1. Energy Management System

1.1. Energy Management System Standard ISO 50001

Today, one of the urgent needs of human societies, especially industries in all countries, is the issue of energy management. Restrictions on non-renewable resources, high fuel costs, environmental pollution and energy crises, and the concept of sustainable development, which is the ultimate goal of all societies, are the main reasons for paying attention to energy. In this regard, the different general offices of Standardization has taken measures in the field of energy management systems, the most important output of which is the European standard EN 16000 and ISO 50001, which was published in June 2011, and now the latest version of this standard is related to 2018.

The purpose of the energy management system standard is to empower general offices in order to establish the necessary systems and processes to improve energy efficiency, including efficiency, operation and energy consumption. The establishment of this international standard is intended to reduce the emission of greenhouse gases and other environmental consequences and reduce energy costs through systematic energy management.

Successful implementation of this standard depends on the commitment of all levels and departments of the General Administration, especially senior management. This International Standard describes the requirements of an energy management system, according to which the General Administration is able to establish and implement energy policy, macro and micro objectives, and executive programs that considers the legal requirements and information on energy use.

1.2 Domain

The audit was conducted in the spring of 1400 in office buildings 1, 2, 3 and 4 and at level 3. Also, energy consumption statistics in 1397, 1398 and 1399 were analyzed which will be examined separately for each building in the continuation of this report.

2. Energy Carriers Examined

This document includes electricity and gas.

2.1 Items to be reviewed in technical audit

The audit of the selected office building is detailed and includes the following:

-Recording and analyzing energy consumption data through bills
-Consumption analysis
-Extraction of green management indicators such as energy intensity, etc. for buildings
-Measurement of temperature and humidity
-Measurement of the brightness in terms of LUX
-Thermal photography of the environment
-Inventory of energy consuming equipment

3 Energy consumption in office buildings of Isfahan University of Medical Sciences at a glance

3.1 Introduction

In this report, the energy consumption statistics of Isfahan University of Medical Sciences in the years 1397 to 1399 with the focus on three energy carriers including electrical and natural gas are discussed.

4. Office buildings of Isfahan University of Medical Sciences

4.1. Building ID

4.1.1 Introduction

The office building of Isfahan University of Medical Sciences has four buildings with a useful area of 7360, which was put into operation in 1364.

4.1.2 General information

The table contains general information about the office buildings of Isfahan University of Medical Sciences

Name of the building: office of Isfahan University of Medical Sciences	**Usage type**: office/administrative
Address: Isfahan University of Medical Sciences and Health Services, Hezar Jarib St., Isfahan Province	
Longitude: 51.6616872	Latitude: 32.6128887 \"N
Year of construction: 1364	Year of operation: 1364
Area of infrastructure area (square meters): 7360	Altitude: 1575
Area under heating system: 7360	Area under cooling system: 7360

5. The Area of the Floors Separately

Floor number	Ceiling height	Area under the cooling system	Area under heating system
Basement	**3**	**664**	**664**
Ground floor	**3**	**1749**	**1749**
1st floor	**3**	**1817**	**1817**
2nd floor	**3**	**1628**	**1628**
3rd floor	**3**	**1146**	**1146**

5.1 General Statistics of Energy Consumption

Total energy consumption in office buildings of Isfahan University of Medical Sciences

Energy consumption of office buildings of Isfahan University of Medical Sciences in the years 1397 to 1399 is as follows:

Diagram of energy consumption of electricity and gas carriers in office buildings of Isfahan University of Medical Sciences (1397 to 1399)

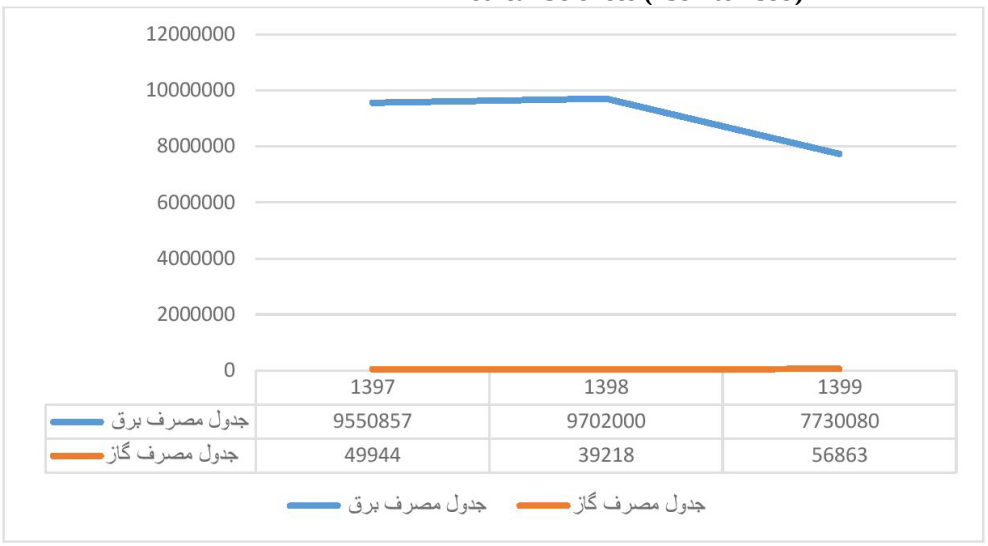


Table of energy consumption and cost of electricity and gas carriers in office buildings of Isfahan University of Medical Sciences (1397 to 1399)

