}5\ W/m^2K \quad (4)$$

$$Q = (U_c + U_r) x\ 2\ x\ \pi\ x d_1 x\ (T_s - T_a) = (5.569 + 6.5) x\ 2\ x\ 3.14\ x 0.1\ x\ (65-10) = 416{,}866\ Kcal/h \quad (5)$$

Table 9. Energy consumption and cost of an uninsulated installation in a hotel with an energy audit

No	**1**	**2**	**3**	**4**	**5**
Site Name	Hot water line	Hot water line	Hot water line	Hot water line	Hot water line
d_1 (m)	0.1	0.065	0.05	0.04	0.032
Ts (ºC)	65	65	65	65	65
T_a (ºC)	10	10	10	10	10
Uc (W/m^{2}K)	5.569	6.202	6.623	7.003	7.405
Ur (W/m^{2}K)	6.5	6.5	6.5	6.5	6.5
Q (Kcal/h)	416.866	285.18	226.63	186.554	153.688
E	353.41	353.41	353.41	353.41	353.41

Heat loss after insulation;

$$Q_{ins} = \left(\pi\, x\, (T_s - T_a)\right)/[(L_n\, x\ d_2/d_1)/2\, x\, \lambda] + [1/(U_{so}\, x\, d_2)] \quad (6)$$

$$Q_{ins} = \left(3.14\, x\, (65-10)\right)/[(4x\ (0.2/0.1))/2\, x\, 1.6] + [1/(30.5\, x\, 0.2)] = 69{,}24\ Kcal/h$$

Table 10. Insulated installation energy consumption and cost of the hotel enterprise whose energy audit was performed

No	**Unit**	**1**	**2**	**3**	**4**	**5**
Site Name		**Hot water line**	**Hot water line**	**Hot water line**	**Hot water line**	**Hot water line**
d_1	m	0.1	0.065	0.05	0.04	0.032
d_2	m	0.200	0.165	0.150	0.140	0.132
Ts	ºC	65	65	65	65	65
T_a	ºC	10	10	10	10	10
L_n	m	4	4.5	5	6	3
λ	W/mK	1.6	1.6	1.6	1.6	1.6
U_{so}	W/m^{2}K	30.5	30.5	30.5	30.5	30.5
Qins	Kcal/h	69.24	48.58	37.06	26.55	44.91

$$Q_t = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 = 416.866 + 285.18 + 226.63 + 186.554 + 153.688 = 1268{,}92\ kcal/h$$

$$Q_{inst} = Q_{ins1} + Q_{ins2} + Q_{ins3} + Q_{ins4} + Q_{ins5} = 69.24 + 48.58 + 37.06 + 26.55 + 44.91 = 226{,}34\ Kcal/h$$

$$Q_v = Q_t - Q_{inst} = 1268.92 - 226.34 = 1042{,}58\ kcal/h$$

$$Annual\ Fuel\ Savings = Q\_v\ \ x\ (((h * y\imath l))\ /\ ((H\_(u\ )\ x\ n)\ )) = 1042.58\, x\ (((24*200))\ /\ ((8250x\ 0.9)\ )) = 673{,}991\ m3/year$$

After the insulation, there is a decrease in consumption of approximately 17% per year.

3.5. Electricity distribution system

There is a main distribution switch with a power of 630 amperes in the hotel where the energy study is carried out. The switch with 630 ampere power is supported and works with a 12-step compensation system. Current, voltage, pf, power and harmonic values were obtained with the analyzer connected to the main distribution switch.

The single term single time industrial low voltage (LV) tariff is used in the hotel business where an energy study is conducted. For the tariff analysis, the bills for the last one year were examined. When the bills were examined, it was seen that the general use was generally during the daytime. Since most of the electricity in the facility is used in the daytime tariff, it can be said that the current single term tariff is a more appropriate tariff.

