Study of Energy Consumption in Mosques

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Abstract

Energy in all its forms is considered one of the most important features that distinguish the modern era from the Middle and Ancient Ages, including electrical energy, which brought about a qualitative shift in human life. One of the ways to sustain it is to rationalize consumption, so our project focuses on finding solutions that help stop this excessive depletion of energy consumption, especially mosques, which represent approximately 5% of the total energy consumption in the Kingdom of Saudi Arabia, and the impact of this with the expected increase in the number of population growth, which amounts to 3.7% annually until reaching the expected population size in 2030 (50 million Capita). In this project, the data collection phase includes observation by reading different literature reviews, using a survey on thermal comfort that satisfies the public, and using simulation programs to reach satisfactory results. The results that this project achieved are knowing many methods to reduce the energy consumption in mosques and knowing alternative solutions for any problem in any mosque, and from these results, many ways to improve the energy consumption can be obtained. Such as collecting data to check the comfort level inside the mosque, installing smart system, and study about the PV system.

Introduction

The term energy can be defined as the quantitative property that is transferred to a body or to a physical system, visible in the performance of work and in the form of heat and light. Energy is a conserved quantity. The law of conservation of energy states that energy can be converted in form, but not created or destroyed. The unit of measurement for energy in the International System of Units (SI) is the joule (J). Because of the expected growth rate of vision 2030 there will be an increase in energy consumption around the whole kingdom of Saudi Arabia. It is obvious that the consumption will increase, and the following figure shows how the energy consumption has changed with the passage of time.

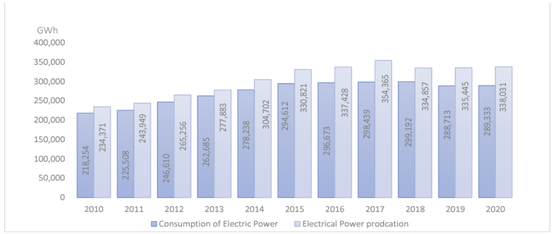

Figure 1. Annual Consumption and production of electrical energy

Aim

The aim of this project is to study the performance of a mosque in term of energy consumption and its reflection on cost and environment to advance the sustainability practice in the country.

Literature Review

➡PV System

The Conventional sources, such as fossil fuels, are used to provide the world's energy demand, which is the primary cause of carbon content in the environment. These carbon contents have been responsible for the undesired climate change or Global Warming Saudi Arabia is ranked 45 in solar power capacity in the world according to Energy monitor. If modern technology is used properly, solar energy is the most efficient renewable energy source. The sunlight is directly turned into electrical energy in a solar PV system. The quantity of energy that a solar cell can produce is mostly determined by the fundamental characteristics of the cells and the amount of solar radiation that falls on the panel. The size of the solar array as well as the AC inverter required for solar PV applications are defined by the type of loads connected. The energy from the panel can also be stored by using battery storage for later use.

Objectives

The project consist of the following objectives:

- To review the relevant literature reviews in the energy consumption of find satisfaction with the thermal comfort of people praying in the mosques. non-domestic building in Saudi Arabia.
- To study an actual mosque located in hot arid climate in term of energy consumption.
- To present benefits of photovoltaic (PV) system for mosques.
- To calculate cost of electricity per month related Incandescent and led lighting in mosques.
- To conduct survey to find satisfaction with the thermal comfort of people praying in the mosques.

Methodology

Selecting the mosque that this study talk about is the most important step to achieve our goals in this project .This study sample is targeted two mosques, the first located in Riyadh, in Alrimal district and with an area approximately 2200 m^2. The other one located in a small town (known Afif), in Al shallal district and with area approximately 1735 m^2. These mosques was chosen because it has not been built yet, as this helps in making some adjustments related to energy consumption in addition to the availability of architectural and energy drawings.

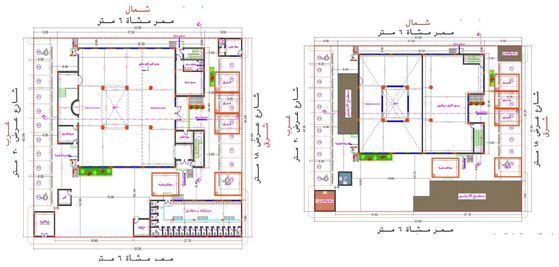

Figure 2. Ground and first floor for Alrimal mosque

Table.1 Area summary

Areas (m^2)		Setbacks (m)				
Land area= 2226.00						
Floor	Area	directions	N	E	S	W
Ground	838.70	limit	6 (Pedestrian)	18 (street)	6 (Pedestrian)	20 (street)
First	378.40	Setback	2.0	9.5	14.60	6.0
Second	38.0					
Electricity room	29.15					
Toilets	223.5					