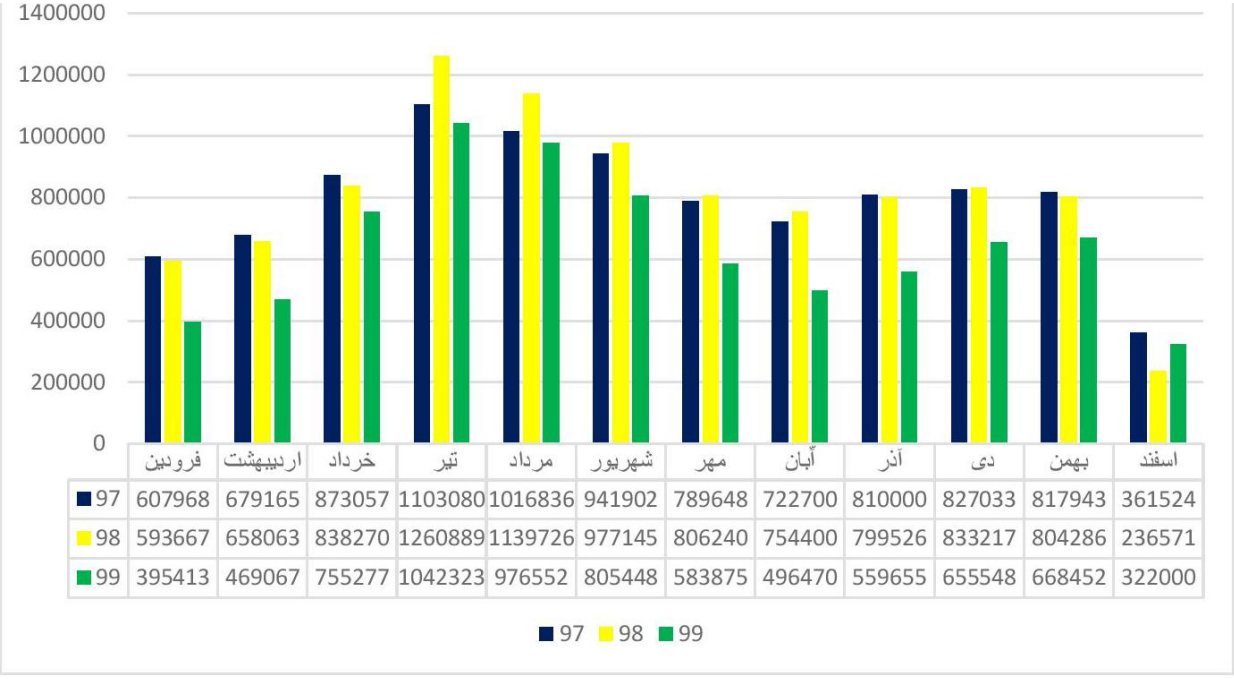
Cost (Rials)	Consumption Amount	Unit of Measurement	Energy Carrier	Year	Number
5,406,298,642	**9550857**	**KW/h**	Electric		**1**
45,787,975	**49944**	**M^3**	Natural gas	**1397**	**2**
6,363,187,899	**9702000**	**KW M^3/h**	Electric		**1**
33،342،882	**39218**		Natural gas	**1398**	**2**
5,449,446,400	**7730080**	**KW/h**	Electric		**.**
89،119،925	**56863**	**M^3**	Natural gas	**1399**	**.**

5.2 Total electricity and gas consumption

In office buildings of Isfahan University of Medical Sciences during 1397 to 1399

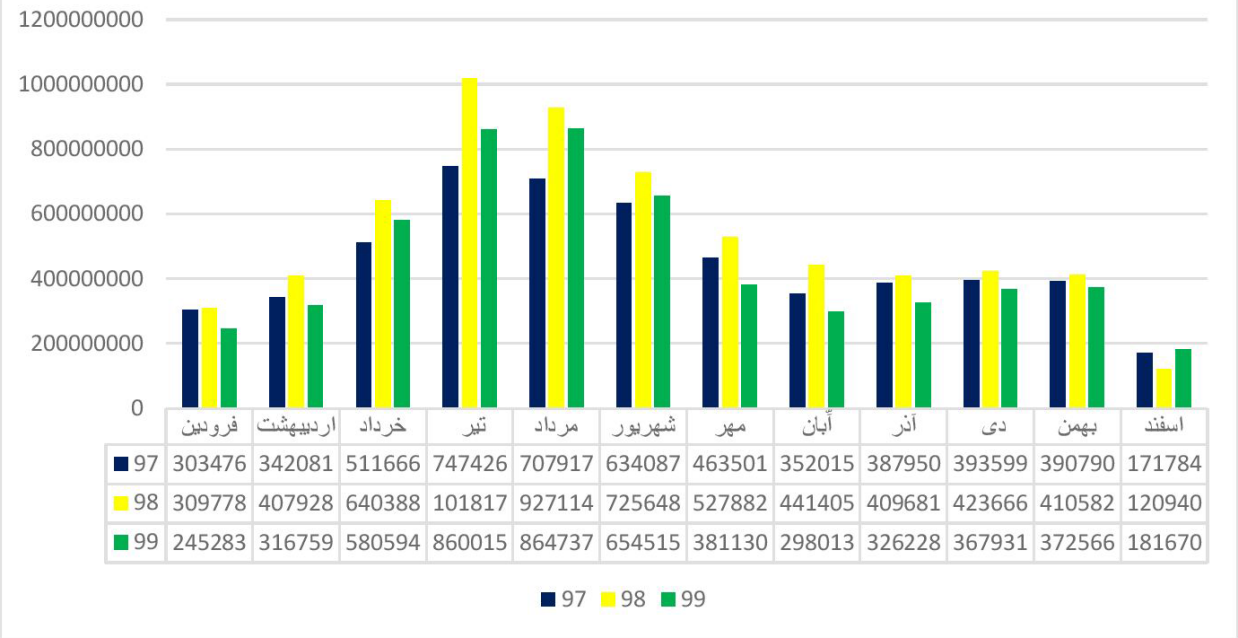
Electricity/power:

Monthly comparison chart of electricity consumption during the years 1397 to 1399



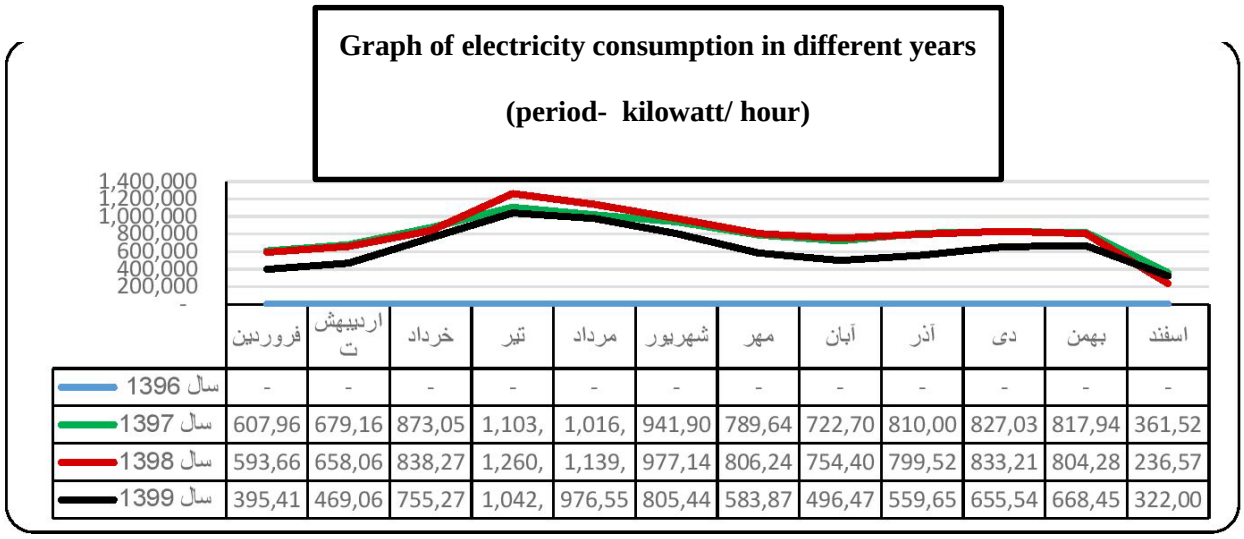
	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
97	607968	679165	873057	1103080	1016836	941902	789648	722700	810000	827033	817943	361524
98	593667	658063	838270	1260889	1139726	977145	806240	754400	799526	833217	804286	236571
99	395413	469067	755277	1042323	976552	805448	583875	496470	559655	655548	668452	322000

