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IDENTIFY SIGNIFICANT PARAMETERS ENHANCE ENERGY CONSUMPTION TO SUPPORT DECISION MAKING OF MOSQUE DESIGN: REVIEW PAPER

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ABSTRACT: The frequent ongoing increase of energy consumption is a current issue world widely.There is a huge increase the energy consumption and big concern being adopted internationally through establishing several legislations. Buildings are the main cause of environmental issues that contribute to excessive resources usein both construction and operation phases, which causesthe increase of pollution in surrounding environment. Mosque is among these buildings that being consumed huge amount of energy. However, there is a need to thoroughly investigate the parameters that are significantly attributed to huge amount of energy consumption especially at the pre-design stage. Additionally, it is important as a step to set a literature review to identify all parameters that significantly contributed in enhancing the energy consumption of Mosque buildings. This study aimed to thoroughly conduct a literature review to identify the significant parameters affecting the energy consumption of Mosque buildings, and reveal the importance of energy efficiency criteria to the thermal system. In addition, the results of literature review of identifyingthe significant parameters can be used in several aspects including of used as a guideline for engineers and architects and to support designers in their evaluation at pre-design stage of Mosque designing. Moreover, the results can be used in further studies consideration in soon future.

KEYWORDS: Energy Consumption, Energy Efficiency, important parameters, Mosque Sustainability Design

I. INTRODUCTION

Recently, energy consumption is considered a key role factor of issues surrounding our environment,and has crucial impact toward the reductions of operating costs. Thus, numerousstudies have concluded the importance of energy consumption topic especially at the early design stage of building(Tran et al., 2019).Energy consumption has become one of the most crucial issues in the world today. The excessive utilization of energy leads to very critical problems that threaten the planet and disturb human thermal comfort. There is a huge increase the energy consumption and big concern being adopted internationally through establishing several legislations. The global industry is facing challenges in many aspects since (in the form of) fusel fuels. Hence the current situation in energy demand underlines the importance of encouraging energy efficiency efforts (Al-Saggaf et al., 2020).

There are serious environmental impacts such as, global warming, ozone layer depletion, and climate change as well as the depletion of natural resources. However, the current efforts from international energy agency have indicated that one third of world energy requirement could be reduced by 2050 (Dodoo, 2011).In latest report of the U.S. Energy Information Administration's showed theworld energy consumption will grow by 28% between 2015 and 2040 and Figure 1.1 represent the total of world energy consumption (International Energy Outlook (IEO), 2017)

