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STUDY ON ENERGY MANAGEMENT IN A PUBLIC BUILDING

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Abstract- Since energy consumption is increasing in Iran, especially in the construction sector and also the cost of the production, transmission and distribution of energy is increasing, presenting techniques for the optimization of energy consumption is one of the most important present needs of the country. The main aim of this paper is to offer a documentary evidence for this high potential of energy saving in office buildings. Thus, through energy auditing of the office building of Electric Power Distribution Management in Malekan city, this facility was considered for its energy consumption, and different techniques for energy consumption optimization were evaluated technically and economically and the best of them were proposed. The results show that the return on investment is reachable within a short period with considerable amounts of saved money that can be used for the development of the company. In addition, the energy waste solutions that are not economically justifiable at present will be justifiable in near future when the energy costs become real. Also possibility of using photovoltaic (PV) system to serve energy needs of this building has studied.

Keywords: Economic Evaluation, Electricity Consumption, Energy Consumption Optimization Techniques, Natural Gas Consumption, PV.

I. INTRODUCTION

The limitation of fossil fuels on the one hand and the polluting nature of these energies on the other hand have placed the knowledge of saving and optimization of energy consumption in a special position in the present economy of the world. The building sector as an unproductive sector of the country consumes more energy than other sectors. Based on the energy balance sheet, annually more than 40% of energy consumption is directly used to serve the needs of this sector in Iran.

Most of the studies in this area show that more than half of this energy goes to waste for different reasons. In fact, in case optimization techniques for energy consumption are implemented in the buildings, through better efficiency and consumption management, the desired conditions can be provided using just half of this amount of energy. Besides, consumption reduction, especially at the peak load time, results in loss reduction and optimum operation of transmission and distribution systems [3].

Energy waste in most of the governmental and public buildings is higher than other buildings and maybe aside from other issues and having similar weak points in most of the buildings, lack of enough motivation and the fact that no one is assigned to follow the optimization issues are among the main reasons for this shortcoming. On the other hand, the electric power distribution companies are in direct contact with people that play an important role in culturalization of the consumption pattern reforms, and can be pioneer in issues related to the optimization of energy consumption.

Not only can they save a lot through the optimization of energy consumption for their own development, but also they can act as a model for other private and public organizations and indeed the whole society [3]. Energy consumption optimization is not possible without energy auditing studies in an office, business, or production building.

In the present paper, some energy auditing studies have been carried out on the office building of Electric Power Distribution Management in Malekan and based on the results and the physical conditions of the building and the climatic and cultural conditions of the city, different methods of energy consumption optimization were technically and economically evaluated. Finally, best optimization methods offered to authorities for implementation [3].

II. SPECIFICATIONS OF BUILDING UNDER STUDY

The office building of Electric Power Distribution Management in Malekan consists of three separate buildings built on an area of 2500 m^2 and in this paper, the term office building refers to these three buildings. The main building is in two floors with an area of 724 m^2, the emergency room covers an area of 29 m^2 and storage office is located in an area of 12 m^2. All of the walls are made of bricks and the building frontage is made of white cement.

The sum of the wall surfaces having heat exchange with the outdoor is 500 m^2. This building has 46 windows that totally cover an area of 96 m^2 and all of them are single layer glass windows. The frames of 36 of these windows are made of aluminum and the other 10 are made of PVC. The sum of ceilings and floors' area is 805 m^2. The ceiling is insulated with a layer of tar and the floor is ceramic.

This building has seven doors that are opened into the outdoor covering an overall area of 21 m^2. Most of the door surfaces are made of glass and except for one automatic door, other ones are made of aluminum. In the emergency room, three personnel are always present working in shifts. A cooler provides the cool air and a gas heater independent from the central powerhouse provides heat.

The storage office and the main building are closed after the office hours and because the toilets are located in the main buildings, the personnel of the emergency power room and the night shift staff walk through the main building. Annual electricity consumption distribution and annual natural gas consumption distribution are shown in Figures 1 and 2 respectively [3].

