

# **Analysis and Energy Strategy of Power Usage in a Mosque : A Case Study of Mosque in Indonesia**

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## **Abstract**

In this research, our team wants to research power usage in a mosque. In this case we will do our research in Darul Ma'arif Mosque, which is located in Pondok Kelapa, at the border of Jakarta and Bekasi. This research is focused on analyzing the power usage in Darul Ma'arif mosque, and will try to calculate the cost of operation in Darul Ma'arif mosque. After we successfully calculate the cost of the mosque operation, we will try to evaluate the current mosque energy strategy, and will try to do efficiency in power usage of the mosque energy usage. After that we can determine that how much cost we save using new energy strategy, and applied on the mosque itself

## **Keywords**

energy management, mosque, energy efficiency, cost analysis, operational analysis

## **1. Introduction**

Indonesia put Pancasila as the basic philosophy of the state where in principle number one commands to Believe in One Almighty God. This implies the Indonesian nation is a religious nation that believes in and pious God Almighty in accordance with their respective religions and beliefs<sup>(1)</sup>. Six religions are recognized in Indonesia, and Islam holds the largest number of followers in Indonesia, around 237.53 million people or 86.9% of the total population as of 31 December 2021<sup>(2)</sup>. Based on data from the Directorate General of Population and Civil Registration (Dukcapil) of the Ministry of Home Affairs, as many as 9.44 million people are followers of Islam based in the national capital, the province of D.K.I Jakarta, and East Jakarta have the largest number of followers with 2.89 million people.

In Islam, the mosque holds important role as a place to worship. According to Rumondor (2019), in the millennium era, the mosque experiences reformation in order to enliven the house of God. Therefore, mosques are focussed for activities like religious studies, commemorating islamic holidays. Beside that, according to Rumondor (2019), mosque function at millennial era is included library, Al-Quran learning center, place for discussion, place for collection zakat, alms, and sadaqah (Z.I.S), place for congregation gathered to eat together. Suhono et al. (2020) stated that all activities in mosques right now, have unique energy use characteristics when compared to other types of buildings such as houses, offices, and commercials. Next is energy consumption at the mosque is unique because its energy usage is not utilized continuously and varies depending on the number of people who come and at a certain period.

Based on the explanation above, and many muslim in East Jakarta are distributed across 1032 mosques (most number of mosques in Jakarta) according to BPS data, this research will try to analyze electricity consumption at Darul Ma'arif Mosque that located at DKI Jakarta, in Pondok Kelapa, East Jakarta..

For reference, Darul Ma'arif mosque had a capacity of 700 people with facilities included like preschool for kids, house of tahfidz Quran, an house for the imam of praying, hospitality room for the ustaz, Z.I.S, and held some activities in the meantime. The mosque is also equipped with some air conditioners to make the mosque more comfortable and do activities in the mosque. Other equipment are digital sound system, multimedia equipment, CCTV and Internet.

## **1.1 Objectives**

The research will elaborate an analysis of energy consumption, then to plan for energy consumption efficiency at Masjid Darul Ma'arif, and eventually will save spending budget for electricity.

## **2. Literature Review**

### **2.1. Mosque Building**

Mosque is an important building typology for Muslim as a place for worshipping and multi-functional community space that involve occupancy (Abdullah et al.2016). The mosque is a building for Muslim worship, which is not only based on Islamic law but also on the cultural adaptation of the building site as a contextual response in design (Harsritanto et al. 2021). Worship carried out by Muslims at the mosque includes activities such as standing, bowing, and prostration as well as during periods. In certain circumstances, worshipers sit on the floor to listen to sermons from a preacher while standing on the floor of the pulpit. The podium or pulpit is usually raised above the floor but varies for different mosques. The architectural forms of mosques, building materials, spaces and construction systems have developed rapidly, mainly as a result of regional, climatic and cultural differences. To make users or worshipers able to carry out worship activities and other activities comfortably, the mosque consumes energy to accommodate the supporting facilities in it. The mosque building is supported by an electrical system to accommodate the use of lights, loudspeakers, fans, air conditioners, and so on. However, recent developments in active environmental control systems (eg air conditioning) have also made positive and/or negative contributions to contemporary mosque architecture (Abdou et al. 2005). The mosque building also has a water system to accommodate ablution (wudhu) activities, sanitation, and so on. This water system ranges from traditional to modern level depending on the type of mosque.

