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Energy Saving in Tehran International Flower Exhibition's Building

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ABSTRACT: The municipality of Tehran is intending to construct a permanent international flower exhibition. The activities for construction began in the year 2006. The exhibition has three distinct areas namely "northern area","southern area" and "central area". In northern and southern area the flowers are supposed to be preserved and in central area, they will be sold out. In the present study, energy consumption in the exhibition building is analyzed. To calculate cooling and heating load TABESH software was used. The heat loss from the building envelope is more than twice as much the standard in Iran. Insulation of walls with 5 cm wool stone and first floor with 3 cm polystyrene can reduce heating and cooling energy consumption by 18% with payback period of two and four years respectively ,according to international energy prices. Other energy saving measures such as double glazing windows are not economical both at national & international energy prices. To achieve national and international building energy standards, more energy subsidies must be provided on costly energy efficiency.

Key words: Energy, Consumption, Saving, Exhibition, Flower, Tehran

INTRODUCTION

Energy is the single most important resource capable of sustaining life on earth. Energy not only is the engine of economic growth but also the cause of important life threatening outcomes. Its ubiquity, its role as life supporting resource as well as its potential to become a cause for the demise of human beings or living things at large makes it the most interesting area of research for public policy making (Yohannes, 2002). According to World Energy Outlook 2005 reported by International Energy Agency (IEA), world primary energy demand is projected to expand by more than 50% between 2003 and 2030, reaching 16.3 billion tones of oil equivalent. Such ever-increasing demand could place significant strain on the current energy infrastructure and potentially damage world environmental health by CO, CO_2, SO_2, NO_x effluent gas emissions and global warming (Omer, 2007). As detailed in the report by the Intergovernmental Panel on Climate Change (IPCC), greenhouse-gas emissions and climate change are also a major concern (Bruce, *et al.*, 1996). These growing environmental concerns also call for a stringent review of the present energy system and energy sector development policies (United Nations Publication, 2001). To ensure energy to meet needs for economic growth and sustainable development more emphasis should be given to energy efficiency for both end-use and supply. An effective energy policy in any country should encourage the different enterprises, utilities, and individuals to employ energy efficient processes, technologies, and materials (Rowshanzamirand Eikani, 2005). The connection between the increased CO_2-discharge to the atmosphere and the use of energy is also a motive to render a more efficient energy usage, and lowering the total energy demand (Moshfegh and Karlsson, 2006). At the dawn of the twenty-first century, we still receive our power from highly polluting fuel fired power plants, live in houses that waste energy, and use inefficient lighting, heating and cooling

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system and appliances. In poorly designed industrial and commercial establishments, people are complaining of the loss in productivity associated with the so-called" sick building syndrome" (United Nations Publication, 2004). It is estimated that while suitable energy saving retrofits in existing building can reduce the energy bill by about 20 percent, if the building are designed with an integrated approach, the energy saving can be as high as 40 to 50 percent (Majumdar, 2002). Iran is one of the world's largest fossil fuel rich countries and holds 9% of the World's oil reserves and 15% of gas reserves (Rostamihozori, 2002). Besides Iran's energy consumption pattern is unquestionably unsustainable and typical of consumption-oriented, highly populated, oil-producing countries with low productivity (Bitaraf, 2003 & Massarrat, 2004). Energy consumption in Iran has risen almost 17 fold over the past 40 years, from 53.4 million barrels oil equivalent (mboe) in 1967 to almost 900 mboe in 2006. This rapid increase in consumption is by no means the result of an ongoing industrialization process and an increase in the performance of Iran's economy. This trend rather reflects two intensifying structural problems: firstly, the level of energy consumption in non-productive sectors has rocketed; secondly, the energy intensity in every social sector has spited the global trend and risen dramatically. Moreover energy consumption in Iran is rising significantly faster than the gross domestic product. This implies that Iran has a considerable energy savings capacity potential (Massarrat, 2004). Commercial and household sector consume about 40% of total energy in Iran. This Consists, 19.17 % of oil products, 69.8% of natural gas and 51% of electricity (Ministry of Energy, 2005). At present, energy consumption per square meter of buildings is equivalent to 30 m^3 of gas per year which is high comparing to European index of 5.5 m^3 of gas per year (Farhanieh and Sattari, 2006). Several ways can be used to reduce the energy consumption in the building sector. In order to conserve energy in the building envelope "The National Building Code, part 19th. was compiled for the first time in 1991 by The Ministry of Housing and Urban Development in Iran, followed by publishing the part 19th guide in 1999. On account of global development of technical knowledge, the 19th. part was reviewed and republished in 2002 for architectures, civil and mechanical engineers.