Comparison chart of monthly electricity consumption costs during the years 1397 to 1399



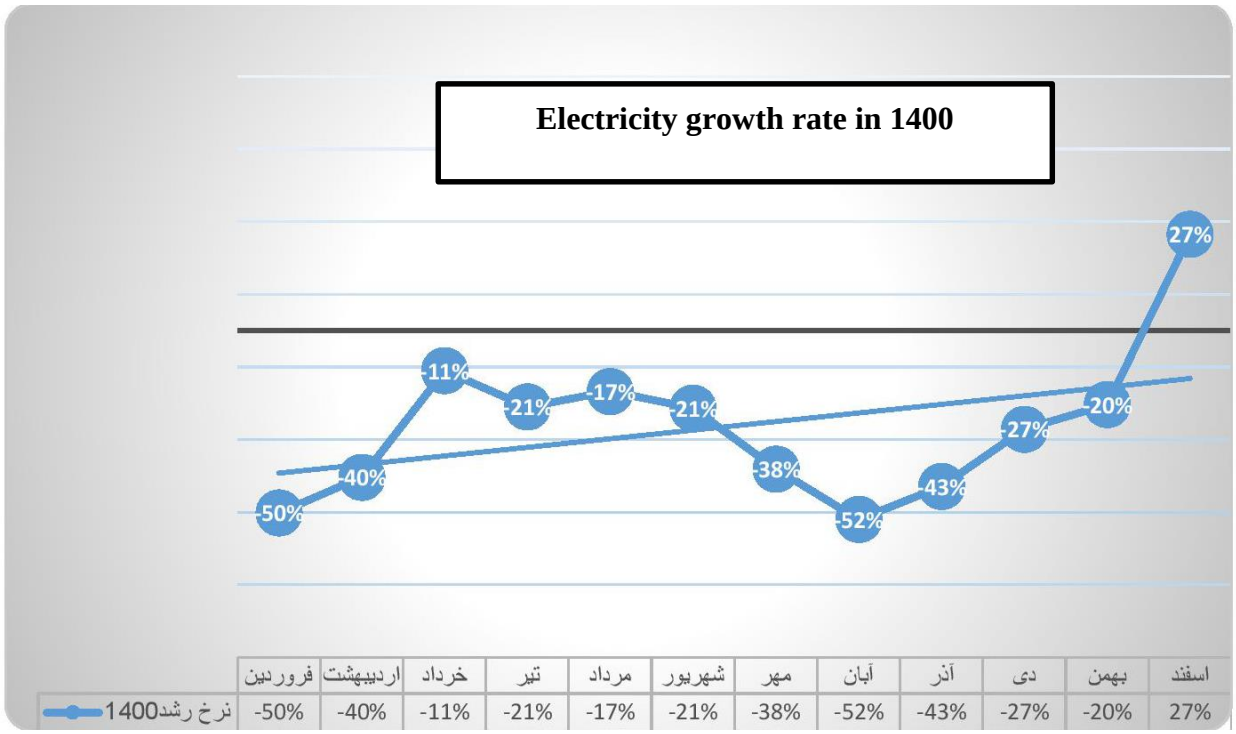
	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
97	303476	342081	511666	747426	707917	634087	463501	352015	387950	393599	390790	171784
98	309778	407928	640388	101817	927114	725648	527882	441405	409681	423666	410582	120940
99	245283	316759	580594	860015	864737	654515	381130	298013	326228	367931	372566	181670

Energy consumption chart during the years 1397 to 1399



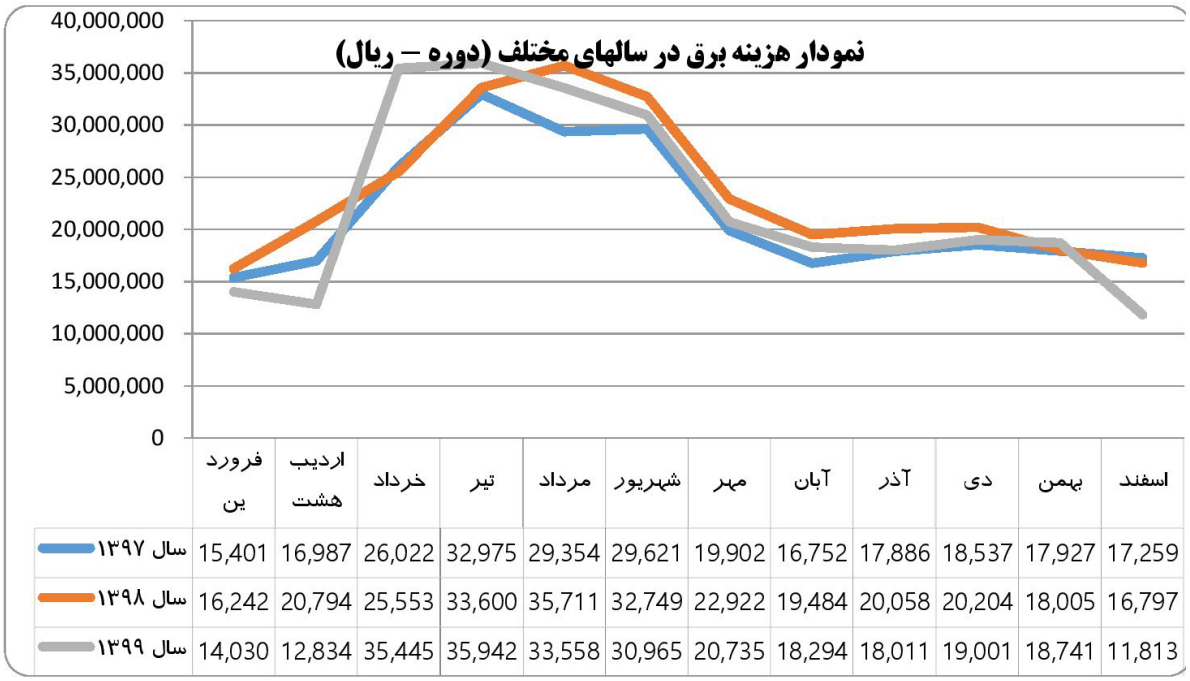
	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
سال 1396	-	-	-	-	-	-	-	-	-	-	-	-
سال 1397	607,96	679,16	873,05	1,103,	1,016,	941,90	789,64	722,70	810,00	827,03	817,94	361,52
سال 1398	593,66	658,06	838,27	1,260,	1,139,	977,14	806,24	754,40	799,52	833,21	804,28	236,57
سال 1399	395,41	469,06	755,27	1,042,	976,55	805,44	583,87	496,47	559,65	655,54	668,45	322,00

Forecast of Electricity Growth Rate by month in 1400 for office buildings of Isfahan University of Medical Sciences



	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
نرخ رشد1400	-50%	-40%	-11%	-21%	-17%	-21%	-38%	-52%	-43%	-27%	-20%	27%