As a result of the measurements, it can be said that the harmonic values are at normal levels. Considering the load distributions, it was seen that it was distributed evenly. The pf value was measured to be close to 1, and it can be said that this value is good.

International Journal of Energy Applications and Technologies, Year 2021, Vol. 8, No. 4, pp. 169-181

Fig. 12. Hotel management main distribution (ADP) panel with energy audit

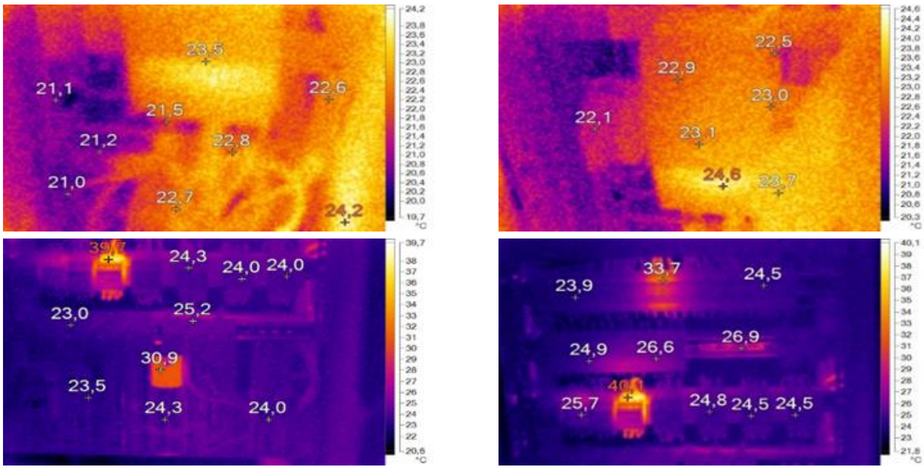


Fig. 13. Thermal view of the hotel management main distribution board for an energy audit

3.6. Electric motors

There are heating, cooling, hydrophore and fire pump motors as electric motors in the hotel where the energy study is carried out. The efficiency classes of existing motors are EFF_2 and IE_1. Replacing low efficiency motors with high efficiency motors will save energy. The efficiency of the electric motors recommended to be replaced is included in the standard efficiency of EFF_2 and IE_1 class. It is recommended to replace them with premium efficiency (IE_4) class motors. When the engine savings analysis was made in the business where energy audit was performed, the investment payback period was calculated.

Example calculation for Heating Circulation Pump in Table 11;

$$Current\ Engine\ Load\ Rate = Measured\ Power / Plate\ Strength = 2.8\ /3 = \%\ 93{,}33$$

$$Mechanical\ Power\ Used = Recommended\ Power\ *\ Current\ Motor\ Efficiency = 2{,}8 * 0{,}8333 = 2{,}33\ kW$$

$$Power\ Taken\ After\ Replacement = \ Recommended\ Power\ *\ New\ Motor\ Efficiency = \ 2.8\ *\ 0.90 = \ 2.52$$

$$Amount\ of\ Savings\ = \ Measured\ Power - Power\ Taken\ After\ Change\ = \ 2.8 - 2.52\ = \ 0.28$$

$$Annual\ Electricity\ Savings\ = \ Savings\ Amount\ x\ Hour\ x\ Year\ = \ 0.28\ x\ 12\ x365\ = \ 1226.4\ kWh$$

Fig. 14. Electrical motors of the hotel management with an energy audit

Table 11. Motor saving analysis for the proposed change in the hotel business whose energy audit was made