Tehran is the capital of Iran that is located on the slopes of the Alborz Mountains and at the foot of Damavand. Average sunlight hours ranges from 6 to 12 h/day (minimum in Dec. & maximum in July). The lowest and highest temperature records are -21°C & 43°C in January and August, respectively. The mean monthly rainfall is about 21 mm/yr. The lowest and highest relative humidity is about 39% and 77% in March and January respectively. Total snowy and rainy days do not exceed 40 days/year (Islamic Republic of Iran Meteorological, 2005). Tehran International flower exhibition (TIFE) building (Fig.1) is a place to offer and sale flower to people.

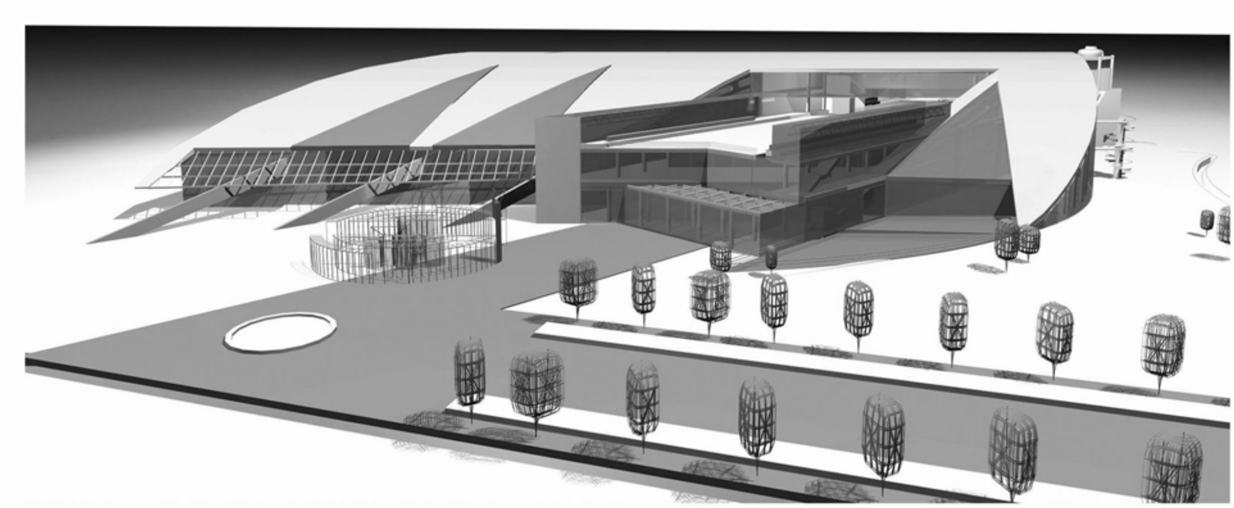

Fig.1. The outlook of Tehran International Flower Exhibition complex

It has 9500 m^2 area consisting of three parts: Northern part, Central part and Southern part which can admit 2500 visitors. If all 2500 visitors attend all together, the average per capita space used by the visitors and stuff is calculated at 2.3 square meters; considering 33% of total area for the exhibition of flowers. The northern and southern parts are semi-glass houses which are built to keep and exhibit flowers and central building is allocated for administrative purposes.

