

STUDYING AND PROVIDING ENERGY CONSUMPTION MODEL PROPORTIONAL TO CHARACTERISTICS OF SANANDAJ TOHID HOSPITAL, RELATED TO KURDISTAN UNIVERSITY OF MEDICAL SCIENCES¹

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ABSTRACT

Hospitals are the most expensive and most widely used public and service organizations that have received little attention in the field of energy consumption and this is while the most controllable costs in hospital are these types of costs. The aim of this study is to determine the energy consumption management model appropriate for Sanandaj Tohid hospital with seven-year process 2007-2013. This study is applied and sectional- descriptive research. For this study, data related to energy consumption is obtained from water, electricity and gas bills and data related to number of beds, number of patients, Inpatient Bed Occupancy Rate and hospital infrastructure area is obtained from statistics of Sanandaj Tohid Hospital were collected at each study years and then energy consumption was determined annually and based on inpatient bed day, bed occupancy day, infrastructure square meters and number of patients who refer hospital and it was analyzed using statistical software Minitab 17 and using statistical analysis and correlation coefficient. Mean water consumption was 1.15 and electricity consumption was 5.23 to 8.27 times the global standard consumption and mean gas consumption per bed day was 10.4 m³. There was positive correlation between some of variables related to bed and electricity, water and gas consumption, but there was not positive correlation between variables related to hospital services and energy consumption. According to study results, using methods such as corrective measures and completing facilities, establishing Energy Committee, appointing posts and employing a special expert for energy, using innovative proposals related to issue, training and cultural building of employees and hospital officials seem necessary and therefore, using building energy management modeling systems is in line with services provided to patients.

KEYWORDS: Consumption Standards, Energy Consumption Management Modeling, Kurdistan.

INTRODUCTION

Every day that passes, human life becomes more dependent on energy consumption. World population growth, rising energy consumption per capita, limited resources and non-renewable energy resources, expensive extraction and utilization of energy types in modern societies have considered the way of energy consumption as a large and important issue (Mousavi Khalkhali, 2000).

Iran is the second country in Middle East in terms of diverse energy resources, but in time investment in energy sector and paying enough attention is essential even in countries that have energy technical resources and provides access to international arena (Salehi, 2002). One of the strategic goals of country's energy sector is optimum consumption of energy. If primary energy consumption in country continues with current trend there is no doubt that, gradually, the cost of energy will be increased and obviously the cost of goods and services, including health services will be increased (Aronsson, 1997). Statistics and figures presented in the research which are related to health care and have been conducted in ENERGY STAR program show that energy consumption per square meter in hospitals is much higher than other types of service institutions (CII Report on Energy Hospital, 2011). Increasing health care costs and some of hospital bed capacity uselessness and lack of proper and rational use of resources will reduce the efficiency of hospitals. Studies show that high bed occupancy rate and rotation of bed occupancy as well as patient low stay and

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duration of beds rotation will reduce the amount of energy consumption (per capita consumption of bed) in hospitals, therefore, it is necessary to know how the hospital bed indicators will be produced with the lowest cost of energy (Riahi, 2011). Determining the amount of consumed energy based on hospital bed can be considered as a measure of calculating energy expenditure in hospitals. It seems that hospital architecture and the way of using equipment and systems effects significantly on energy consumption in hospitals. In a study conducted by Evian and colleagues (2006) in one of Japan hospitals, it was demonstrated that there is a significant relationship between electrical energy consumption and air conditioning systems, lighting and medical equipment and energy consumption in hospitals is more than other buildings. In general, using new energy systems such as solar energy and improved energy management systems will result in saving and cost efficiency (Xuan, 2007).