No	Unit	M_1	M_2	M_3	M_4	M_5
Information		**Heating circulation pump**	**Fan Coil Heating circulation pump**	**Fan Coil Cooling circulation pump**	**Heating fan motor**	**Aspirator fan motor**
Current Measured Powers	kW	2.8	2.9	2.6	3.2	2.4
Available Plate Powers	kW	3	3	3	4	3
Available Motor Efficiencies	%	83.1	83.1	83.1	84.7	83.1
Current Load Rate	%	93.33	96.67	86.67	80.00	80.00
Mechanical Power Used	kW	2.33	2.41	2.16	2.71	1.99
Recommended Engine Power	kW	1.1	1.5	2.2	3	4
New Engine Efficiency	%	90,00	90,00	90,00	90,90	90,00
Power Taken After Change	kW	2.52	2.61	2.34	2.91	2.16
Unit price	TL	0.46	0.46	0.46	0.46	0.46
Annual Electricity. Saving	kWh	1226.4	1270.2	1138.8	1270.2	1051.2
Annual Money Savings	TL	564.144	584.292	523.848	584.292	483.552
Investment Cost	TL	781.00	781.00	781.00	1104.50	781.00
Payback Period	Year	1.38	1.33	1.49	1.89	1.61

3.7. Lighting

Low-efficiency light bulbs were used in the hotel where energy study was conducted, and 100% energy savings were achieved by replacing the bulbs with LED-efficient luminaires.

Table 12. Fixtures recommended for replacement for the hotel whose energy audit

No	Unit	1	2	3	4
Info		**Floors**	**Boiler Room**	**Basement**	**Basement Office**
Current Armature Power	W	40 W	72 W	36 W	36 W
Recommended Fixture Power	W	20 W	36 W	18 W	18 W
Energy Consumption of Current Luminaire per Year	kWh/year	34689.6	1681.92	525.6	1419.12
Energy Consumption of the Recommended Luminaire per Year	kWh/year	17344.8	840.96	262.8	709.56
Unit Investment Cost	TL	50	180	90	90
Total Investment Cost	TL	6600	1440	450	540
Annual Energy Savings	kWh/year	17344.8	840.96	262.8	709.56
Annual Energy Savings	TL	7978.6	386.84	120.88	326.39
Payback Period	year	0.82	3.7	3.7	1.65

International Journal of Energy Applications and Technologies, Year 2021, Vol. 8, No. 4, pp. 169-181

$$1\ kW/h = 1000\ W/h$$

For example, changing a 40 Watt Incandescent crystal bulb with E27 base Osakalight 20W bulb;

$$40\ W/h = 0.04\ kW/h$$

$$Energy\ Consumed\ by\ the\ Light\ Bulb\ in\ a\ Day\ =\ Light\ Bulb\ Power\ *\ Hours\ Worked\ in\ a\ Day$$

$$Energy\ Consumed\ by\ the\ Light\ Bulb\ in\ a\ Day =\ 0.04\ *\ 18\ =\ 0.72\ kW$$

There are 132 40 Watt Incandescent crystal bulbs in total in the 1st floor, 2nd floor, 3rd floor, 4th and 5th floors.

$$Total\ energy\ spent\ in\ a\ year\ =\ Number\ of\ bulbs\ *\ Power\ consumed\ in\ a\ day\ *\ year$$

$$Total\ energy\ spent\ in\ a\ year =\ 132\ *\ 0.72\ *\ 365\ =\ 34689.6\ kW\ /\ year$$

The power to be consumed by the recommended 20 Watt bulb per day;

$$Energy\ Consumed\ by\ the\ Light\ Bulb\ in\ a\ Day\ =\ Bulb\ Power\ *\ Hours\ Worked\ in\ a\ Day\ =\ 0.02\ *\ 18\ =\ 0.36\ kW$$

$$Total\ energy\ expended\ in\ a\ year = 132 * 0.36 * 365 = 17344{,}8\ \text{kW/year}$$