MATERIALS & METHODS

In this study, it is tried to estimate energy consumption at the under construction building of permanent international flower exhibition of Tehran and its degree of compliance with the National Building Code, part 19$^{th.}$. According to National Building Code (part 19$^{th.}$) energy efficiency measures in all kinds of building must adopt to the national standards. To calculate the total cooling and heating load of this building we used TABESH software which is designed by a group of Iranian engineers. In the present study, firstly, we collected construction maps of flower exhibition along with the type of materials that are going to be used in construction. Secondly we entered the collected data into TABESH software. The input data includes:

1. General information such as summer dry bulb, winter dry bulb, summer wet bulb, winter wet bulb, relative humidity, atmospheric clearness number, daily temperature range, cooling degree day, heating degree day, population, elevation and latitude of Tehran, building occupancy, yearly energy requirement ,type of fuel consumption & etc .
2. Material properties that are going to be used in this building such as complete details of walls, partitions, windows, doors, floors and ceilings, including thickness , material, thermal conductivity factor & etc .
3. Spaces specifications such as area, height, summer dry bulb, winter dry bulb, summer wet bulb, winter wet bulb, areas and type of out walls, partitions, windows, floors and ceilings, the amount of fresh air requirement, lightings specification & etc (ASHRAE Handbook Fundamentals, 1993 & Tabatabaie, 2002). The output of software include the followings:

A. Total cooling load of each space
B. Total heating load of each space
C. Total cooling load of building
D. Total heating load of building

RESULTS & DISCUSSION

Table 1 encompasses some general information that is incorporated into the TABESH software. The table shows that both cooling and heating system are required in TIFE. Considering climatic condition of Tehran city, it should also be pointed out that not only Tehran city but many other cities in Iran enjoy vast amount of solar energy. Tables 2 and 3 shows various material properties of TIFE building. In this table U-value of materials along with their density and thickness are provided. Among the various materials used in the building, it can be noticed that walls, concrete floors and roof has the high heat conductance property. Thus, much of energy loss can occur through walls, concrete floors and roof.

Subsequently the cooling and heating loads were computed for various spaces in the building (Table 4). Such computations are carried out for winter and summer times. The data in Table 3 shows that southern part needs highest energy for heating and cooling.

Table 1. General Information of TIFE complex and it's vicinity

Specification	Unit	Value	
Summer Dry bulb	f	100	
Summer Wet bulb	f	73.47	
Winter Dry bulb	f	24	
Winter Wet bulb	f	74	
Elevation	ft	4000	
Latitude	deg	35.8	
Daily Temperature Range	f	27	
Atmospheric Clearness Number	%	0.85	
Cooling Degree Day (DDC)	-	865	
Heating Degree Day (DDH)	-	1810	
Number Of Rooms	-	Northern part	1
		Central part	18
		Southern part	1
need for heating	-	Yes	
need for cooling	-	Yes	
To enjoy Solar Energy	-	Yes	
Yearly Require Energy	-	Medium	

Table 2. Material properties in TIFE building

No.	Type	Slope deg	Material Admixture	U-Value in summer (Btu/h*ft²F) Heat Flow Down	U-Value in summer (Btu/h*ft²F) Heat Flow up	U-Value in winter (Btu/h*ft²F) Heat Flow Down	U-Value in winter (Btu/h*ft²F) Heat Flow up	Density Kg / m³	Thickness cm
1	Out Wall 1	90	Aluminum Polyethylene Aluminum Air Film Total	0.955		1.034		2707.04 52.86 2707.04 0 -	0.04 0.4 0.04 0 0.48
2	window	90	Glass Total	1.03		1.03		2700.63 -	0.6 0.6
3	Partition 1	90	Glass Air Film Total	0.666		0.666		2700.63 0 -	1 0 1
4	Partition 2	90	Plaster Layers With Fire Resistance Cover Air Layer With 51 to 100 mm Thickness Plaster Layers With Fire Resistance Cover Air Film Total	0.214		0.199		900.21 0 900.21 0 -	1.6 8 1.6 0 11.2
5	Roof	15	galvanized sheet wool stone Aluminum Air Film Total	0.104	0.118	0.118	0.108	7128.01 20.82 2707.04 0 -	0.05 7 0.05 0 7.1
6	Floor1	0	Concrete Air Film Total	0.327	0.418	0.327	0.418	2300.18 0 -	27 0 27
7	Partition 3	90	Concrete Air Film Total	0.326		0.326		2300.18 0 -	40 0 40
9	Ceiling1	0	Concrete Air Film Total	0.418	0.327	0.418	0.327	2300.18 0 -	27 0 27
11	out wall 2	90	Concrete Air Film Total	0.383		0.395		2300.18 0 -	40 0 40
12	Roof	0	Glass Total	1.145	1.145	1.145	1.145	2700.63 -	0.6 0.6
13	Roof	0	Concrete Polyethylene bitumen Poly ester bitumen Concrete Air Film Total	0.309	0.504	0.505	0.355	2300.18 949.87 999.52 1550.54 999.52 1800.42 0 -	27 0.1 0.1 0.1 0.1 10 0 37.4