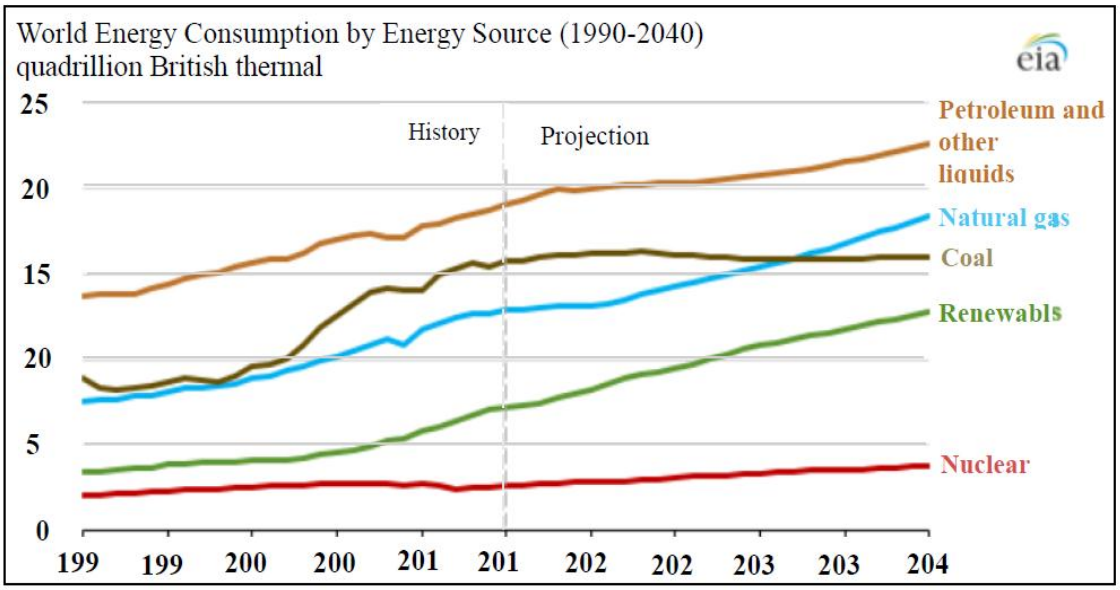

Figure 1.1 World Energy Consumption Projections 1990 – 2040(IEO), 2017)

Recently, the energy efficiency design has become a hot topic and has received an increased attention from governments, researchers, owners, and developers (Li et al., 2019).The Building sector is the main cause of environmental issues that contribute to the excessive use of resources in both construction and operation stages which causes the pollution of surrounding environment, Buildings are not only used as resources but also play crucial role in achieving sustainable development (Ngo et al., 2019).Thetargeted desire to reduce the GHGs from the building sector needs more efforts to tackle serious drawbacks with greater seriousness comparing with the past efforts, with respect to energy-efficiency criteria and sustainable buildings requirement.

Comparing to other types of buildings, Mosque is considered as the most temporarily and frequently used building. Unfortunately they consume a huge amount of energy due to several reasons such: improper and poorly design, lack of studies, and improperly operated. However, the potential for energy conservation is significant (Alsaeah 2013; Budaiwi et al., 2013). The literature review has indicated thatthere is a clear gab and lack of case studies toward enhancing sustainability and reduce energy consumption and how mosques should be designed properly. Usually mosque is found to unreasonably consuming a huge amount of energy which isrelatively harmful for the sustainability of theenvironment (Abdou et al., 2005).Thus many studies have been conducted on energy conservation in other types of buildings (Budaiwi et al., 2013).

II. LITERATURE REVIEW

Till this date, there are no studies that clearly identified the most significant parameters that are crucially enhancing the energy consumption, especially in the mosque buildings. However, as per the conducted literature review only limited parameters that have been identified by previous researchers that relatively contribute to energy consumption. This study aimed to thoroughly conduct a literature review to identify the significant parameters affecting the energy consumption of Mosque buildings, and reveal the importance of energy efficiency criteria to the thermal system. In addition, the results of literature review of identifying the significant parameters can be used in several aspects including of used as a guideline for engineers and architects and to support designers in their evaluation at pre-design stage of Mosque designing

Most of buildings researches including thermal systems performance are mainly focused on non-residential buildings such as hotels and offices. Hence, the literature indicated that there is stilla clear lackof research in many aspects of energy in mosques (Al-Tamimi&Qahtan 2018). However, many studies have been conducted on energy conservation in other types of buildings (Budaiwi et al., 2013).There are only few researches have been found that identified some of the significant parameters that play an important role inincreasing the energy consumption and reduced the thermal comfort system of mosque building such as: (Alabdullatief et al., 2016; Azmi&Kandar, 2019; Alabdullatief& Omer, 2017; Budaiwi et al., 2013; Ibrahim et al., 2014).