Electricity cost chart during the years 1397 to 1399

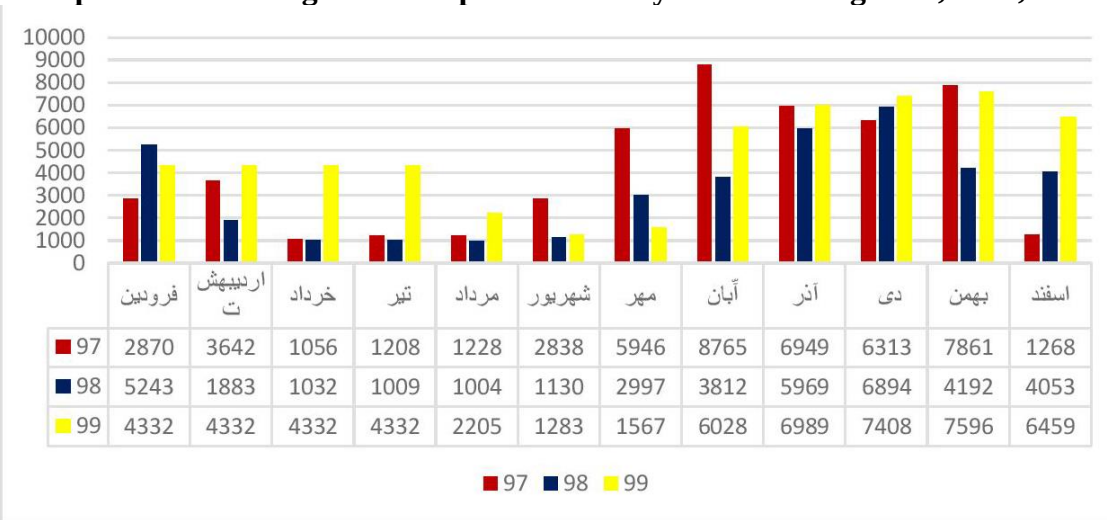


	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
سال ۱۳۹۷	15,401	16,987	26,022	32,975	29,354	29,621	19,902	16,752	17,886	18,537	17,927	17,259
سال ۱۳۹۸	16,242	20,794	25,553	33,600	35,711	32,749	22,922	19,484	20,058	20,204	18,005	16,797
سال ۱۳۹۹	14,030	12,834	35,445	35,942	33,558	30,965	20,735	18,294	18,011	19,001	18,741	11,813

Gas:

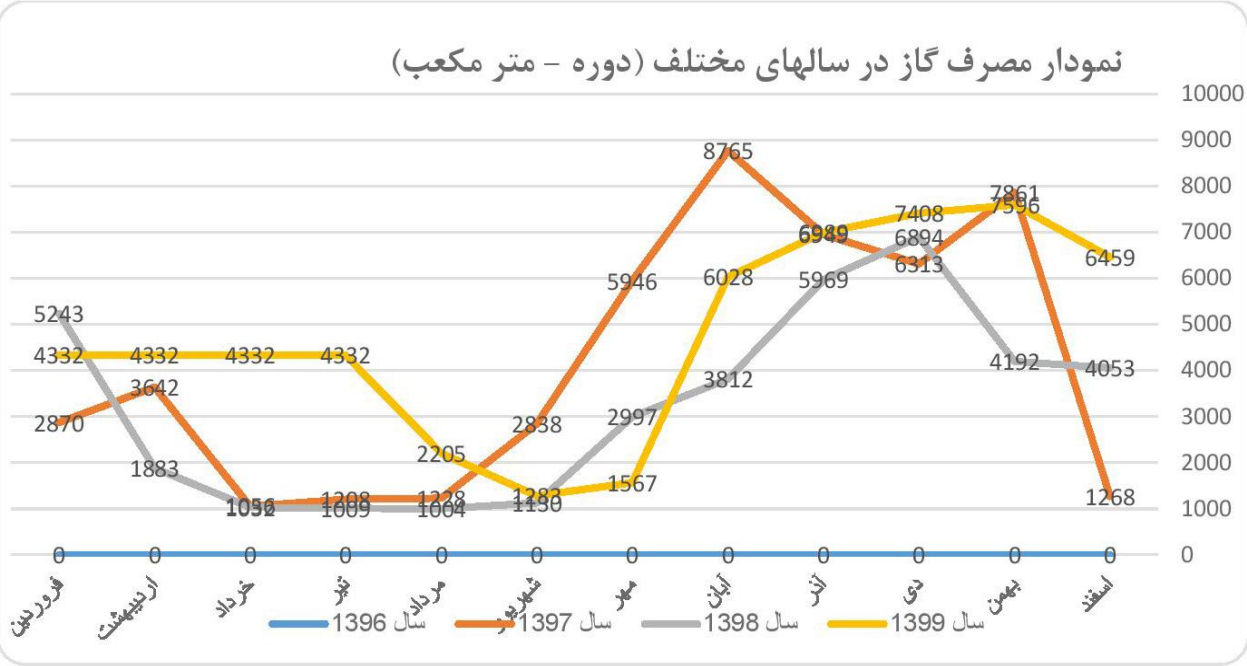
Gas consumption chart in the office buildings of Isfahan University of Medical Sciences during the years 1397 to 1399 :

Comparison chart of gas consumption month by month during 1397, 1398, 1399



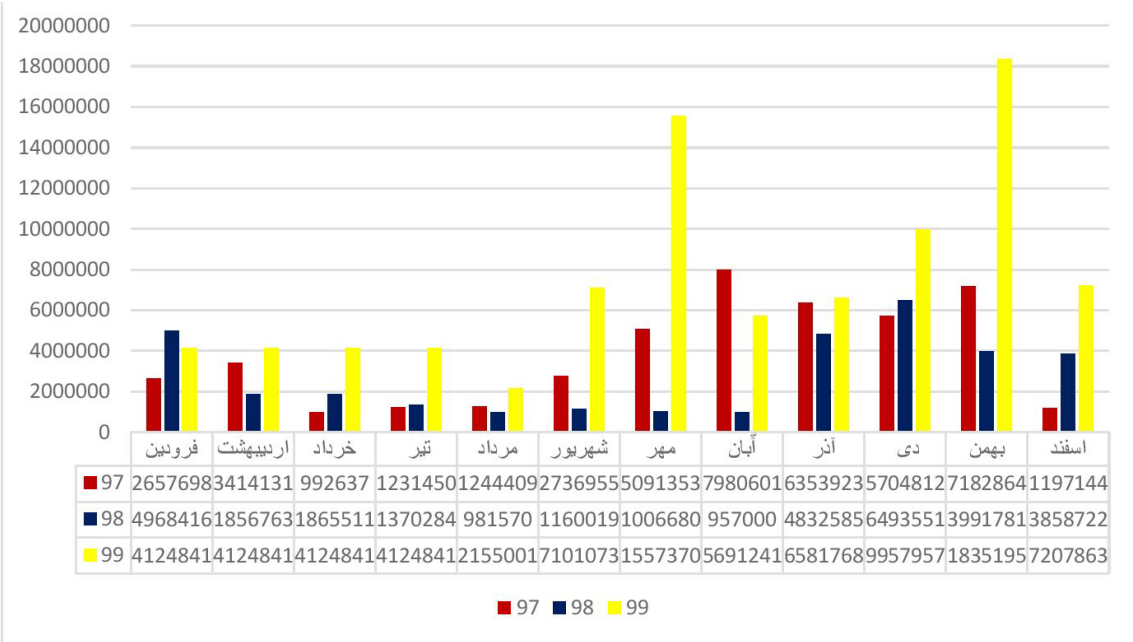
	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
97	2870	3642	1056	1208	1228	2838	5946	8765	6949	6313	7861	1268
98	5243	1883	1032	1009	1004	1130	2997	3812	5969	6894	4192	4053
99	4332	4332	4332	4332	2205	1283	1567	6028	6989	7408	7596	6459