Table 3. Material properties in TIFE building

No.	Material	Type	Slope deg	U-Value ($Btu/h*ft^2F$)
1	External Door	Flat Glass- single	90	1.02
2	Internal Door	Flat Glass-Double	90	0.79
3	Internal Door	Steel	90	0.58

Table 4. Space specification and their heating & cooling loads in TIFE complex

Location	Area	Summer Dry bulb	Summer Wet bulb	CFM	Height	Winter Dry bulb	Winter Wet bulb	Total Cooling Load	Total Heating Load	Lighting
	m^2	f	f		m	f	f	Btu/h	Btu/h	w
Northern Building	628	75	65	4140	12.6	70	61	467308	1046119	4360
Southern Building	2219.7	75	65	14600	12.6	70	61	2787296	5140025	12472
Central Hall	1940.2	78	65	11200	4.5	74	57	700380	1126692	15300
Main Entrance	243.96	80	66	1200	4.5	68	52	513559	301407	756
West Control Room	37.99	78	67	102.3	4.5	72	54	31195	43918	300
East Control Room	15.67	78	67	43	4.5	72	54	18134	23725	240
4.5 Level Hall	2215.5	78	65	12000	4.5	74	57	749953	1387477	14040
4.5 Level Toilet	29.4	80	66	646	2.4	68	52	825	-1107	288
4.5 Level South Air Conditioner Room	37.5	80	66	40	4.5	68	52	-10642	11219	360
4.5 Level North Air Conditioner Room	59.05	80	66	40	4.5	68	52	19475	58820	400
9 Level corridor	404.16	80	66	1088	4.14	68	52	1108935	497529	4050
9.30 Level Trade Center	320.02	78	65	1600	3.84	74	57	693787	368849	3300
9.30 Level Air Conditioner Room	39.5	80	66	40	3.84	68	52	6509	22924	360
9 Level Air Conditioner Room	59.05	80	66	40	4.14	68	52	18511	55455	360
13.14 Level Restaurant	1176.6	78	67	50664	4.74	74	55	860329	1148372	6030
15.94 Level Air Conditioner Room	55.04	80	66	40	2.82	68	52	16266	40864	360
13.14 Level Toilet	55.68	80	66	1199	2.82	68	52	11286	34634	612
16.95 Level Toilet	10	80	66	215	1.8	68	52	864	394	144

In general overall cooling & heating loads of Tehran's international flower building are about 7537760 & 11307315 Btu/h, respectively (Table 4). Thus, annual energy for cooling and heating in TIFE building is equal to 39614897 Mj. In other words the cooling and heating energy requirements are 4150 Mj/m^2. More over the natural gas consumption is about 482159 & 684701 m^3/yr for cooling and heating purposes. It should be pointed out that natural gas is the main source of energy for heating & cooling in TIFE. Thus, according to National Building Code (article 19$^{th.}$) of energy consumption in buildings that is set by the ministry of Housing and Urban Development, the present TIFE building's design is indicative of negative deviation (about twice as much) from standards.