In addition, currently there is a need to identify the important building parameters at early stage of design. Hence, as per the result of conducted literature review no studies have identified the energy efficiency and energy efficiency design parameters for mosque buildings. This identification of significant parameters will play a crucial rule in future studies especially at the early stage of design mosques as well as for developing better and accurate simulation and prediction tools

In addition, currently there is a need to identify the important building parameters at early stage of design. Hence, as per the result of conducted literature review no studies have identified the energy efficiency and energy efficiency design parameters for mosque buildings. This identification of significant parameters will play a crucial rule in future studies especially at the early stage of design mosques as well as for developing better and accurate simulation and prediction tools. In addition, currently there is a need to identify the important building parameters at early stage of design. Hence, as per the result of conducted literature review no studies have identified the energy efficiency and energy efficiency design parameters for mosque buildings. This identification of significant parameters will play a crucial rule for developing better and accurate simulation and prediction tools as well as in future studies especially at the early stage of design mosques (Alsagaf et al., 2020). Therefore, identifying the influence of building parameters on a building's energy performance can support the decision-making process during the architectural design steps.Another essential point is that effects of these parameters should be known in the earlier stages of architectural design, because later attempts to improve the energy performance constitute a loss of opportunity for a more cost-effective solution. Knowing which parameters are most important is essential for developing efficiency in the design process of buildings that have high energy performance and also for supporting policy makers in the development of local energy-efficient design rules and limits based on the climatic conditions (Ngo et al., 2019).

III. METHODOLOGY

The main aim of this paper is to review and revise wide range of parameters (factors and sub-factors) that play crucial role in influencing the energy consumption in relate with mosque buildings from different literature resources and articles of energy consumption of Mosque buildings. This can be done by obtaining numerous researches and articles which were sorted and limited to articles that have been published from the year of 2000 till 2020.

Therefore, the conducted literature review has investigated different websites and domains such as Science direct, Springer, and Web of sciences, proQuest, Scopus, and Google Scholars databases were used for searching in both stages. Scholarly journal articles and conference papers published in English were selected for the review, which help to obtain related thesis and articles in the focused field of energy consumption in Mosques. The main objectives included:

- Identify which parameters are significantly affect the energy consumption of mosque buildings.

- Classification and analyzing of the identified parameters based on its importance toward increasing the energy consumption amount

IV. RESULTS AND DISCUSSION

There are some researches have indicated some parameters that crucially affect the indoor environment, thermal comfort, and lighting energy requirement which include orientation of building, shape of the building , and window to wall ratio(WWR). While there are number of studies have identified some of the important parameters, only limited studies have identified specifically which factors and parameters are contribute to energy consumption in mosques. Examples of these parameters are including, passive design, roof design and its insulation, shading, and wall strategies.

Some researchers have highlighted the huge amount of energy waste due to improperly designing of mosque building in general such as (Azmi and Kandar, 2019) and have concluded that the potential for energy- saving would be significant. However, their study found out that there are only few researches targeted the study environmental impact on mosque buildings, especially from the design and architectural perspective. In addition, since there are large numbers of mosques spreading in the world, there is a great potential to reduce huge amount of energy consumption by applying new strategies and criteria for energy-efficiency of mosque design (Elshurafa et al., 2019). Usually, mosque is found to unreasonably waste a huge amount of energyconsumption, which is considered as not environmentally sustainable (Abdou et al., 2005).

Azmi&Kandar (2019) in their study to improve the environmentally sustainable mosques, have only identifies four factors to be taken into consideration when designing mosques such as i) the activity level of users and clothing type; ii) occupancy pattern; iii) fix orientation of prayer hall; iv) spatial layout & volume. These four design factor can be obtaining as guideline and basis for future studies in terms of establishing different design options with different regions and climate condition to choose in order of enhancing the energy-efficiency criteria and sustainability of mosque design.The study of (Ibrahim et al., 2014) in Malaysia has reported as per the ASHRAE international standard the range of temperature which can be considered comfortable is ranging between (16C to 29C). in addition, the indoor thermal and comfort condition for people found to be ranging between 24C to 31C. These results found to be higher than the actual requirement for comfortable temperature for people especially for the results found in the South East of Asia region.

Alabdullatief& Omer, (2017) in their research study which has the aim to estimate the best sustainable features and most efficient design for mosques in different climatic zones. However,their study was mainlyfocusing on finding the best Roof material options as a significant parameter by applying several simulation tools such as Design Builder software in order to reduce the building energy consumption in Riyadh climate zone. The study has proposed numerous suggestions when considering mosque designing such as:

(i) Orientation of the buildings;
(ii) Shape and Form;
(iii) Shading techniques;
(iv) Natural light;
(v) Doors;
(vi) Windows;
(vii) Functional partition;
(viii) Roof options.