The hospitals have high potential for savings in energy consumption, so that energy consumption in hospitals can be reduced to 10% with no special budget, however, there is possibility of saving in developed countries such as Germany to 20% and Netherlands to 44% (JakZlius, 2014). In Bull and Adams study (2008), in the state of America, it was shown that using automated systems in buildings, improving facilities and mechanical and electrical equipment and developing curriculum and alerting health sector partners have been effective on energy consumption (Bull, 2008). Effort to inhibit the energy consumption is a necessity for them. In fact, energy cost constitutes a significant part of non-personnel costs in hospitals and effects directly on cost of each service unit (Sheikh Abumasudi, 2005). In roundtable on energy consumption management of health care sector in 2010, it was expressed that energy cost is the most manageable costs in hospitals; therefore we can have intelligent intervention in this field and implement easy cost control in the health system.

A study entitled comparison study of energy consumption and its management in Farabi Eye Hospital, Tehran in 2011 showed the reason for adoption of energy consumption management methods in Farabi Hospital; the results showed a downward trend (based on inpatient bed and bed occupancy days) in water and gas consumption to 31% and gas consumption has declined by 28% in 2010 compared to base year 2008 years. A study on performance indicators associated with energy consumption in selected hospitals of Tehran University of Medical Sciences in years 2008 to 2010 presented that the average consumption of water is 2.99 times and electricity 13.38 to 22.30 times international standard consumption and average gas consumption per bed day is 19.5 m³ (Goudarzi, 2013).

In a study entitled “How is energy consumption in selected hospitals of Isfahan (in years 2003-2009)?” the findings indicated that in macro view, amount of energy consumption of hospitals over five-year period is more than global standard and in micro view, energy consumption in public hospitals is more than private hospitals and concluded that according to results of research, applying methods seems necessary to save energy use in all hospitals and therefore, using building energy management system BEMS was recommended (Sheikh Abumasudi, 2005). In another study, entitled “Economic analysis of strategies to reduce energy of Ruzbeh hospital aimed to achieve standards of building energy consumption”, the results showed that implementing strategies to optimize the structure of Roozbeh Hospital, annual consumption of the building fell to 2712640 (Aliyari, 2012).

This study aimed to determine the power consumption management model appropriate for characteristics of groups of hospitals; study case was Sanandaj Tohid Hospital in 2007-2013 years and evaluated the energy consumption (water, electricity and gas) in Sanandaj Tohid Hospital and reviewed and compared process and consumption in seven years considering corrective measures in order to reduce energy consumption. Consumption rate is measured based on parameters such as inpatient bed, inpatient bed day, bed occupancy day, infrastructure area and number of patients in order to perform comparison with other hospitals.

MATERIALS AND METHODS

This study is applied and sectional- descriptive research. Study population was conducted as a case study on how energy consumption management was conducted in SanandajTohid Hospital related to Kurdistan University of medical care. Sampling was not used in this study and only Sanandaj Tohid hospital was studied as consensus, data related to energy consumption was obtained from water, electricity and gas bills and data related to number of beds, number of patients, Inpatient Bed Occupancy Rate and hospital infrastructure area is obtained from statistics of Sanandaj Tohid Hospital were collected at each study years and then energy consumption was determined annually and based on inpatient bed day, bed occupancy day, infrastructure square meters and number of patients who refer hospital and data

was analyzed using Excel 2013 software and using cost accounting. Significant difference between data was examined using statistical software Minitab 17 and statistical analysis and correlation coefficient.

RESULTS

The standard amount of global water consumption is 500 liters per bed day (Sheikh Abumasudi, 2005).