Table 5. Overall heating & cooling analysis in TIFE complex

Specification	Unit	Value (Northern & Southern Building)	Value (Administrative Building)
CFM	-	18,740	80,157
Area	m^2	2,847	6,699
Total Cooling Load	Btu/h	3,254,603	4,283,157
Total Heating Load	Btu/h	6,186,144	5,121,171
Annual Energy For Cooling	Mj	6,032,255	10,337,053
	Mj/m^2	2,119	1,543
	m^3/y	177,681	304,479
	Mj	13,039,057	10,206,531
Annual Energy For Heating	Mj/m^2	4,580	1,524
	m^3/y	384,066	300,634
Coefficient of heat loss of the building	w/k	30,582	28,284
Required coefficient of heat loss	w/k	11,392	14,421

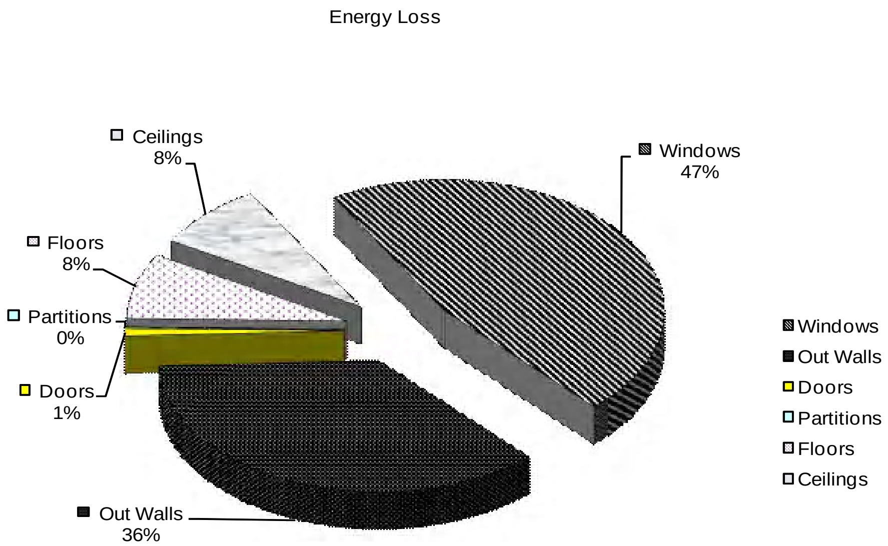

Fig. 2. Percentile of energy loss from different sector of TIFE complex

Percentile of energy losses from different sectors in TIFE complex is shown in Fig.2. It is evident that the highest energy loss occurs from out walls and windows. Total cooling loads at various sections of TIFE complex is shown in Fig.3. The figure clearly shows that higher energy consumption is attributed to southern building.

Energy consumption for lighting system has been computed for various spaces at TIFE building (Fig.4).

The overall electricity consumption by lighting system is about 312653 KWh/yr. It is evident that 94% of total electricity consumption by lighting system is being used in only 8 spaces of TIFE building. The share of different types of lights in electricity consumption is shown in Fig.5. Generally filament lights have a greater share in electricity consumption. Following is the percentile of electricity consumption by various types of