Locus	**Fixture Type**	**Recommended Fixture Type**	**Luminaire Power (W)**	**New Luminaire Power (W)**	**Daily Working Time (hour)**	**Piece**
Ground floor	40 W Incandescent crystal bulb	20W Osakalight bulb with E27 socket	40	20	18	32
1 Floor	40 W Incandescent crystal bulb	20W Osakalight bulb with E27 socket	40	20	18	20
2 floors	40 W Incandescent crystal bulb	20W Osakalight bulb with E27 socket	40	20	18	20
3 floor	40 W Incandescent crystal bulb	20W Osakalight bulb with E27 socket	40	20	18	20
4th floor	40 W Incandescent crystal bulb	20W Osakalight bulb with E27 socket	40	20	18	20
5th floor	40 W Incandescent crystal bulb	20W Osakalight bulb with E27 socket	40	20	18	20
Boiler Room	2x36 W T8 luminaire	2x18 W T8 luminaire	72	36	8	8
Basement	1x 36 W T8 luminaire	1x 18W T8 luminaire	36	18	8	5
Basement Floor Office	1x 36W T8 luminaire	1x 18W T8 luminaire	36	18	18	6

4. Conclusions

In this study, the energy consumption and improvement of consumption values of the hotel business in 2019, whose energy study was conducted, was examined. As a result of the energy study, the business was evaluated in terms of energy management, and priority savings projects were investigated according to the results of the measurements and calculations.

- The heat losses of the building surface of the hotel were measured with a thermal camera. Values between +6.3 ^{0}C and +22.6 ^{0}C were obtained on the building surface.

There is more temperature transition on the window sills compared to other surfaces.

- Using the boiler efficiency and flue gas measuring device, 3.1% oxygen and 107 ^{0}C flue gas temperature was determined in the flue gas. Losses are examined according to the determined values. In this case, according to the measurements, it can be said that the combustion efficiency is good when the hot water boilers of the hotel where the energy study is performed are examined.
- The motors used in the ventilation system have EEF_2 efficiency. If motors with IE_4 efficiency are used in this system, 15% energy efficiency will be achieved.
- When the insulation recommended for the valves and flashes on the hot water installation line in the facility is evaluated, it is seen that the annual consumption is reduced by approximately 17% after the insulation is made. The investment payback period will be within 2,47 years.
- The single term single time industrial low voltage (LV) tariff is used in the hotel business where an energy study is conducted. For the tariff analysis, the bills for the last one year were examined. When the bill was examined, it was seen that the general use was generally during daylight hours. Since most of the electricity in the facility is used in the daytime tariff, it can be said that the current single term tariff is a more appropriate tariff.
- As a result of the main distribution panel measurements, it can be said that the harmonic values are at normal levels. Considering the load distributions, it is seen that it is evenly distributed. The pf value was measured to be close to 1, and it can be said that this value is good.
- After heating, booster and fire pump motors with efficiency class EFF_2 were replaced with IE4 efficiency motors, it is seen there is a 6.9% increase in motor efficiency. As a result of replacing the IE_1 class engine used in the cooling system with an IE4 class engine, the engine efficiency is expected to increase by 6.2%.

As a result of the analysis of the luminaires recommended to be changed in the business, the total annual electricity savings were determined as 19158.12 kW / year. The investment payback period will be within 2.46 years in average.

Acknowledgment

This study is prepared as a part of Fatma Nur GÜNAY's MS Thesis. (Advisor: Dr. Fatih AYDIN).

ORCID

F. Aydın 0000-0003-4828-0649

F. N. Günay 0000-0002-4600-5216

Nomenclature

%	Percent
ADP	Main Distribution Board
BTU	British Unit System
°C	Degree
Cal	Calories
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EFF_1	First Class Improved Engine
EFF_2	Second Class Improved Engine
°F	Fahrenheit
IE_1	Standard Efficiency (EFF_2
IE_2	High Efficiency (EFF_1 According
IE_3	Very High Efficiency
IE_4	Super High Efficiency
J	Joule
kcal/h	Kilocalorie / Hour
kWh	Kilowatt-Hour
LV	Low Voltage
m^3	Cubic Meter
O_2	Oxygen Gas
Pf	Power Factor
ppm	Parts Per Million
PVC	Polyvinyl Chloride
SI	International System Of Units
T	Tone
TOE	Ton Equivalent Oil
TL	Turkish Lira
VRF	Variable Refrigerant Flow
W	Watt
W/m^2K	Heat Transfer Coefficient

References

[1] Kıyılmaz, M. B., 2019, Principles of energy management in industry and investigation of energy efficiency, Master Thesis, Muğla Sıtkı Kocaman University, Institute of Science, Muğla, 2-3.