Table 1. Energy consumption per years, based on various indices

Studied years		Water consumption (liters)			
		Per inpatient <i>bed</i> count day	Per <i>bed</i> occupancy day	Per square meter infrastructure	Per patient number
2007	333 inpatient bed	10754	528	1953	148
	68 occupancy rate				
2008	345 inpatient bed	9712	497	1825	127
	65 occupancy rate				
2009	342 inpatient bed	20112	1049	3746	243
	64 occupancy rate				
2010	375 inpatient bed	15961	801	3266	220
	66 occupancy rate				
2011	371 inpatient bed	9815	473	1986	133
	69 occupancy rate				
2012	364 inpatient bed	7777	361	1545	97
	72 occupancy rate				
2013	376 inpatient bed	7889	397	1620	93

Studied years		The power consumption (kWh)			
		Per inpatient <i>bed</i> count day	Per <i>bed</i> occupancy day	Per square meter infrastructure	Per patient number
2007	333 inpatient bed	501	24.6	91	6.9
	68 occupancy rate				
2008	345 inpatient bed	513	26.3	96.6	6.7
	65 occupancy rate				
2009	342 inpatient bed	409	21.3	76.2	4.9
	64 occupancy rate				
2010	375 inpatient bed	434	21.8	88.7	6
	66 occupancy rate				
2011	371 inpatient bed	417	19.7	82.8	5.6
	69 occupancy rate				
2012	364 inpatient bed	446	21.4	91.5	5.8
	72 occupancy rate				
2013	376 inpatient bed	143	47.8	194.8	11.1

Studied years		Gas consumption (m ³)			
		Per inpatient <i>bed</i> count day	Per <i>bed</i> occupancy day	Per square meter infrastructure	Per patient number
2007	333 inpatient bed	520.68	25.55	94.57	7.16
	68 occupancy rate				
2008	345 inpatient bed	156	7.99	29.33	2.05
	65 occupancy rate				
2009	342 inpatient bed	289	15.07	53.84	3.50
	64 occupancy rate				
2010	375 inpatient bed	80.58	4.04	16.49	1.11
	66 occupancy rate				
2011	371 inpatient bed	151.28	7.30	30.61	2.05
	69 occupancy rate				
2012	364 inpatient bed	104.62	4.85	20.79	1.31
	72 occupancy rate				
2013	376 inpatient bed	199.87	10.06	41.04	2.35

Table 2. The correlation between the amount of water, power and gas and variables including number of inpatient bed count, bed occupancy day and bed occupancy day rate

Variable name	Water consumption rate		Power consumption rate		Gas consumption rate	
	The correlation coefficient	Pvalue	The correlation coefficient	Pvalue	The correlation coefficient	Pvalue
Inpatient bed	0.214	0.002	0.321	0.001	0.087	0.000
bed occupancy day	0.571	0.001	0.25	0.003	0.071	0.001
Bed occupancy day rate	0.505	0.004	0.108	0.001	0.054	0.002
Inpatient number	0.679	0.003	0.571	0.000	0.036	0.001
Number of customers	0.321	0.002	0.179	0.001	0.357	0.003
Number of imaging	-0.179	0.702 ^{ns}	0.286	0.53 ^{ns}	-0.107	0.81 ^{ns}
Number of tests	-0.429	0.337 ^{ns}	0.000	1 ^{ns}	-0.214	0.64 ^{ns}
Number of surgical operations	-0.571	0.180 ^{ns}	0.536	0.2 ^{ns}	0.321	0.48 ^{ns}

Ns : This symbol indicates that the variable is not significant at 1 and 5 percent level.

Average water consumption in the course of seven years is 50100429 liters in studied hospital and 578 liters of water was consumed for bed days. Average water consumption of Tohid Hospital during a seven-year is 1.15 times the international standards. Standard power consumption per bed-day is 5-3 kW power requirement of hospital (Sheikh Abumasudi, 2005). Average power consumption of seven-year period at Tohid Hospital is 2267343kW and 26.16 kW power is used for every bed days. Average power consumption over a period of seven years at Tohid Hospital is 5.2 to 8.27 times the international standards. Average gas consumption of hospital in the course of seven years is 900,970 cubic meters and for every bed occupancy day is 10.4 cubic meters. Table 1 shows water and electricity consumption per inpatient bed day, bed occupancy day, the number of patients and infrastructure square meters at Tohid Hospital during study. (Tables 1 and 2)

