Analysis of Energy Consumption Management in Office Building (Case Study of Building X in South Jakarta)

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Abstract:- Due to High Energy Consumption in Indonesia Energy Consumption Management in Office Building is need to achieve efficiency in Energy Management. This Research is conducted in Building X Located in South Jakarta by Observing and Analyzing Energy Consumption in the Building. The HVAC System become first priority to be conducted efficiency by Installation Building Management System. Research found that Installed BAS in HVAC Could saving IDR 1,3M yearly operational.

Keywords:- *Component; Energy Management; Energy Efficiency; Building Automation System.*

I. INTRODUCTION

In Indonesia, the building and construction sector plays a major strategic role for economic and sustainable development. Like other economic sectors, the building and construction sector contributes to a high number of jobs but also to the negative effects of global climate change.

Based on Indonesia Energy Outlook 2019 data, total energy consumption in Indonesia in 2018 was around 114 million tonnes of oil equivalent (MTOE) which came from 40% transportation, 36% industry, 16% household, 6% commercial sector and 2% industrial sector. other.

Meanwhile, the distribution of electrical energy consumption can be seen in Figure 2, where the share for households is 39.4% and for commercial buildings 24.2%. %. Electricity consumption in the commercial sector, which includes offices, hotels, restaurants, hospitals and other services, is mostly used for air conditioning (cooling, ventilation, fans), hot water production, water pumps and electric lights.

Energy consumption in buildings, especially electrical energy, is very important. You can see that lighting equipment, electronic equipment, water pumps, and air conditioning systems are key pieces of equipment in building operations. Energy efficiency needs to be implemented to address energy waste that affects the increase in electricity bills. The method currently used to rationalize the use of electrical energy is energy conservation. Energy conservation means increasing the efficiency of energy use or energy saving processes. This process involves calculating the energy consumption of a building or structure and looking for potential savings in the equipment used in the building.

II. LITERATURE REVIEW

Energy Consumption Management is defined as: The activity of identifying the type and amount of energy used in the working parts of an industry/factory or building and attempting to determine possible energy savings. The purpose of an energy audit is to determine energy usage patterns, that is, to obtain data on the fluctuations in energy consumption. By measuring power consumption at any time, you can obtain energy consumption fluctuation data and create a graph of when a company's power consumption is highest and when it is lowest. Also, energy balance is determined by power consumption (input = output). This balance shows how much energy is being used and identifies waste from the system. Energy consumption intensity (IKE) is the most important part of an energy audit. IKE is a measure used to classify the type of energy consumption in a building as wasteful or compliant. The IKE value of a building can be found in the Indonesian National Standards (SNI). (Wardhana and Damarwan, 2023)

TABLE 1. Standard IKE Values in Building

Criteria	Energy Consumption (kWh/m2/month)	
	AC Building	Non AC Bulding
Very Efficient	4,17 - 7,92	-
Efficient	7,92 - 12,08	0,84 - 1,67
Quite Efficient	12,08 - 14,58	1.67 - 2,5
A bit Wasteful	14,58 - 19,17	-
Wasteful	19,17 - 23,75	2,5 - 3,34
Very Wasteful	23,75 - 37,5	3,34 - 4,17

Another outcome of an energy audit is the identification of sources of energy waste. This can be determined by measuring energy consumption. After receiving savings measures, the planned savings must be prudent and optimal. A return to the concept of energy conservation: saving without reducing demand.

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III. METHODOLOGY

Observation was conducted at Building X in South Jakarta, Building Primary Source is form Perusahaan Listrik Negara an State Owned Electric Company and 2 generating sets as back-up. In preliminary data collection phase, exhaustive data collection was made using different methods such as observation, interviewing key persons, and measurements. The following steps were taken for data collection: A visit to each of the workshops, laboratories, offices and other entities of the institution. Information about the general electrical appliances was collected by observation and interviewing. The Site drawing of available building lay-out and Electricity distribution were collected. Electricity bill was collected from the personnel in-charge. Information was also collected on redundant / non-operational energy systems. The details of usage of the appliances were collected by interviewing key persons e.g. Electrician, caretaker (in case of departments) etc. and approximations and generalizations were done at places with lack of information.