In another study by (Alabdullatief et al., 2016) which is mainlyaim to identify themost crucial and effective factors that significantly enhancingthe building energy consumption and reduce the indoor comfort system. Down below is a list of five parameters that were found to be crucial and need to be considered for future building design of mosque in different climatic zones in the world which include:

(i) Shape & Orientation:
(ii) Building Envelops Materials:
(iii) Blinds and Shading:
(iv) Other Sustainable Systems:
(v) Green Roofs

On the other hand, several studies have been conducted to improve the environment and thermal systems and reduce the energy consumption of mosque building by applying different strategies and techniques such as (passive designs, louver shading techniques, green roofs, PV solar system on roofs, window glazing techniques, PMV for thermal indoor comfort). These previous studies have significant attribution toward environment sustainability and reduce energy consumption of mosques. In addition, down below is a summary of literature review of significant parameters affecting the energy consumption in mosque buildings that were identified in previous studies:

1- **Roof (Uvalue) and insulation**

The study of (Ibrahim et al,. 2014) have used the Corrected Effective Temperature (CET) to test different retrofit designs in an existed mosque by testing different materials and insulation layers on an existed roof of the building. The Roof design wasre-tested with different materials and features such as (fibrous plasterglass ceiling, install rockwool layer, thermal radiant barrier, fiberglass and coating paint. In order to get the best results of material simulation war running by the use of EnergyPlus software with applying different internal and external temperature. The results have shown a distinct improvement of Rood design when adding insulations comparing with the original design. the second option was found the best selection for initial and operating cost. However, the study entails and recommended four design options when considering Roof in the mosque designincluding:

1- Roof with tiles insulation
2- white chipped stones finishing (20cm thickness) Insulation
3- Green roof insulation.
4- Movable shading for whole roof.

2- Wall (Uvalue) and Insulation.

The study of (Budaiwi et al., 2013) found that the preventing of air leakage by using thermal treatment forwall can be reached to about 25% of energy savings. In addition, the employing of mechanical method to reduce the cooling loadhas approved its applicability as well as increases the indoor thermal comfort (Azmi&Kandar, 2019).

The study of (Alabdullatief et al., 2017) has applied greener strategies on wall and in the top of mosque roof after testing different strategies. This implementation of greener strategies has been succeeded in reducing the amount of gas emissions, improve the quality of air, managing the water system. There are different type of greener planet which provide multiple benefits such as better of visual value, vegetable production, cover open spaces, and acoustic absorption On the other hand, green roof aids in increasing life for the roof, insulating building and energy efficiency (Aziz & Ismail 2011).

3- Window glazing and Shading Devices

- Windows: double window glazing is used as the best suggestion for buildings. However, the design of no windows in the west side is considered as the worst in terms of solar heat gains. Similarly, walls that have been designed with more of thickness will act like a thermal mass wall. In the study of (MokhtarAzizi et al., 2013) in his conducted research he applied double glazed glass strategies with low thermal massively layer which can optimize the daylight to reduce heat gain in the building thermal envelope.

- Shading:the shading devices have been added to south, east, and west façade which can provide optimal shading and lower heat gain from direct sunshine. In addition, the louver shading devices are more recommended recently to be added on windows. Another benefit of shading devices is applying it in (Minaret) which is a taller structure design with at least one or two as compulsory step toward design mosques. Minaret can be allocated on the south side direction which can help reduce the cooling load amount by its reflecting shadow

A study by (Mushtaha&Helmy, 2017) has applied different shading devices which integrate the external windows and they came up with different solutions and techniques to increase the indoor thermal comfort condition. The improvement was approved especially in the façade cavities, which transmit the most radiation into the building. The implementation of the system of hybrid air-conditioning is another supportiveapproach, and the annual energy consumption can be reduced about 67.5%, which allowsfor a smaller HVAC system (Mushtaha&Helmy, 2017).