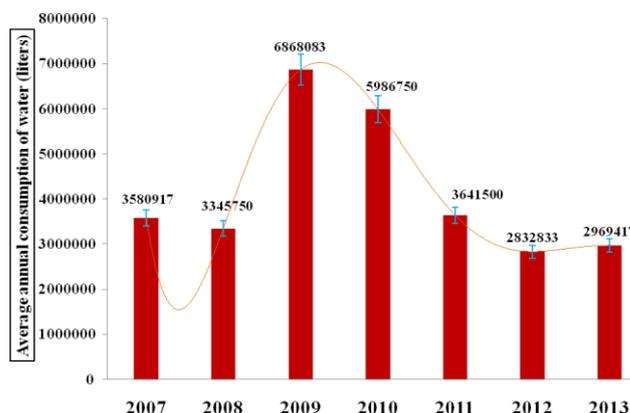


Figure 1. Mean annual water consumption (liter)Tohid Hospital in the years 2007-2013

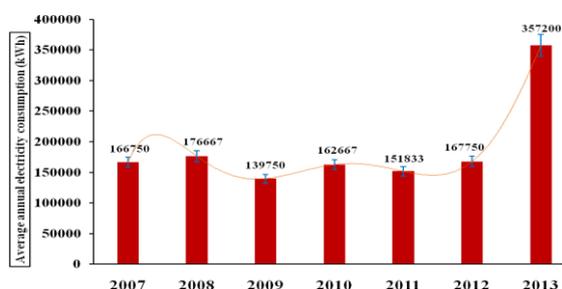


Figure 2. Mean annual electricity consumption(kWh)Tohid Hospital in the years 2007-2013

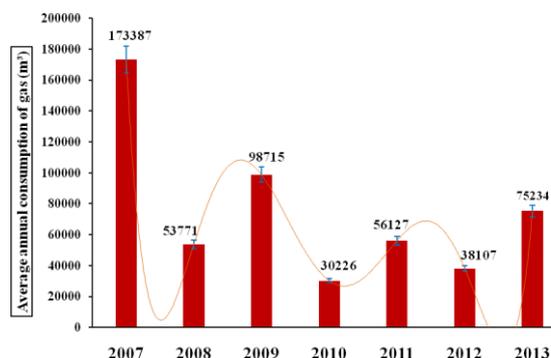


Figure 3. The average annual gas consumption (m³) Tohid Hospital in the years 2007-2013

DISCUSSION AND CONCLUSION

In study Hospital, the average water consumption was 50100429 liters, power consumption was 2267343 kW and gas consumption was 900,970 cubic meters per bed day over a period of seven years. As the results show, there was positive correlation between energy consumption and number of inpatient bed, bed occupancy days, percent of bed occupancy days, the number of in-patients and number of clients who have referred to hospital; variables of number of imaging, laboratory tests and surgical procedures were not effective factors on energy consumption. In a study entitled "Energy consumption and cost in training center of Shahid Rajae" that was conducted in the course of one year, hospital had 167 inpatient beds. According to reported results, water consumption was 0.63 cubic meters, power

consumption was 55.7 kW and gas consumption was 23 cubic meters per bed occupancy days (Nazari 2004). The results of Sheikh Abumsudi study in Esfahan showed that water consumption was 728.72 l, power consumption was 20.57 kW and gas consumption was 18.8 cubic meters per bed day and generally acknowledged that energy consumption of all hospitals was higher than international standard. In this study, the energy consumption of public hospitals was much higher (Mossadegh, 2004).