Graph of gas consumption in different years (cubic meter / period)



Graph of gas consumption cost in office buildings of Isfahan University of Medical Sciences during the years 1397 to 1399:

Monthly Comparison Chart of Gas Consumption during 1397, 1398, 1399

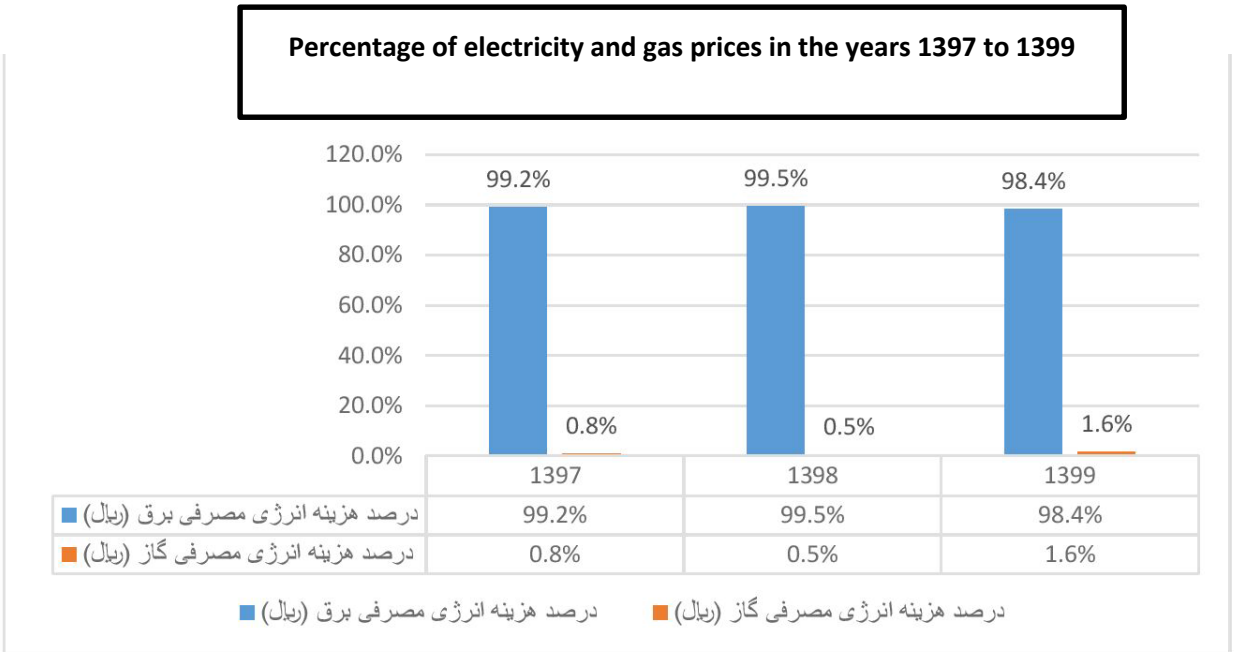


	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
97	2657698	3414131	992637	1231450	1244409	2736955	5091353	7980601	6353923	5704812	7182864	1197144
98	4968416	1856763	1865511	1370284	981570	1160019	1006680	957000	4832585	6493551	3991781	3858722
99	4124841	4124841	4124841	4124841	2155001	7101073	1557370	5691241	6581768	9957957	18351957	7207863

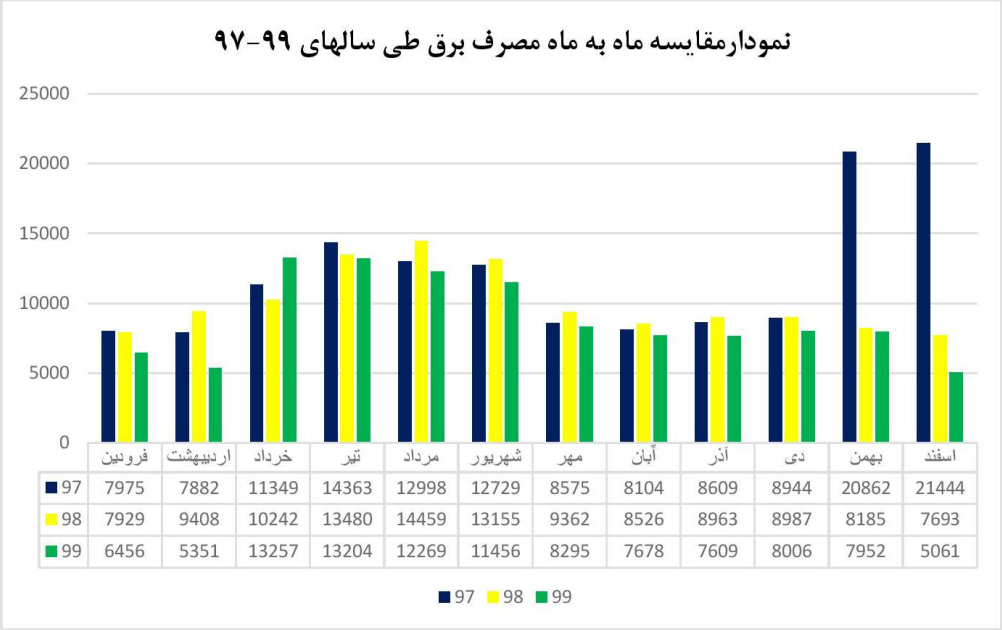
General table of total energy consumption in 1397 to 1399 in the office buildings of Isfahan University of Medical Sciences

Total net consumption cost (Rials)	Percentage of gas cost	Percentage of electricity costs	Net gas payment fee	Net electricity bills	Gas percentage	Percentage of electricity	Total	Electricity to thermal value	Gas to thermal value	Gas consumption table	Power consumption table	Year
5,452,086,618	0.8%	99.2%	45,787,975	5,406,298,642	5.2%	94.8%	34381	32597	1784	49944	9550857	1397
6,396,530,781	0.5%	99.5%	33,342,882	6,363,187,899	4.1%	95.9%	34513	33113	1400	39218	9702000	1398
5,538,566,324	1.6%	98.4%	89,119,925	5,449,446,400	7.1%	92.9%	28413	26383	2031	56863	7730080	1399