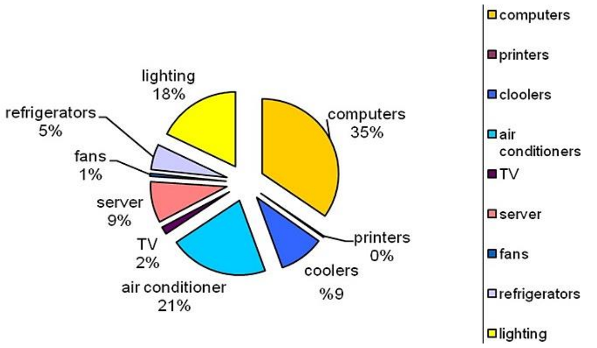

Figure 1. Annual electricity consumption distribution [3]

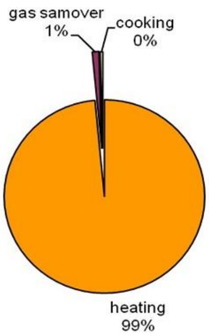

Figure 2. Annual natural gas consumption distribution [3]

The standards related to the article 19 in the national construction code are not observed in these buildings' construction. Based on the materials used the thermal conductivity of different parts of the buildings is considered in the calculations based on Table 1. The amount of the Building Load Factor Coefficient (*BLC*) is calculated as [1]:

$$BLC = 3.4462 \text{ kW/K} \quad (1)$$

Table 1. Thermal conductivity of different parts of the building [1]

Wall	Roof	Floor	Door	Glass
1.4	0.95	1.45	5	4.8

The energy label of this building is G, which indicates low efficiency of energy consumption. Energy consumption in this building is 80 kWh/m^2 which is 6.8 times more than standard [3].

III. WEATHER CONDITIONS

The amount of energy consumption depends on the weather conditions and the length of the day. In different seasons, the amount of energy consumption is changed based on the different heating or cooling equipment, temperature change and humidity and also the length of the day. Malekan is located in the south of East Azerbaijan province and has a cold mountainous climate. The average monthly temperature in 2011-2012 for this city is shown in Figure 3 in degrees centigrade [2]. Moreover, they are used in calculations. During a year, the cooling systems are used for 3 months and the heating systems are used for 5 months [3].

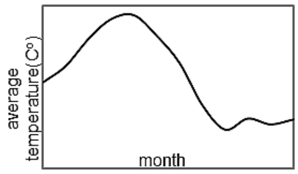

Figure 3. Average monthly temperature of Malekan in 2011-2012 [2]

IV. ENERGY CONSUMPTION OPTIMIZATION TECHNIQUES

After the collection and analysis of the data about the equipment using energy, the consumption model and also the physical conditions of the building, the final step of energy auditing is to find and technically and economically evaluate the energy consumption optimization techniques. In this step first the existing techniques are determined and then the amount of energy saving is calculated for them.

Then, the initial cost of investment needed for implementation with the return on investment is calculated and finally best techniques are chosen and implemented. Two samples of techniques that are not proper for this building are also mentioned. In economic evaluation of the techniques, the cost of each kilowatt-hour of electrical energy is assumed 1500 Rials and each cubic square meters of natural gas is assumed 3000 Rials [3].

A. Thermal Insulation and Using Double Layer Glass Windows

There is some relation between the indoor thermal comfort and energy consumption [4-6]. Heat losses from windows are the greatest amount of the total heat loss of a building [7-9]. The use of improved energy saving double layer windows can contribute considerably to the energy efficiency [10] for heating, cooling and lighting of buildings as well as to improvement of thermal & acoustic comfort conditions [11] in indoor environment [12].

The use of double layer glass windows results in a reduction of heat exchange with the outdoor by the surfaces in contact and less energy consumption is needed to be maintained at the desired temperature indoors. For the insulation of the building under study, a pouring Polyurethane insulator with thickness of 2 cm and a density of 30 kilograms for each m^3 was chosen and the economic and technical studies are carried out on this basis. Although using Polystyrene Insulation is more cost effective, in a technical point of view polyurethane is more suitable for this building.

The Polyurethane foam is made of two isocyanate with a polyol liquids that are combined in mixing gun of the equipment under pressure and heat. It is increased in bulk within seconds and forms a compressed, solid foam with desired thickness depending on the amount of poured polyurethane material. Among the advantages of pouring polyurethane is the high heat resistance coefficient, high adhesiveness to all types of surfaces, easy implementation, and the possibility of reaching blind spots of the building in different conditions.

Integrity of the insulator and so reaching higher heat resistance coefficient, covering all of the surfaces without having any joints and fractures, short installation time (300 m^2 daily with each unit), possibility of different densities of polyurethane depending on application type, the foaming up capability of the insulator and possibility of choosing the necessary density at the time of installation. Polyurethane will be poured on the floor ceramics and then another layer of ceramic will be installed. For the ceiling the polyurethane is poured on the tar layer and then it will be cemented so than sunlight does not damage it.

In the cost related calculations, the cementing cost of ceiling and the re-flooring are considered [3]. Figure 4 shows the effects of thermal insulation of different elements of the building on the reduction of electricity consumption and Figure 5 shows the effects of thermal insulation of different elements of the building on the reduction of natural gas consumption in 2011-2012 and on the desired temperature of 22 centigrade degrees.