Mosque buildings can be classified as follows:

1. Big mosques located in big cities, these mosques are usually built by the government or the private sector as a form of commitment to Islam. This mosque is generally large and has a large room capacity. This mosque usually becomes a public landmark in the big city which has multiple functions besides a place of prayer, such as for meetings, weddings, religious tourism, research centers, and other big activities.
2. Community Mosques, which are mosques spread across rural and urban Muslim settlements. This mosque is of medium-large size and the room capacity is medium-large. The mosque can also function as a school, library, meeting room and so on besides its main function as a prayer room. The mosque is usually used for daily and Friday prayers.
3. Small local mosque located in a small neighborhood, which has a small-medium capacity.

### **2.2. Mosque Electricity Consumption**

Electricity consumption represents the amount of electrical energy that has been consumed over a specific time, in units of Wh (or kWh), electricity demand represents that rate at which electrical energy is consumed for a needed output rating, in units of W (or kW) (Martínez et al. 2019). Mosques consume high energy in their operations. Electricity consumption in mosques is used to power electronic devices in mosque facilities such as loudspeakers, lights, fans, air conditioners, water pumps, TV screens, and so on in order to accommodate activities in the mosque so that they run well and comfortably. Mosques are used not only during prayer time but also in other activities such as lecturing, wedding, and similar activities where people tend to stay longer and consume high energy during day and night time for lighting, cooling and so on. Many studies have used dynamic simulation software to study the architectural designs of mosques and their impact on energy consumption in hot regions; a few have discussed the use of passive design and environmental aspects of architecture to achieve thermal comfort for prayers and reduce energy consumption (Sayed Hassan Abdallah 2022). The energy used by an electric equipment is equal to the rate of energy use (power) multiplied by the time during which the tool is used (Suhono et al. 2020). The formula of the electrical energy consumption by equation below :

$$E = P \times t$$

Where

E : Electrical energy-daily (watt hours)

P : Power of the electric equipment (watt)

T : Duration-daily (hours)

There are study done by (Purisari 2020) by saving electricity in Baiturrahman mosque, Tangerang. Method for the approach is that during the renovation the lighting control system will be changed from the traditional light switch to a control system integrated with fitting for better lighting control. With fitting all lighting will have a schedule so not everything turns on at the same time and can be adjusted if necessary . Beside control the mosque will have some area and entrance renovated so that light can enter mosque area as much as possible to reduce lamp usage