Comparison of the percentage of expenses paid for electricity and gas prices during the years 1397 to 1399



Monthly comparison chart of electricity consumption during the years 1397 to 1399

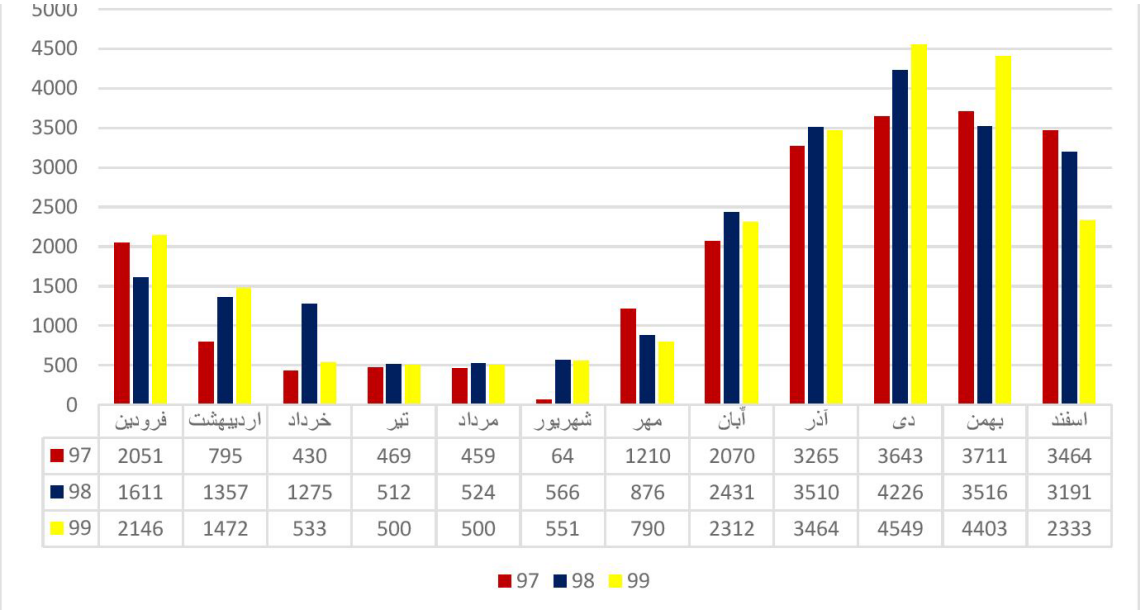


	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
97	7975	7882	11349	14363	12998	12729	8575	8104	8609	8944	20862	21444
98	7929	9408	10242	13480	14459	13155	9362	8526	8963	8987	8185	7693
99	6456	5351	13257	13204	12269	11456	8295	7678	7609	8006	7952	5061

Electricity Carrier Index chart (KW/H)

Gas consumption index as a monthly comparison during the years 1397, 1398, 1399

Monthly comparison chart of gas consumption during the years 1397, 1398, 1399

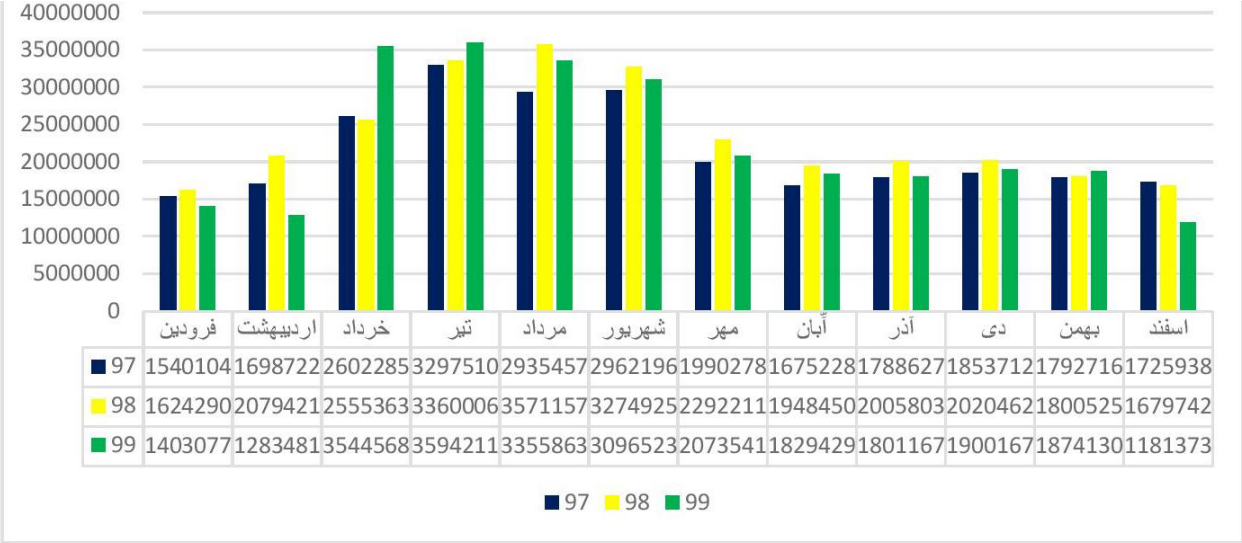


	فروردین	اردیبهشت	خرداد	تیر	مرداد	شهریور	مهر	آبان	آذر	دی	بهمن	اسفند
97	2051	795	430	469	459	64	1210	2070	3265	3643	3711	3464
98	1611	1357	1275	512	524	566	876	2431	3510	4226	3516	3191
99	2146	1472	533	500	500	551	790	2312	3464	4549	4403	2333

Graph 1: Natural gas energy carrier index in office buildings of Isfahan University of Medical Sciences (m3)

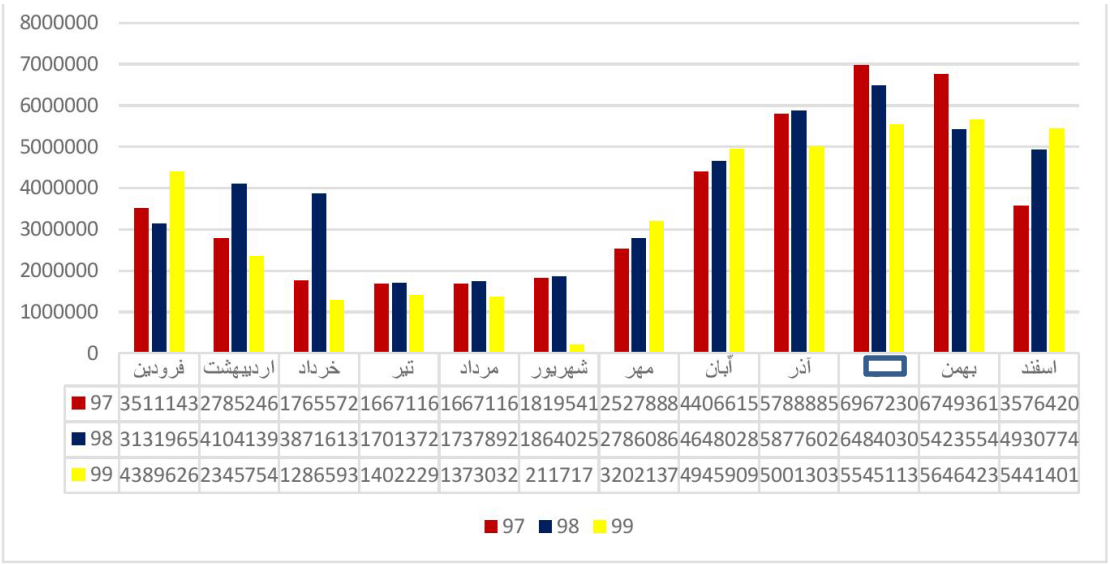
Cost chart: Comparing the cost of electricity consumption in the building during the years 1397 to 1399