The calculations is done with the degree-day method. It was found that the insulation of ceiling, floor and walls and using double layer glasses for windows have the most effect on reduction of energy consumption respectively. Table 2 shows the economic evaluation of implementing this energy saving technique [3-13].

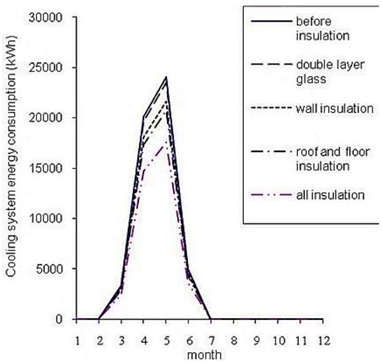

Figure 4. The effect of thermal insulation of different elements of the building and using double layer glass windows on the reduction of electricity consumption in 2011-2012 and the desired temperature of 22 degrees centigrade [3]

Table 2. The economic evaluation of building thermal insulation and using double layer glass window in 2011-2012 and the desired temperature of 22 degrees centigrade [3]

The sum of reduction of annual costs for electrical and natural gas energies (in Rials)	The cost of implementing the technique (in Rials)	The period of the return on investment (in years)
60676302	415000000	6.83

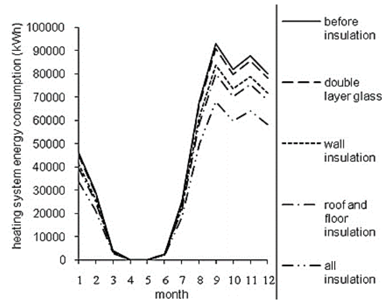

Figure 5. The effect of thermal insulation of different elements of the building and using double layer glass windows on the reduction of natural gas consumption in 2011-2012 and the desired temperature of 22 degrees centigrade [3]

B. Installing Automatic Control System on Powerhouse

Installing automatic control system, the powerhouse can be turned on one hour before the office hour at 6:30 am and turned off at 2 pm. 30 minutes before the end of the working hour so that the personnel have the comfort of having a desired temperature. In this method, the powerhouse will be turned on for 7.5 hours in a day, while previously it was tuned on for 24 hours a day and worked for 16.5 hours without anybody present in the building and so wasted lots of energy.

Based on the assumption that the powerhouse heating system runs for five months of the year, the amount of natural gas saving and also the electrical energy saving in electrical equipment of the powerhouse are shown in Table 3 [3]. In addition, the automatic control system keeps the buildings temperature within the desired conditions, in a way that turns off the powerhouse if the temperature exceeds the desired conditions and prevents waste of energy and fuel, and if the temperature is less than the desired conditions powerhouse is turned on [3].

Table 3. The Economic evaluation of installing automatic control system on the powerhouse [3]

The sum of reduction of annual costs for electrical and natural gas energies (in Rials)	The cost of implementing the technique (in Rials)	The period of the return on investment (in years)
33067770	16000000	0.48

C. Changing One-Pole Switches with Two-Pole Switches

In each room there are two rows of Compact Fluorescent lamps (CFLs), the first row is close to window and the second row is close to the door. The rooms have big windows that can let in sufficient daylight. The switches of some of the rooms have one pole, replacing them with two pole switches make it possible to turn off the row that is near the windows. Therefore, within the office hours twelve 23-Watt CFLs can be turned off without causing any troubles. Economic evaluation of this technique is shown in Table 4 [3].

D. Installing Occupancy Sensors on Lighting System

Occupancy sensors save energy by automatically turning off the lights in spaces that are not occupied. In the off office hours 3 personnel are present in the emergency room that walk through the area, halls, and the toilets.

In order to provide the light for the halls and toilets at night seven 23-Watt CFLs and four 15-Watt CFLs are permanently turned on that through the use of the occupancy sensors the period in which the CFLs are turned on is reduced up to 70 percent. The economic evaluation of this technique is shown in Table 5 [3].

Table 4. The economic evaluation of changing one-pole switches with two-pole switches [3]

The reduction of electricity consumption (in Rials)	The cost of implementing the technique (in Rials)	The period of the return on investment (in years)
1057770	1300000	1.23