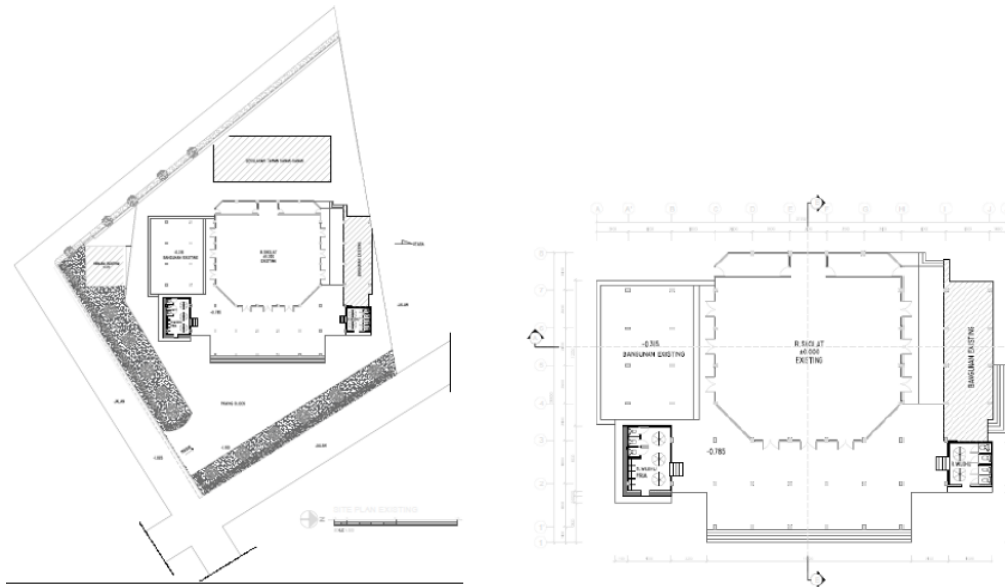


Figure 1. Mosque current site

To further reduce lamp usage the lamp lux intensity will be different depending on how wide and the function of said area. Some areas will use dimmer light while others will use brighter lamps to reduce electricity usage.

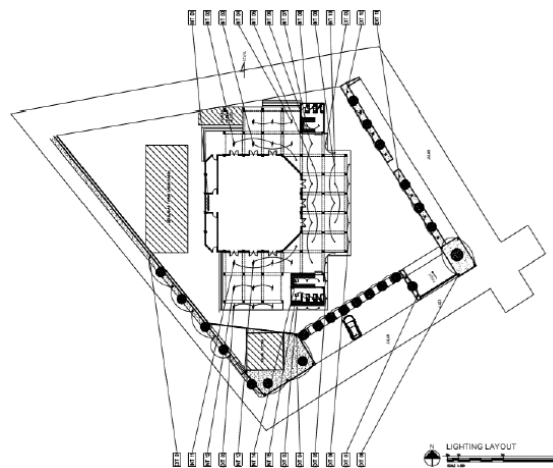


Figure 2. Lighting new layout

### 2.2.1. Thermal Comfort

Thermal Comfort is vital in providing healthy indoor living, quality of life in the urban environment and reducing energy consumption. Thermal comfort is a condition of mind that expresses satisfaction with the thermal environment. Thermal comfort is significant to determine the quality of the indoor environment in urban mosques. The indoor thermal environment should be designed to increase human productivity and performance. A quality indoor environment of an urban mosque can increase people's occupancy and level of concentration (Zhang, H. et al. 2022).

Offering an acceptable thermal comfort in urban mosques is very significant because urban mosque is not only a congregational place for worship but also a place for urban social-culture gatherings such as providing accommodation (retreat), welfare, education and other social cultural activities. This multi-functional spaces needs energy demands in cooling down the building when the space is accommodated for that functional activities and that thermal considerations are vital in most buildings involving people occupancy

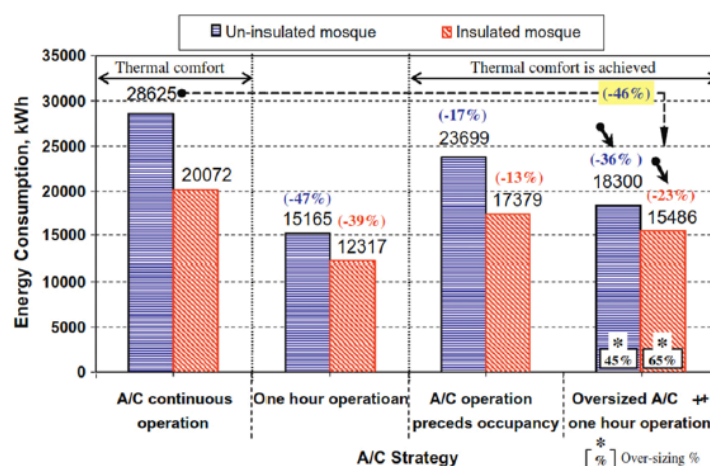
Regulating thermal comfort plays an important role for saving energy since it can reduce the electricity usage such as AC to minimum. To achieve this mosque material and its thickness need to be insulated from external heat and can keep the inside temperature cool like example in table 1

**Table 1.** Building material used in the existing mosque

Building part	Material	U-Value (W/m <sup>2</sup> K)	Thickness (m)
Glass windows	Single glass	5.7	0.006
External walls	Brick (finishing)	0.986	0.48
	Air cavity		
	Red Brick		
Roof	Inside wood coating	2.93	0.60
	Clay tile (roofing) with slope		
	Insulation		
	Concrete slab		
	Cement plaster (coating)		

U-value is number measure for thermal transmission through a building part (such as a wall or window) or a given thickness of a material (such as insulation) with lower numbers indicating better insulating properties.