Comparison chart of monthly electricity consumption costs during the years 1397 to 1399



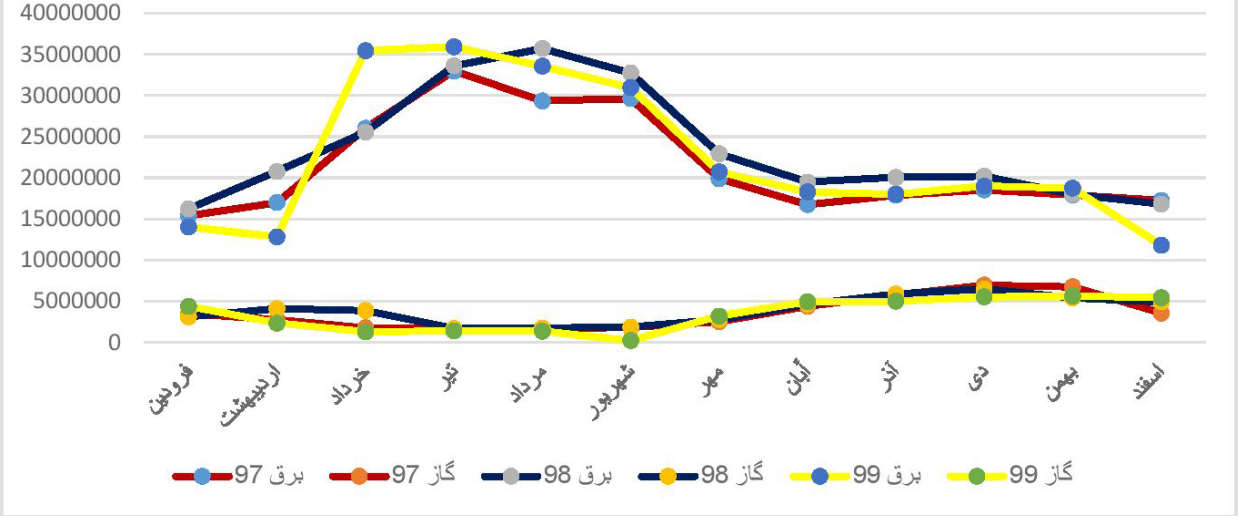
Cost comparison chart of gas consumption costs in Isfahan medical sciences office buildings during the years 1397 to 1399

Comparison chart of gas consumption month by month during 1397, 1398, 1399



Cost chart of energy carriers in office buildings of Isfahan University of Medical Sciences (1397 to 1399)

Comparison of gas and electricity payment costs (Rials) during the years 1397 to 1399



From the above diagrams, it can be concluded that the thermal value of gas compared to electricity in the office buildings of Isfahan University of Medical Sciences has been higher. Therefore, the amount of electricity payment tariff is much higher than gas

Table of consumption and cost performance indicators in office buildings of Isfahan University of Medical Sciences (R & SEC)

Gas consumption compared to the infrastructure	Gas cost compared to the infrastructure	Year
6.1	5,583.90	1397
4.8	4,066.21	1398
6.9	10,868.28	1399

Power consumption compared to the infrastructure	The cost of electricity compared to the infrastructure	Year
1164.7	659,304.71	1397
1183.2	775,998.52	1398
942.7	664,566.63	1399

Electricity and gas consumption based on thermal value relative to the substructure	The cost of electricity and gas compared to the infrastructure	Year

4.19	664,888.61	1397
4.21	780,064.73	1398
3.47	675,434.92	1399

5.3 Energy consumption index (SEC) in office buildings of Isfahan University of Medical Sciences

R =5.603	Building to building (ideal energy consumption)	**Energy ratio**
408.11	In terms of kilowatt hours per square meter per year	**Energy consumption index**
Large office / non-residential		**usage**
Esfahan		**City**
Semi-dry (74)	Based on 8 divisions	**Climate**
7360		**Useful infrastructure**
Isfahan University of Medical Sciences and Health Services, Hezar Jerib St., Isfahan University, Esfahan province		**Address**

item	Place of use	Name of equipment, goods	Number	Average actual sampling consumption	Average operation per day (hours)	Average daily consumption (kw/h)	Average monthly consumption (kw/h)	Average annual consumption (kw/h)	Percent share
1	central building	PC msi	**25**	**200**	**8**	**40.0**	**793.3**	**9520.0**	**2.94%**
2	central building	Computer (case)	**360**	**120**	**8**	**345.6**	**6854.4**	**82252.8**	**25.41%**
3	central building	monitor	**398**	**130**	**7.9**	**408.7**	**8106.8**	**97281.5**	**30.05%**
4	central building	Laser Printer	**88**	**466**	**0.5**	**19.6**	**389.2**	**4670.5**	**1.44%**
5	central building	Printer, scanner	**93**	**599**	**0.5**	**27.9**	**552.4**	**6629.1**	**2.05%**
6	central building	scanner	**54**	**40**	**0.5**	**1.1**	**21.4**	**257.0**	**0.08%**
7	central building	Copy device	**16**	**1347**	**0.5**	**10.8**	**213.7**	**2564.7**	**0.79%**
8	central building	Fax	**31**	**50**	**0.5**	**0.8**	**15.4**	**184.5**	**0.06%**
9	central building	Refrigerator	**11**	**36.5**	**24**	**9,6**	**191.1**	**2293.4**	**0.71%**
10	central building	Paper Shredder	**35**	**294**	**0.3**	**3,1**	**61.2**	**734.7**	**0.23%**
11	central building	TV	**14**	**36.5**	**3.6**	**1,8**	**36.5**	**437.8**	**0.14%**
12	central building	Water cooler	**54**	**396**	**8**	**171,1**	**3392.9**	**40715.1**	**12.58%**
13	central building	microwave	**12**	**850**	**1**	**10.2**	**202.3**	**2427.6**	**0.75%**
14	central building	Blower fan	**32**	**257**	**3.4**	**28.0**	**554.6**	**6654.9**	**2.06%**
15	central building	Tea maker, electric kettle	**18**	**1200**	**0.4**	**8.6**	**171.4**	**52353.9**	**0.64%**
16	central building	Electric motor	**27**	**1216**	**6.7**	**220.0**	**4362.8**	**12724.8**	**16.17%**
116	central building	Other cases	**32**	**417.7**	**4**	**53.3**	**1060.4**		**3.93%**
					Total:	**1360/33**	**26979.9**	**323758.71**	**100%**