Detailed analysis of data collected was done. Energy consumption per month in kWh is calculated. The analysis of data is done in following way: the database prepared was further studied and the results presented graphically, this helped to identify the areas with maximum energy saving potential. Recommendation On the basis of results of data analysis and observations, some steps for reducing power consumption were taken.

IV. RESULT AND DISCUSSION

The Building X in South Jakarta was built in 1997 and has 18 floors. The B1 floor is a basement for parking. The first floor consists of a lobby, multipurpose room, bank, and food and beverage tenants. The 2nd to 16th floors are the floors where building owners and tenants actively use their rooms. However, the 17th floor will serve as the board lounge. The entire building is subject to this investigation. Overall, all rooms surveyed are carpeted and have acoustic ceilings. The rooms on each floor are separated by partitions. The walls are plastered with wallpaper and glass. The building area is 27,338 m2 with a height of 62.9 with detailed floor data as follows :

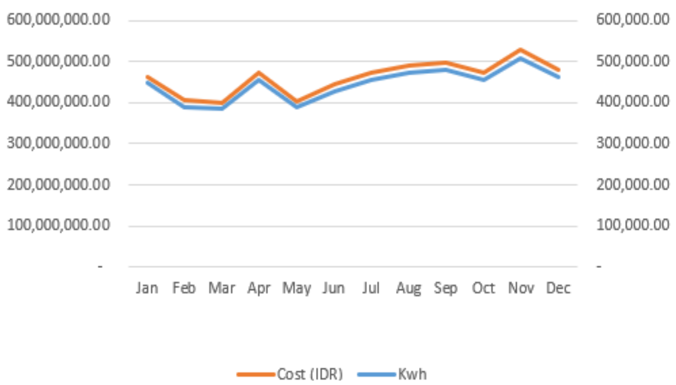
TABLE 2. Used Area Per Floor in The Building X

No	Floor	Gross floor area (m2)	Area used
1	Basement	2,432.25	0
2	1st Floor	2,245.24	2178.55
3	2nd Floor	1,499.88	1388.7
4	3rd Floor	1,499.88	1374.65
5	4th Floor	1,499.88	1374.65
6	5th Floor	1,499.88	1374.65
7	6th Floor	1,499.88	1431.73
8	7th Floor	1,499.88	1373.66
9	8th Floor	1,499.88	1373.66
10	9th Floor	1,499.88	1376.95
11	10th Floor	1,499.88	1376.95
12	11th Floor	1,499.88	1376.95
13	12th Floor	1,499.88	1376.95
14	13th Floor	1,499.88	1376.95
15	14th Floor	1,499.88	1376.66
16	15th Floor	1,499.88	1376.66
17	16th Floor	1,499.88	1376.66
18	17th Floor	162.31	0

Annual Energy Consumption in 2022 Showing that building X included in criteria "a bit wasteful" with average shown by an average value of 16.23 refer to IKE (energy consumption) table. The following table shown monthly energy consumption in 2022.

TABLE 3. Monthly Energy Consumption 2022

No.	Month	Kwh	Cost (IDR)	IKE	Criteria
1	Jan	446,448.00	463,413,024.00	16.33	It's a bit wastef
2	Feb	389,765.00	404,576,070.00	14.26	Quite Efficient
3	Mar	385,563.00	400,214,394.00	14.10	It's a bit wastef
4	Apr	455,473.00	472,780,974.00	16.66	It's a bit wastef
5	May	387,148.00	401,859,624.00	14.16	Quite Efficient
6	Jun	427,624.50	443,874,231.00	15.64	It's a bit wastef
7	Jul	454,320.00	471,584,160.00	16.62	It's a bit wastef
8	Aug	471,299.00	489,208,362.00	17.24	It's a bit wastef
9	Sep	480,175.00	498,421,650.00	17.56	It's a bit wastef
10	Oct	454,505.00	471,776,190.00	16.63	It's a bit wastef
11	Nov	508,430.00	527,750,340.00	18.60	It's a bit wastef
12	Dec	462,052.90	479,610,910.20	16.90	It's a bit wastef