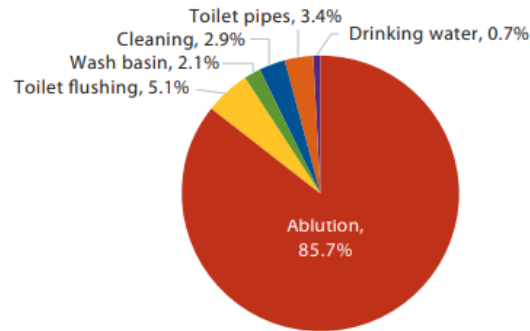
Layout of the mosque also affects the thermal condition such as ventilation for air flow and amount of sunlight that can enter the building. with the correct layout and amount of ventilation and the size of AC use, the mosque can reduce electricity consumption to around 10%.



**Figure 2 A.** HVAC strategy on insulated Mosque. Budaiwi and Abdou (2013).

### 2.3. Mosque Water Consumption

Water is one of the four elements of prayer, ablution (wudu) is mandatory for Muslims that is repeated several times a day (mandatory prayer is five times daily) (Harsritanto et al. 2021). Ablution is done by washing several parts of the body according to the requirements to purify oneself before prayer. In performing ablution, a Muslim must participate in saving water and developing water resources as part of an ongoing effort in Islam. Activities that demand water in the Mosque include ablution, irrigation, residential consumption, cleaning, and restroom use. As an example of mosques in Malaysia based on data source from Suratkon et al.2014, the majority of water use in mosques is consumed for ablution activities with a size of 85% of total consumption, followed by toilet flushing, wash basins, cleaning, toilet pipes, and drinking water activities which can be seen in the graph in the figure 3.



**Figure 3.** Lighting new layout (Marinshaw & Qawasmeh, 2020)

There have been several previous studies discussing energy saving in mosques with several methods. (Puspitasari 2021) have done studies for energy saving by controlling water usage in Al-Barokah Mosque, Bandung by using Plug Valve for several reason :

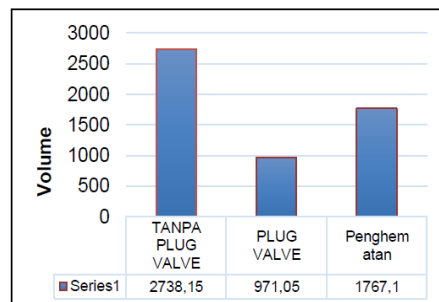
- Affordable
- Easy to install
- Easy to adjust water flow
- No need for electricity

Plug Valve is a type of valve that has an opening hole that can be rotated around 90 degrees so that water flow can be adjusted depending on how big the opening hole. Valves are an important part in the piping system for controlling pressure, stream and direction of the flow.



**Figure 4.** Plug Valve

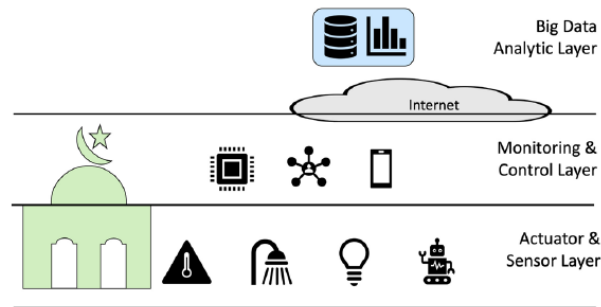
By using the Plug Valve Puspitasari manage to save water usage by comparing the water volume for wudhu one with valve and the other without the valve and manage to save water by 60%, on average water is saved by 1233,838 ml by 20 respondent



**Figure 5 .** Water volume difference

(Harsritanto et al. 2021) studied on saving water on mosques by implementation of Internet of Things.with the rapid popularization of Internet of things and smart city technologies , there have been countless smart objects in the world. Smart objects can be understood as physical or digital objects with sensing, information processing,

network communication and other functions . They can perceive their own situation and interact with users or provide various services autonomously (Zhang et al. 2022). Smart objects can carry some simple applications, such as object search and anomaly detection. By using IoT technology it is possible to control the amount of water that is being used.