Figure.3 AC distribution in ground and first floor

Red : AC Area
Purple : Non-AC Area
Green : UN Covered Area

Results and Analysis

Lightening Calculations

The average operating hours of the mosque were Identified at 7 h/day for the main hall ,which is represented the most dense area of the whole mosque. Due to the similar area of the main hall of the two mosques, the energy drawings has made lightening calculations for both in the same tables. The types of lightening, Incandescent lightening and LED lightening, were identified in the two projects to create energy consumption tables to find differences in terms of consumption and cost. *Consumption tariff was Identified by (SEC).

Table.2 Incandescent lightening

Zones	Total Wattage (Wh)	Area (m^2)	Lightening density (Wh/sq.m)	Cost/month (SR)
Area 1	322.72	6.7	48.16	21.68
Area 2	654.54	17	38.50	43.98
Area 3	1106.81	30.7	36.05	74.377
Area 4	909	22	41.31	61.08
Area 5	900	49	18.36	60.48
Area 6	1356.81	43	31.55	91.17
Area 7	1509.09	27	55.89	101.41
$\sum n$	6758.97	195.4	34.59	454.13
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Table.3 LED lightening

Zones	Total Wattage (Wh)	Area (m^2)	Lightening density (Wh/m^2)	Cost/month (SR)
Area 1	71	6.7	10.5	4.77
Area 2	144	17	8.5	9.67
Area 3	243.5	30.7	8	16.36
Area 4	200	22	9	13.44
Area 5	198	49	5	13.30
Area 6	298.5	43	7	20.05
Area 7	233	27	8.6	15.65
$\sum n$	1628	195.4	8.33	112
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Source: Saudi Electricity Company

From the previous tables, we note that the consumption percentage of LED lighting for Incandescent is 24%, and therefore this means that using LED saves the amount of energy consumption by 76%.

Table.4 Lightening summary

Lightening type	Total wattage (Wh)	Lightening density (Wh/m.sq)	Total cost (SR/month)
Incandescent lightening	6758.97	34.59	454.13
LED lightening	1628	8.33	112
L/I	24%	-	-
Diff.	5130.97	26.26	342.13

PV Calculations

Product introduction:

Cell: Mono

No. of cells: 144（6×24)

Rated Maximum Power(Pmax): 550W

Maximum Efficiency: 21.3%

Junction Box: IP68,3 diodes

Maximum System Voltage: 1000V/1500V DC

Operating Temperature: -40℃～+85℃

Table5. PV calculation

process	calculation
Watt per hour	$\frac{1628}{7\times30} = 7.75$ kw/h
Conversion to watt	$7.75 \times 1000 = 7752.4$ w
Calculate the number of cells	$\frac{7752.4}{550} = 14\ cell$
Calculate the total cost	$7.75 \times 3500 = 27125\ SR$

The total cost for 1 kilowatt is (3,200 ~ 3,500) Saudi riyals, according to the local market price.

7.75×3500=27125 SR

Therefore, the total cost is 27125 SR

Survey

The survey conducted on a mosque in Riyadh city in Laban district. The survey consist of 10 questions about the thermal comfort inside the mosque. The participants on the survey was 35 persons with different ages. First it asks about general information such as the age of the person, favourite season in the year, then about the thermal comfort inside the mosque.

Conclusion

Through this study, there are some recommendations helps to control the energy consumption and divided into :

1. Guidelines before constructing the building.
- building should receive less direct sunlight to interior areas.
- Decrease the number of windows in the building.
- Use of bright colors in order to reflect the sunlight and thus reducing absorbed heat into the building.
- Pay attention to trees and shading to reduce the temperature around the mosque.

2. Guidelines should be considered during the building process.
- Use of thermal insulation materials in the building.
- Use of thermal heat glass.
- Installation of compact fluorescent lamps/power-saving lamps.
- Buying air conditioners with high efficiency.
- Take advantage of the natural light provided by the sun to save electricity during the day.

3. The use of thermal isolation.

Use of thermal isolation has many features, such as:

- Reduction of consumed electric power used for cooling and heating.
- Protection of furniture in the building.
- Achieving comfortable range inside the mosque.
- Protection of the environment.

4. Reasons behind bills increase in summer season.
- Increases in electricity consumption for air conditioning.
- Absence of thermal insulation in some mosques.
- Keep using AC or lightning when it is not needed.