Bull and Adams, in their review, estimated the average power consumption at a hospital in New York State (Buffalo Public Hospital) 1160 kWh per bed and average gas consumption as 6.74 cubic meters. Average annual consumption of electricity among hospitals of New York State is significantly different (Bull, 2008). In Riahi review on hospitals of Hamadan, average amount of energy and water consumption per bed occupancy days was 24.5 kilowatts of power, 14 cubic meters of gas, 0.3 liters of diesel and 939 liters of water, respectively. He showed that there is significant difference between bed occupancy rate and energy consumption and energy consumption and water consumption per bed occupancy day and each monthly inpatient bed (Riahi, 2011). Toledo and Demajoroik in a study on Brazil selected hospitals estimated the average power consumption as 86.24 kW and stated that there is significant difference between selected hospitals in power consumption and hospitals offering customers a variety of services and facilities use more energy. Also, they showed that area and installation systems effect on energy consumption (Toledo, 2006). Some studies have shown that water consumption of many hospitals in America is normally 300 to 550 liters and in Germany is 300 to 611 liters per bed and in Europe hospital with less than 300 beds consume 312 liters of water and 328 kW of power, between 300 and 600 beds consume 335 liters of water and 241 kW of power and more than 600 beds consume 367 liters of water and 261 kilowatt of power. Generally, the findings suggest that energy consumption of studied hospital is very different from international standards. The results revealed that there is significant relationship between hospital performance indicators and energy consumption of Tohid Hospital and energy can be mentioned as one of the factors that produce these indicators, although, there is no significant differences with some variables related to hospital services. It emphasizes the hospital administrators to control and manage the energy consumption. According to the fact that the energy consumption is not desirable in Sanandaj Tohid hospital, through implementing energy efficiency measures, we can prevent paying high energy costs and loss of state capital in addition to saving and standardizing energy consumption. The results showed a downward trend in water and gas consumption during study years except in 2013 that show positive effect of measures related to energy consumption management in order to reduce energy consumption. The observed downward trend in water consumption does not apply for power and gas in 2013 and energy consumption in line with development of strategies and policies in different areas and policy of movement from in-patient services towards outpatient hospital services doesn't continue and power and gas consumption of hospital is increased, the below reasons could be outlined for this increase:

- Commissioning and opening Shahid Boroujerdi's heart surgery center in 2013
- Construction and reconstruction operations due to hospital archaism
- Purchasing advanced medical equipment in order to provide better services
- Purchasing appropriate heating and cooling systems
- increasing the number of clinics and working hours in medical centers
- 14.23% increase in the number of in-patients in 2013 compared to years before study
- increased number of operation rooms, work days and hours in treatment centers
- 25% increase in the number of patients referred to imaging units in 2013 compared to years before study
- 23.63% increase in the number of patients referred to laboratory in 2013 compared to years before study

Of course, it might be noted that taking into account the indexes related to bed it became clear that power and gas consumption has increased in 2013 compared to before study years, but looking at the calculation related to number of patient index who referred to hospital and considering the upward trend and increased number of patients the extensive reconstruction and development activities in hospitals, power consumption became 11.1 kW per patient in year 2013 (Compared to 2012 year and before, 5.8 kW per patient that confirms the effectiveness of measures. In this study, international standards of consumption and types of hospital performance indicators are considered for comparison with other hospitals consumption, but the important point is that criteria and standards and variety have resulted in not a good comparison. For example, the consumption index per in- patient bed, in- patient bed day and bed occupancy day, considering some hospitals' movement from in- patient services to outpatient services will result in deviation in comparison and benchmarking, because the hospital needs energy consumption for outpatient services like in- patient services. According to results of study, using methods such as corrective measures and completing facilities, establishing energy consumption committee, appointing posts and employing a special expert for energy, using

innovative proposals related to issue, training and cultural building of employees and hospital officials seem necessary and therefore, using building energy management modeling systems is in line with services provided to patients. According to economic transformation of financial institutions and health care costs, promoting effective methods of energy consumption management, specialized and experienced engineers and technicians relationship with hospitals in order to exchange experiences and clarify the current status of energy consumption in health centers can optimize the consumption and achieve appropriate model for annual hospital cost reduction.

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