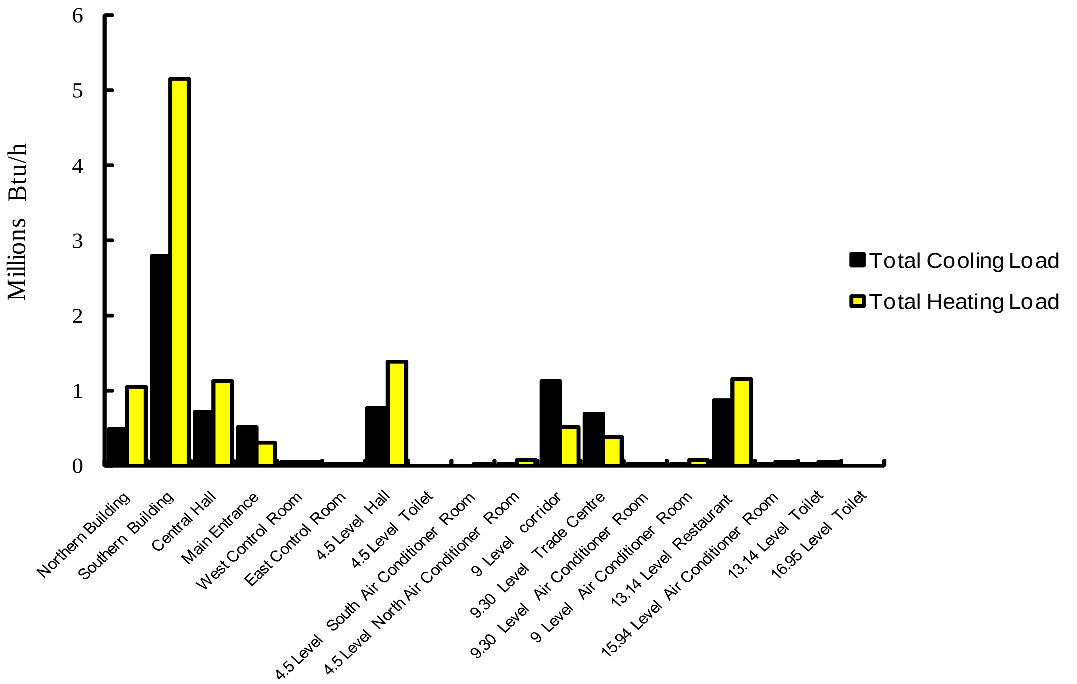

Fig. 3. The outlook of Tehran International Flower Exhibition complex

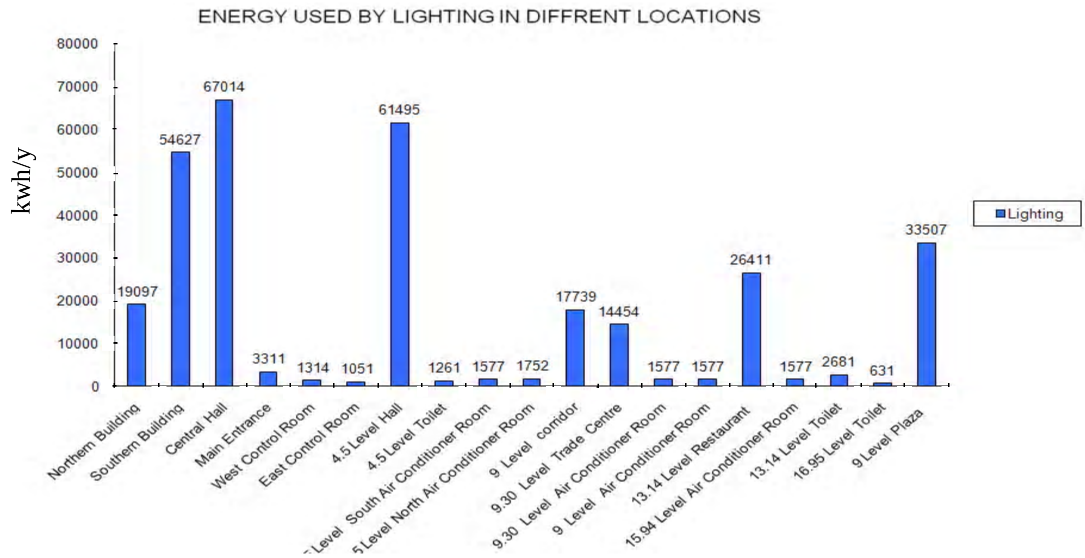

Fig. 4. Electricity used by different types of lights in TIFE complex

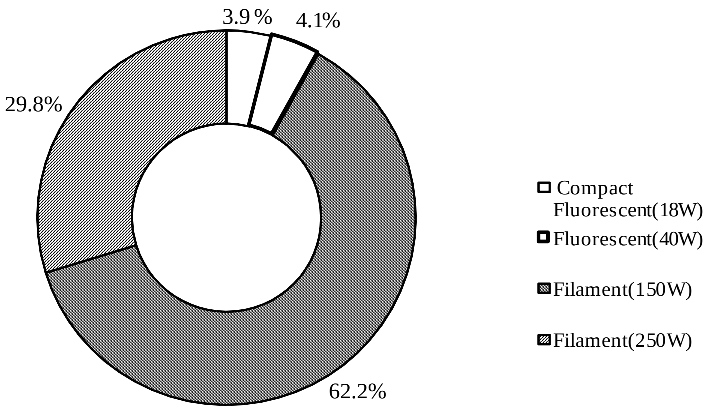

Fig. 5. Electricity used by different types of lights in TIFE complex

Table 6. Insulation material properties in TIFE building

No.	Type	Slope deg	Material Admixture	U-Value in summer (Btu/h*ft^{2}F)		U-Value in winter (Btu/h*ft^{2}F)		Density Kg / m^3	Thickness cm
1	Out Wall	90	wool stone	0.125		0.127		30.43	5
			Aluminum					2707	0.04
			Polyethylene					949.9	0.4
			Aluminum					2707	0.04
			Air Film					0	0
			Total					-	5.48
2	Out Wall	90	wool stone	0.105		0.106		30.43	5
			Concrete					2300	40
			Air Film					0	0
			Total					-	45
				Heat Flow Down	Heat Flow up	Heat Flow Down	Heat Flow up		
3	External Roof	0	Concrete	0.107	0.123	0.123	0.112	2300	27
			Polyethylene					949.9	0.1
			bitumen					999.5	0.1
			Poly ester					1551	0.1
			bitumen					999.5	0.1
			Polystyrene					33.64	4
			Concrete					1800	10
			Air Film					0	0
			Total					-	41.4
				Heat Flow Down	Heat Flow up	Heat Flow Down	Heat Flow up		
4	Roof	15	galvanized sheet	0.092	0.103	0.103	0.095	7128	0.05
			wool stone					20.82	8
			Aluminum					2707	0.05
			Air Film					0	0
			Total					-	8.1
				Heat Flow Down	Heat Flow up	Heat Flow Down	Heat Flow up		
5	Floor2	0	Concrete	0.131	0.143	0.131	0.143	2300	27
			Polystyrene					33.64	3
			Air Film					0	0
			Total					-	30

There are many methods of energy saving to promote energy efficiency in TIFE buildings. Some of these methods are:
The external walls and roof of a building are the interface between its interior and the outdoor environment. Insulation of the external walls and roof is the most cost-effective way of controlling the outside elements to make homes more comfortable. Fuel consumption and operational costs are reduced by increasing the thickness of the external walls and roof (ceiling), despite an increase in the investment costs. Insulation as a single investment pays for itself many times over during the life cycle of building reduced energy consumption also benefits the environment. In other word increasing the thickness of the insulation material will not only decrease air pollution but also increase energy saving (Sisman, *et al.,* 2007).