V. TECHNIQUES WITH CONSIDERABLE AMOUNT OF ENERGY SAVINGS WITCH ARE NOT QUANTIFIABLE

1. Changing the place of radiators: all of the radiators are exactly placed under the windows that results in the waste of heat through windows. In addition, the vent of cooler is exactly positioned above the radiator that works as a chimney and transfers the heat to outside the building. Closing the vent in seasons the air conditioner is turned off not only stops loss of heat, but also stops the entrance of dust and so reduces the damage to the computers [3].
2. Planting some trees in front of the east side of the building: three rooms in the east side of the building use gas air conditioner. Within the office hours the east side of the building faces the sunlight that during summer results in the over heat of the rooms and more use of the air conditioner. If some trees are planted in the east side of the building then during the summer the shadow of trees stop the direct sunlight and so results in a save of energy and in the winter with the falling of the tree leaves the sunlight directly hits the building and helps it heat [3].
3. Planting evergreen trees in the north side of building prevents direct breezing cold winds and results in the prevention of heat waste [3].
4. The adjustment of the ratio of fuel to air in order to reach efficient combustion in the powerhouse and so reach an optimized use that is possible through the use of gas analyzer [3].
5. Based on Figure 1 within the office hours the computers have the biggest share in electricity consumption. The computers can be adjusted in a way that if there are not used for more than 10 minutes then they go to standby or hibernate mode in order to save energy [3].
6. Thermal Insulation of cooler channels [3].

VI. COMMON TECHNIQUES FOR ENERGY CONSUMPTION REDUCTION WITCH ARE NOT PROPER FOR THE BUILDING

A. Using LED Light Bulbs for Illumination of Area

In order to light the area at night sixteen 23-Watt CFLs are used. The economic evaluation of replacing them with LED 7-Watt light bulbs is offered in Table 6 [3]. Today because of the expensiveness of LED light bulbs and also the nominal and low price of electrical energy, the use of LED light bulbs for this building is not economically justifiable [3].

Table 5. The economic evaluation of installing occupancy sensors on the lighting system [3]

The reduction of electricity consumption (in Rials)	The cost of implementing the technique (in Rials)	The period of the return on investment (in years)
2032758	2700000	1.33

Table 6. The Economic evaluation of replacing CFLs of the area with LED light bulbs [3]

The reduction of electricity consumption (in Rials)	The cost of implementing the technique (in Rials)	The period of the return on investment (in years)
64240	4400000	68.5

B. Illumination Standardization

In most of the cases, it is seen that the illumination in the buildings and public places is more than the standard and through illumination, calculations, and reducing it to the standard amount the electrical energy consumption can be reduced. The illumination calculations was done for this building and it was observed that the number of light bulbs in the rooms and their amount of illumination is less than the standards, but because through the office hours mostly the day light is used then there is no or little need to light bulbs. Therefore, within office hours this building has no potential for reduction of electric energy consumption [3].

VII. INSTALLING PV SYSTEM

We are going to study installing PV system to serve a part of energy needs of this building in this section. Working time is 7:30 to 14:30 and we need a very low amount of energy in the night. So this PV system do not need any batteries and become cost effective. According to calculations we can install a PV system which has a panel with 60 m^2 area and 5 kw capacity and produce 9125 kwh annually according to the regional conditions.

We can sell surplus energy in nonworking time and holidays. The economical evaluation of installing PV system is presented in Table 7. Installing PV system for this building is not economically justifiable because the period of the return on investment is more than lifetime of the system.

Table 7. The economic evaluation of installing PV system in the office building of Electric Power Distribution Management in Malekan

The reduction of electricity consumption (in Rials)	The cost of installing the system (in Rials)	The period of the return on investment (in years)
13681500	450000000	32.87

VIII. CONCLUSIONS

In this paper through the energy auditing of the office building of Electric Power Distribution Management in Malekan all of the possible techniques for the reduction of energy consumption from economic and technical points of view are evaluated and the best of them are chosen and proposed. The economical evaluation of implementation of all of the proposed techniques (except the ones with unquantifiable saving) is presented in Table 8.

Table 8. The economic evaluation of implementation of all of the proposed techniques for the reduction of energy consumption in the office building of Electric Power Distribution Management in Malekan

The reduction of electricity and gas consumption (in Rials)	The cost of implementing the technique (in Rials)	The period of the return on investment (in years)
96834600	435000000	4.49

The return on investment for the implementation of all of these techniques is 4.49 years. Through investigations at least 15 years of the useful life of the building has remained. Therefore, implementation of all of these techniques is very economical. After implementation of the second phase of Targeted Subsidies Act in Iran and the increase in the cost of energy the return on investment will be reduced and the importance of energy consumption optimization will become more significant.

Therefore, implementation of techniques like using LED light bulbs that is not economical for this building now, will be economically justifiable in the near future. Also we studied installing PV system to serve a part of energy needs of this building. Economic feasibility study shows that today installing PV system for this building is not economically justifiable because of the expensiveness of PV systems and also the nominal and low price of electrical energy in Iran. We propose the government increase electrical energy and natural gas price and gives grant to installing renewable sources in buildings.

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BIOGRAPHY

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