Another recommendation is applying the use of adjustable shading devices to allow solar access in multiple seasons depending on the climate condition. The climatic zones can be affected depending on the material and type of shading elements. Furthermore, another recommendation by using the wind catcher on the (Minaret) to work as natural ventilation and reduce the cooling load and the study of (Alabdullatief& Omer, 2017) has examinedmultiple design alternatives for the (porous ceramics structure)which can be used in the (Minaret) for the purpose of cooling load evaporative.

4- Footprint (plan) shape

The building plan shape is considered a very important parameter as an area of external surfaces to determine the demand for cooling and heating energy. The rectangular and square shape
With aspect ratio of 1:2 percentages are most suitable choices (Alabdulatief et al., 2016). In addition,the use of courtyards has approved its applicability for hot climate regions. Additionally, some studiesshowed the courtyards implementation can provide a great energy-saving in hot climatic regions (Almhafdy et al. 2013), however, applying an extra area of external surface providesgood amount of heat removing

5- Building Orientation

The building orientation is provides a significant reductions of energy consumption and cooling loads by decreasing the solar penetration through windows, walls,and roofs based on the climate zone and condition. In

addition, selecting the appropriate orientation can maximize the cross ventilation which has been found to be more suitable for hot regions.In general, it has been widely agreed that southern direction is much optimal for controlling solar radiation in summer and gaining heat in winter. Similarly, the longest wall should be designed to be oriented toward southern direction especially for cubic designs which is considered as the best efficient shape (Shen et al., 2020). For designing mosques most designers are tending to apply the necessary requirement for set the orientation to be toward Qibla direction, which is located toward the direction to holy mosque ofMakakh city. Thus, there is a possibility of changing the building orientation to any direction but not for the prayer hall (Mihrab) as well as the possibility of manipulates the exterior facade to minimize the direct heat gained from the sunshine.For example the glazing on the west façade especially of hot regions should bereduced and building orientation to face the east-west direction to reduce penetration of solar heat gained by envelope of building (Al-Shaalan et al., 2017).

6- Building envelope Materials

MokhtarAzizi et al., (2013) have reported that the selection of building envelope would provide a good impact on terms of cooler selection and building indoor operation and maintenance. In addition, the building exterior materials play an important role toward energy performance, control the heat transfer, airflow, and solar radiation. The optimum R-values of walls in hot and dry cities such as Riyadh was estimated to be between (2 to 2.9) m2.K/W. Additionally, for external surfaces such as roofs and walls, the best option for colors is light colors which can work to reflect the heat (Al-Sanea et al.2016). The inner and outer thermal properties of roofs and walls, playing an important key role for the occupancy level of comfort inside the mosque. In terms of storage capacity of internal thermal system (thermal system) is knowing one of most important element of sustainability in buildings.**T**he shape of building and form has studied by (Mushtaha&Helmy, 2016) and the results of the study have recommended the selecting of octagonal shape when designing mosque especially for hot climatic regions. The rectangular shape design isselected with an aspect ratio of 1:2. On the other hand, the courtyards is suggested for mosques in hot climatic regions and applied to be on the opposite side of Qibla direction (Alhemiddi, 2003)

7- Zoning and occupancy

The study of (Alshaalan et al., 2017) has tested different zoning, occupying, and thermal insulation for big Mosque in Saudi Arabia.Three cases are simulated by eQuest(Quick Energy Simulation Tool) which is designed to perform detailed analysis.Firstly, mosque with effect materials, secondly mosque with inefficient materials, thirdly, mosque without zoning and finally, mosque with zoning of efficient materials. These factors may help in lowering the rates of energy consumption in mosques and hence contribute to energy conservation.