Calculations of TIFE building retrofit effectiveness shows that the replacement of windows with double glazed ones is not as effective in terms of heat energy saving as are the insulation of a roof, walls and other improvements because the investments are large and take a long time to be repaid. However, in addition to energy saving, window replacement improves the indoor climate of the building, its interior and architectural appearance as well as its market value (Kaklauskas, *et al.,* 2006). Beside, Good glazing design can reduce energy outputs by lowering the requirements for heating or cooling (Menzies; Wherrett, 2005 & Karlsson, 2001).

Solar water-heating systems as a means of conventional energy substitution can reduce the use of electricity or fossil fuels by as much as 80%. However, current low prices of natural gas and expensive present technology, does not make solar water heating economical. Although solar water heater offer long term benefit (such as environmental benefit), that go beyond simple economics.

Numerous energy efficient lighting technologies already exist and are being developed. Natural light varies according to the time, weather and season, so it has to be combined with artificial lights and appropriate control systems. Some reports show that energy efficiency of lighting is improved by 15-30% using daylight in commercial buildings (Tanishima, 2003). A lighting retrofit is replacing inefficient lighting with the efficient one. Electricity savings over time is significant enough to not only pay for the new lighting, but also produce return on the investment. This can be done by either reducing the input wattage or reducing the hours of operation of the lighting to reduce energy consumption (Mahlia, *et al.,*2003).

To improve building envelope energy efficiency, insulation materials can be used as shown in Tables 6 &7.