**Figure 6.** IoT layer for strategies orchestration in the sustainable Mosque

To achieve this concept of the sustainable Mosque, there are three layers for orchestrating the previously mentioned strategies. At the bottom layer, each sensor and actuator run independently for avoiding waste of resources, e.g., water, electricity, and light. This layer can be applied by creating closed loop sensors– controllers– actuators, so that it can moderately regulate the usage of resources against the needs of resources. If there is no need for the resources, the system will automatically cut off the resources. In the middle layer, the actuators and sensors are connected to each other for controlling and monitoring their performance through a local network. This layer not only communicates among devices but also enables the users to directly control and monitor each sensor and actuator on the site. The upper layer contributes a vital role in diagnosing any unextracted features/information in the lower layer through Big Data analytics. The Machine Learning algorithm extracts some information from the uploaded data and recommends some actions for improving the performance of the components in the lower layer. Users can also send restricted types of commands for controlling the aforementioned strategies if needed.

Using automatic ablation devices it is possible to prevent any excess water waste, but they are expensive and high-cost maintenance. The tap type for ablation affects water consumption, so, tap design can help the user to save more water.

**Table 1.** Ablution tap types

Tap type	Average total ablation time (s)	Percentage of wasted water (%)
Mechanical knobs-tap	59.9	47
Mixing short neck-tap	57.2	42
Mixing high neck-tap	42.8	38
Mechanical push bottom tap	49.8	37
Automatic tap	49.4	30.3

### 3. Methods

In this research, our methods of research are by gathering electricity usage data from the mosque guard. Using historic data from the mosque guard we can calculate the average usage of the electricity. After that we also conducted an interview with the mosque guard to grasp more information about the mosque itself. For saving prediction, we estimate the saving by predict how much it will saved and calculate the prediction up to 3 years to see the result




### 4. Data Collection

The following is a calculation of monthly electricity usage and electricity costs with the S-2/TR social electricity rate :

**Table 2.** Mosque equipment quantity and usage

<b>Equipment</b>	<b>Name</b>	<b>Qty</b>	<b>Pwr (W)</b>	<b>Usage (hr/day)</b>	<b>Usage monthly (H)</b>	<b>Energy (kWh)</b>	<b>Cost per month (IDR)</b>
	Ultralink Sound system	1	1000	5	150	150	44.250
	Ac second floor	4	1080	12	360	1555,2	458.784
	Honora Pump	1	250	6	180	45	13.275
	Spotlight	2	50	12	360	36	10.620
	Toa Tower	4	50	1	30	6	1.770
	Motion sensor light Kawachi	8	15	2	60	7,2	2.124



	LED Philips	74	20	12	360	532,8	157.176
	Ceiling fan Panasonic	6	50	7	210	63	18.585
	Toa indoor	16	300	12	150	720	212.400
	AC first floor	13	1900	12	360	6156	1.816.020
	Calion Security Camera	9	10	24	720	64,8	19.116
	Mosque running text	1	10	24	720	7,2	2.124
<b>Vacuum Cleaner</b>	Vacuum Cleaner	1	1600	2	60	96	28.320
<b>Total</b>		<b>136</b>	<b>6335</b>	<b>124</b>	<b>3720</b>	<b>9439,2</b>	<b>2.784.564</b>

## 5. Results and Discussion

Using data we got from the mosque guardian, we got that the mosque paid nearly 3 million rupiah or Rp. 2.784.564 to be exact for the electricity of the mosque each month. Based by the data we got also, we can conclude that Air Conditioner is one of the top contributors of the electricity usage in the mosque. Where Air Conditioner contributed almost 82 % of the total electricity usage in the mosque itself

The total amount of electricity usage can be vary in each month especially at the month where there are lot of activities in the mosque such as ramadhan where the monthly electricity usage of the mosque can spike up to around Rp. 6.000.000 alone in that month itself.