Sampling statistics of active equipment carrying electric energy

Name of the building: office buildings of Isfahan University of Medical Sciences														
Average annual yield (kg per hour)		Number of days of use per year	Average daily consumption	Average consumption per hour	Maximum consumption	Minimum consumption	Capacity (kilowatt-hours)	Maximum (kg per hour)	Minimum (kilo per hour)	efficiency	number	Type of heating equipment	Room and location used	Item
۳۳۰۰۰	۲۲۸۵		۲۳۸	۲	4.8	0.7	0.5	44000	3500	75%	11	oven	Central building	1
۴۷۲۵۰	۱۶۳۸۶		238	۳	۲۲,۹۵	3.3	1.8	63000	5500	75%	1	Wall water heater	Central building	2
۴۰۲۵			135	۸	۰,۶	0.9	0.3	5750	4000	70%	1	Heater	Central building	3
۸۴,۲۷۵	19,319		611,000	۱۳	۲۸,۳۵	4.90	2.60	112,750			13			

High-consumption equipment based on sampling process (office buildings of Isfahan University of Medical Sciences)

5.4 Separate statistics of electrical energy consumption in the office buildings of Isfahan University of Medical Sciences

According to the analysis of electricity consumption in different parts of the building, It can be said that 33% is used in the air conditioning sector, 27% in the lighting sector, and 19% in the office machinery sector.

Percentage of applied electrical energy in office buildings of Isfahan University of Medical Sciences

5.5 Lighting System

The most important points that should be considered in the design and evaluation of indoor artificial lighting system include the following:

-The fit of the lighting system to the work environment
-The fit of lights and lamps to the needs of the job and the nature of the work
-Observing the average light intensity required (Eavg)
-Providing color temperature and color expression index of resources according to job needs
-Considering the technical considerations in the design (such as the height of the lights, the correct arrangement to provide uniform lighting, control of luminosity)
- Maintenance considerations

5.6 General statistics of lighting system of office buildings of Isfahan University of Medical Sciences

The general statistics of the lighting system can be seen in the table below

Table of coefficients used in calculating the energy of the lighting system of the office buildings of Isfahan University of Medical Sciences

Error coefficient	Nominal watt	Real watts	Ampere	Power factor	voltage
0. 7328794	12485	9150.5	6.31	0.522571429	215.71

5.7 Evaluation of lighting system performance in the office buildings of Isfahan University of Medical Sciences *[1]

The ILER*[2] ratio of each room, if numbers were between 75% and 1.0, indicates the optimal performance of the lighting system.

[1] Refer to the record document and lighting system performance report
[2] Existing performance ratio relative to target performance

Numbers from 51% to 74% and ILER below 50% need immediate action. A number greater than 1 is in the energy dissipation range

5.8 Heating, Cooling and Air Conditioning Systems in the office buildings of Isfahan University of Medical Sciences

Thermography, thermal imaging camera of engine room of office buildings (chimneys, breaking points, wasted energy)

Fanger equations are used to calculate Predicted Mean Vote (PMV) in a large set of samples for a specific combination of air temperature, average radiant temperature, relative humidity, air velocity, metabolic rate, and clothing insulation.

Zero (0) is the ideal value, indicating thermal neutrality. The comfort zone is defined by a combination of parameters in which PMV is in the proposed range. (PMV between +0.5 and 0.5) Although predicting thermal satisfaction in a population is an important step in determining which conditions are comfortable, it is more useful to consider whether people are satisfied or not.

This method treats all residents in the same way and does not pay attention to the location and adaptation to the thermal environment. It basically states that the ambient temperature should not change with the change of seasons. Instead, the temperature should be the same throughout the year. This takes a more indifferent position that humans should not adapt to different temperatures because it will always be constant.

ASHRAE 55 2010 standard used PMV model to specify prerequisites for internal thermal conditions. At least 80% of residents must be satisfied.

The formula for calculating PMV is:

$$PMV = [0.303e^{-0.036M} + 0.028]\{(M - W) - 3.96E^{-8}f_{cl}[(t_{cl} + 273)^4 - (t_r + 273)^4] - f_{cl}h_c(t_{cl} - t_a) - 3.05[5.73 - 0.007(M - W) - p_a] - 0.42[(M - W) - 58.15] - 0.0173M(5.87 - p_a) - 0.0014M(34 - t_a)\}$$

Predicted Mean Vote calculation formula (PMV)

Where,

Table of parameters of the formula for calculating the comfort temperature using the PMV method

Euler's number (2.718)	E
clothing factor	f_{cl}
convective heat transfer coefficient	h_c
clothing insulation [clo]	I_{cl}
metabolic rate [W/m^2] 115 for all scenarios	M
vapor pressure of air [kPa]	p_a
clothing thermal insulation	R_{cl}
air temperature [°C]	t_a
surface temperature of clothing [°C]	t_{cl}
mean radiant temperature [°C]	t_r
air velocity [m/s]	V
external work (assumed = 0)	W

And also the PPD (Predicted Percentage of Dissatisfaction) formula is as follows:

Equation 2: PPD calculation formula (Predicted Percentage of Dissatisfaction)

$$PPD = 100 - 95e^{[-(0.3353PMV^4 + 0.2179PMV^2)]}$$

The following table shows the computational information of office buildings of Isfahan University of Medical Sciences based on the spring and summer 1400 audit data.

Table for calculating comfort temperature using PPD and PMV methods in office buildings of Isfahan University of Medical Sciences, Spring 1400

PPD[3]	PMV	The amount of coverage[4]	Metabolic Rate of the body [5]	Average wind speed	Medium humidity	Average temperature inside the building	Season
0.34	**25.9^{0}C**	**0.5**	**1.1**	**0.1 m/s**	**19.66%**	**30.509**	**The first six months of 1400**

As can be seen in the data in the table and chart below, the office buildings of Isfahan University of Medical Sciences in the spring and summer of 1400 with 21% of the spaces were at a comfortable temperature and 79% of the spaces are above the comfort temperature and 21% of the residents are satisfied and we do not have a temperature lower than the comfort temperature. One of the reasons for the high temperature is the prevalence of coronary heart disease, which has caused the windows of most rooms in office buildings to be open and the comfort temperature to be close to the ambient temperature.

Graph of energy consumption share of different heating system equipment in office buildings of Isfahan University of Medical Sciences

Percentage of Consumption	Average Annual Yield (kg per hour)	Title
89%	33000	Oven
6%	4725	Wall water heater
5%	4025	Heater

[3] Predicted Percentage of Dissatisfaction
[4] Average clothing of an adult in winter
[5] The metabolic rate of the body for a person sitting at a computer is calculated to be۱٫۱