[2] Karluk, S. R., 2007, Structural Transformation of the Turkish Economy of the Republic of Turkey Today, Page 239, Beta Bookstore, 11. Printing, ISBN: 9786053331858, İstanbul.

[3] Gezer, E. S., 2019, Energy efficiency of elevators, Master Thesis, Karabük University, Institute of Science, Karabük, 35-36.

[4] Kavak, K., 2005, Energy Efficiency in Turkey and the world and Investigation of Turkish Industrial Energy Efficiency, State Planning Organization, Publication No DPT: 2689, Pages 2-40, Ankara.

[5] Yaşar, N., 2011, Within the context of municipal energy policies efficiency of energy in buildings sample of Isparta, Master Thesis, Süleyman Demirel University, Institute of Social Sciences, Isparta, 9-94.

[6] Şenol, M. A., 2011, Turkey Evaluation of the Potential Energy Efficiency, Ministry of Energy and Natural Resources, 2nd National Energy Efficiency Forum, Ankara, Turkey.

[7] Tuncer, T., 2012, Energy efficiency in buildings and according to degree day regions of determination of optimum insulation thickness with different materials, Master Thesis, Dokuz Eylül University, Institute of Science, İzmir, 13-14.

[8] Aksüzek, Y., 2003, Energy productivity and energy economy in complexs building, Master Thesis, Süleyman Demirel University, Institute of Science, Isparta, 1-3.

[9] Ascione, F., Bianco, N., Mauro, G.M. and Napolitano, D.F., 2019, Building envelope design: multi-objective optimization to minimize energy consumption, global cost and thermal discomfort. Application to different Italian climatic zones, Energy, Volume 174, Pages 359–374.

[10] Belussi, L., Barozzi, B., Bellazzi, A., Danza, L., Devitofrancesco, A., Fanciulli, C., Scamoni, F., 2019, A review of performance of zero energy buildings and energy efficiency solutions, Journal of Building Engineering, Volume 25, 100772.

[11] Nazi, W.I.W.M., Royapoor, M., Wang,Y. and Roskilly, A.P., 2017, Office Building Cooling Load Reduction Using Thermal Analysis Method – A Case Study. Applied Energy, Volume 185, Part 2, Pages 1574–1584.

[12] Cheung H., Langner M.R. and Braun J.E., 2020, "Methodology to assess "no-touch" building audit software using simulated utility data" Science and Technology for the Built Environment, Doi Number: 10.1080/23744731.2020.1732160, pp.1-15.

[13] Hwang D.K., Cho J. and Moon J., 2019, "Feasibility study on energy audit and data driven analysis procedure for building energy efficiency: bench-marking in Korean hospital buildings", Energies, 12, 3006, Doi number: 10.3390/en12153006.

[14] Balan K.N. and Yashvanth U., 2020, "Energy audit in residential building – replacement of portable air conditioner by an energy efficient centralized air conditioner", International Journal of Ambient Energy, 41:2, 179-182.

[15] Fluke, 2009, Fluke Thermal Imager, PN 3433221, July 2009, Rev.1,5/11, USA.

[16] Chauvin Arnoux, 2013, Three-Phase Electrical Networks Analyser, Code 694286A02 France.

[17] Madur, 2019, Portable Gas Analyser GA-21 Plus, Zgierz/ Poland.

[18] Testo, 2017, Differential Pressure Measuring Device, https://www.testo.com/tr-TR/testo-510-set/p/0563-0510, Germany.