The study of (Al-Ajmi, 2010) compared between five case studies in Kuwait. The level of indoor thermal comfort was achieved through the zoning of occupancy as well as the insulation of building envelope which have lowered the energy consumption and improved the thermal comfort. In addition, some studies have concluded that the existing scale to measure the indoor thermal comfort is not applicable for the typology of mosque building.

8- Passive design

Passive design is needed to be taken into consideration as one of the most significant design approach in terms of achieving environment sustainability with minimum economy cost (Azmi&Kandar, 2019). The passive design of building is largely demand on the climatic zones and geographic conditions of the region. Consequently, each location would have a specific set of passive designing techniques, many of which can be found in the vernacular architecture of that region.

Some of conducted studies of built-mosques in Saudi Arabia such as (Alabdullatif et al., 2016) have indicated that the implementation of passive concept design on the building envelope which could potentially reduce the cooling load of mosque in the approach to reduce both cooling energy and peak cooling load. However, most researches have also concluded that the totalenergy consumption can be easily reduced about (30% to50%)byjust applying passive strategy to improve energy efficiency criteria during the pre-design stage. The strategy of passive design can be applied successfully in the early design stages with no additional cost and also minimize the use of intensive resources which can harmful the sustainability of environment.

9- Climate conditions

The similar climatic zone of mosques that located in one area, would have similar requirement for passive design criteria and strategies. On the other hand, other important elements can be selected individually such as, zoning materials, dimensional, and size of opening. The selection of these elements is depending on the condition of the climate. However, some elements that approved its applicability are not necessarily to be appropriate for other climate conditions.The more climates suitable a building is, the more passive the design is, which allows for optimization of energy usage as well as enhancing user comfort. It is thus the architect's responsibility to design a mosque while keeping the passive designing techniques in consideration during the design phases.

On the other hand the study of (Azmi&Kandar, 2019) came up with severalrecommendations and different strategies for mosque designing in terms of energy saving. The study has compared between four different designs criteria anddesign factors in enhance the sustainability environment of mosque buildings. These four design factors including occupancy pattern, spatial layout, clothing type and user activity level, and orientation of prayer hall. The study also outlined extra steps to be taken into consideration during the pre-design stage to build sustainable mosques. Therefore, the finding of specific climatic zone is not necessarily applicable for other climatic zones which entail different characteristics of thermal properties and requirement. This results stresses the fact that mosque is highly unsustainable especially with respect to the surrounding environment.

V. CONCLUSION AND FUTURE WORKS

There is a huge increase the energy consumption and big concern being adopted internationally through establishing several legislations. The global industry is facing challenges in many aspects since (in the form of) fusel fuels. Hence the current situation in energy demand underlines the importance of encouraging energy efficiency efforts. Buildings are the main cause of environmental issues that contribute to excessive resources use in both construction and operation phases, which causes the increase of pollution in surrounding environment(Al-Saggaf et al., 2020).Mosque is considered as the most temporarily and frequently used building. Unfortunately they consume a huge amount of energy due to several reasons such: improper and poorly design, lack of studies, and improperly operated. However, the potential for energy conservation is significant (Alsaeah 2013; Budaiwi et al., 2013).

Unfortunately, there are not many case studies for modern sustainable mosques as this field has not yet been thoroughly researched nor developed in practice. There are only few researches that identified some of the effective factors that play a key role in building energy features and indoor thermal comfort of Mosques

In addition, currently there is a need to identify the important building parameters at early stage of design. Hence, as per the result of conducted literature review no studies have identified the energy efficiency and energy efficiency design parameters for mosque buildings. This identification of significant parameters will play a crucial rule in future studies especially at the early stage of design mosques as well as for developing better and accurate simulation and prediction tools. In addition, it hoped that these significant parameters can be standardize and used in several aspects such as a guideline for engineers and designers, baseline for environmentally sustainable mosque, and for expanded and further future studies. In addition, the standardization of significant parameters can support architects and designers in their evaluation at early design stage of mosque.

Declaration of Conflict Interests

The authors declare no potential conflict of interests at all in this paper

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