Table 7 . Insulation material properties in TIFE building

No.	Material	Type	Slope deg	U-Value (Btu/h*ft^{2}F)
1	Double Glazing	1/2 in air space	90	0.57
2	Double Glazing	1/2 in Argon space (low-e)	90	0.228
3	Sky Light	1/2 in air space - Double	0	0.55
4	Sky Light	1/2 in Argon space(low-e)- Double	0	0.228

Table 8 and 9 shows various energy saving mechanism and pay-back period in TIFE complex. It can be noticed that many of measures are not economically feasible even at international energy prices.

CONCLUSION

Using insulation materials with energy saving architectural design of buildings have more effect on energy saving in building sector (Mohsen; Akash, 2001 & Comakli; Yuksel, 2003). Since construction of a zero energy consumption building will never be wise & economic, we propose municipality of Tehran to adopt the most effective energy efficient measures that include:
Wall insulation, first floor insulation, central heating intelligent management installation, replacement of filament bulb with compact ones. If municipality of Tehran adopts these measures, considerable amount of air pollutants as well as greenhouse gases will be reduced (Table10).

Government of Iran is highly dependent on oil & gas export revenue. Thus, it will be sensible to provide subsidies on solar water heaters to free more energy for export.

Table 8. Various energy saving mechanism and pay-back period in TIFE complex

Type Of Insulation	Annual Energy For Cooling (Mj)*		Annual Energy For Heating (Mj)*		Energy Saving (Mj)	Energy Saving (M^3)	Energy Saving (%)	Energy Saving ($) According to Local Price	Energy Saving ($) According to International Price	Total Cost	Pay Back (Year)	
	Flower House	Central	Flower House	Central						$	Local Price	International Price
Without Energy Saving	2,688,895	2,486,839	5,626,474	5,203,675	-	-		-	-			
Double Glazing Window	2,343,198	2,007,862	4,903,107	4,201,424	2,550,292	75119	6.22	667.72	3004.76	33,990	51	11
Double Glazing Low-e Window	2,086,179	1,691,418	4,365,300	3,539,269	4,323,716	127355	10.54	1132.05	5094.22	83,087	73	16
Wall (With 5 cm wool stone extra layer)	1,197,273	1,861,979	2,505,278	3,896,164	6,545,190	192789	15.96	1713.68	7711.56	11,699	7	2
Slope Roof (With 1 cm wool stone extra layer) and Concrete Roof (With 4 cm polystyrene extra layer)	2,670,278	2,322,541	5,587,519	4,859,883	565,662	16662	1.38	148.10	666.46	5,707	39	9
Floor (With 3 cm polystyrene extra layer)	2,688,895	2,223,735	5,626,474	4,653,133	813,647	23966	1.98	213.03	958.64	3,978	19	4
Total Insulation	-	-	-	-	12,248,214	360772	29.86	3207	17436	104,471	33	6
Central Heating Intelligent Management	-	-	-	-	2,464,628	72596	6.01	645	2903.83	300	0.5	0.1
Solar Water Heating		-	-	-	806,682	23761	1.97	211	950.44	12,222	58	13

Table 9. Various energy saving mechanism and pay-back period in TIFE complex

Type Of Insulation	Energy Saving (Kwh)	Energy Saving (%)	Energy Saving ($) According to Local Price	Energy Saving ($) According to International Price	Total Cost ($)	Pay Back (Year) According to Local Price	Pay Back (Year) According to International Price
Compact Fluorescent Bulb	232044	74%	11602	20884	1777	0.15	0.1
Lighting Control With EMS & Compact Fluorescent Bulb	256227	82%	12811	23060	3999	0.31	0.2

* According to conduction heat loss from building envelope

Table10. The emission of pollutant after the four proposed measures

Fuel	Reduction of Air Pollutants Emission (ton)*					
	NO_X	SO_2	CO_2	CO	CH	SPM
gas(m^3)	0.6	0	659	0.1	0	0.1
oil(lit)	0	0.1	4	0	0	0
diesel(lit)	0	0	8	0	0	0
TOTAL	0.6	0.1	671	0.1	0	0.1

* Based on four proposed measurements

It should be pointed out energy efficiency measures are more cost effective than utilization of renewable energies in Iran. Hoewer, this should not hinder the gradual utilization of renewable energies. Bsides, environment costs of fossil fuels as well as electricity must assessed. Internalization of extenalities needs further research.

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