### **5.1 Numerical Results**

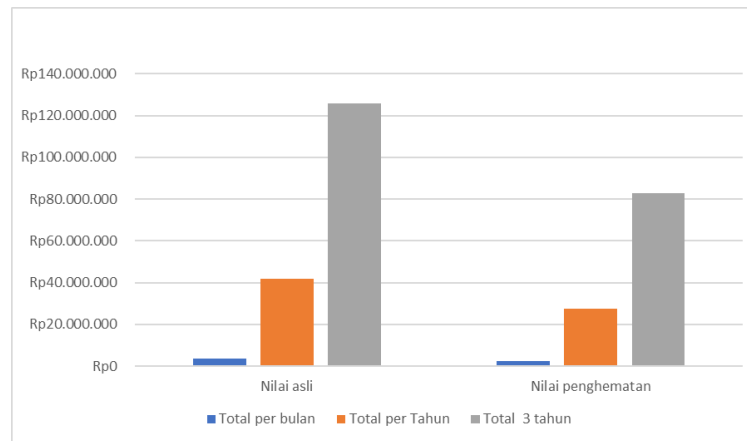
After we got the data from the mosque guardian, we then come with a new plan to reducing the mosque electricity usage. Here are our estimated electricity usage with our new suggested plan

**Table 3. Mosque New Electricity Plan**

Alat	Quantity	Power	Useage	Price estimation (IDR)
Ultralink Sondsistem	1	1000 watt	5 hours/day	Rp 6.500
Ac first floor	12	320 watt	6 hours/day	Rp 34.560
Ac second floor	4	320 watt	2 hours/4 day	Rp 7.680
Honora Pump	1	250 watt	6 hours/day	Rp 2.250
Spotlights	2	50 watt	12 hours/day	Rp 1.800
Toa tower	4	50 watt	1 hours/day	Rp 300
Motion sensor light Kawachi	8	15 watt	2 hours/day	Rp 360
Osram LED	74	12 watt	12 hours/day	Rp 15.984
Ceiling Fans Panasonic	6	50 watt	7 hours/day	Rp 3.150
Calion Security Camera	9	10 watt	24 hours/day	Rp 3.240
Mosque Running Text	1	10 watt	24 hours/day	Rp 360
Toa Indoor	9	10 watt	5 hours/day	Rp 675
<b>Total per Hari</b>				Rp 76.859
<b>Total Per Bulan</b>				Rp 2.305.770
<b>Total per Tahun</b>				Rp 27.669.240
<b>Total 3 Tahun</b>				Rp 83.007.720

## 5.2 Graphical Results

Based on our calculation, here is how much money will be saved if we continue to use our new scheme and plan for the mosque electricity usage



**Figure 7.** Mosque new electricity plan saving

### 5.3 Proposed Improvements

After got the information, here are the solution that we proposed to reduce the electricity consumption in the mosque

1. Replace all the lights used, with LED lights and regulate how the light used in the mosque
2. Add inverter to the Air Conditioner
3. Reducing the Air Conditioner usage in the mosque by regulating the hours it used
4. Adding fan in the mosque as the Air Conditioner replacement
5. Regulate the inside speaker usage, to reducing the electricity usage

### 6. Conclusion

Based on our research we can conclude that it took a large amount of electricity to operate a mosque. The mosque usage frequency is one of the determining factors that determines how much electricity will be use in the mosque. We also learned that tools like Air Conditioner is one of the top contributors in mosque electricity consumption, where it happened because mosque always use all of their air conditioners to keep the temperature comfortable enough for the people in there

There's lot of electricity usage cause by unregulated use of electricity happening in the mosque such as fan, air conditioner, lamps, etc. To reduce the electricity consumption in a mosque, the mosque guardian need to create some sort of rules to use electronics in the mosque, that way the mosque can keep their electricity usage low and keep the mosque operational cost low.

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## **Biography**

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