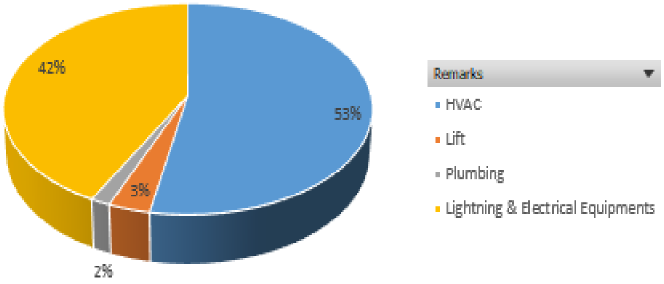


GRAPH 1. Monthly Energy Consumption2022

Researchers measured electrical panels throughout the building to obtain energy distribution data. Measurements were carried out over a period of one month from 1-30 September 2023. The results of these measurements are as follows :

TABLE 4. Building Energy Distribution

No.	Group	Number of Panel	Status	Usage Faktor Meter	Floor	Remarks
1	EL	120701 24174	On	1463	1	Lightning & Electrical Equipments
2	TN	24732	On	1720	1	Lightning & Electrical Equipments
3	EL	24505	On	1820	1	Lightning & Electrical Equipments
4	AC	133738	On	0	1	HVAC
5	AC	24450	On	30	1	HVAC
6	UT	1512011249070	On	451	1	Lightning & Electrical Equipments
7	UT	1512011249131	On	3876	1	HVAC
8	UT	1512011249053	On	1603	1	Lightning & Electrical Equipments
9	UT	1512011249054	On	3140	1	Lightning & Electrical Equipments
10	EL	16011375	On	137	1	Lightning & Electrical Equipments
11	UT	0073797	On	986	2	Lightning & Electrical Equipments
12	EL	6905	On	518	2	Lightning & Electrical Equipments
13	EL	1606231126467	On	358	2	Lightning & Electrical Equipments
14	TN	16011459	On	186	2	Lightning & Electrical Equipments
15	TN	1606231126454	On	450	2	Lightning & Electrical Equipments
16	TN	1606231126512	On	309	2	Lightning & Electrical Equipments
17	UT	4307607	On	829	3	Lightning & Electrical Equipments
18	UT	1512011249084	On	855	4	Lightning & Electrical Equipments
19	UT	0057445	On	862	5	Lightning & Electrical Equipments
20	UT	0068000	On	1028	6	Lightning & Electrical Equipments
21	UT	0069137	On	520	7	Lightning & Electrical Equipments
22	UT	058409	On	648	9	Lightning & Electrical Equipments
23	TN	1606231126481	On	13680	6	Lightning & Electrical Equipments
24	UT	0079773	On	546	11	Lightning & Electrical Equipments
25	EL	1512011249135	On	3480	13	Lightning & Electrical Equipments
26	SR	73728	On	65901	Basement 1	Lightning & Electrical Equipments
27	TN	D04811512011249072	On	2020	14	Lightning & Electrical Equipments
28	UT	85MD3	On	495	15	Lightning & Electrical Equipments
29	EL	1504231063787	On	2024	15	Lightning & Electrical Equipments
30	EL	1504231063791	On	307	15	Lightning & Electrical Equipments
31	EL	1504231063808	On	4876	15	Lightning & Electrical Equipments
32	EL	978225	On	90	16	Lightning & Electrical Equipments
33	TN	5479	On	646	17	Lightning & Electrical Equipments
34	TN	110875	On	280	17	Lightning & Electrical Equipments
35	EL	12809015923	On	2205	17	Lightning & Electrical Equipments
36	TN	8924997	On	115	17	Lightning & Electrical Equipments
37	AC	DGT09	On	4520	17	HVAC
38	UT	1512011249081	On	6	17	Lightning & Electrical Equipments
39	AC	DGT10	On	8200	17	HVAC
40	UT	1512011249122	On	223	17	Lightning & Electrical Equipments
41	UT	1512011249062	On	1688	18	HVAC
42	UT	1512011249102	On	1	18	Lightning & Electrical Equipments
43	UT	1512011249109	On	572	18	HVAC
44	UT	1512011249060	On	428	19	Lightning & Electrical Equipments
45	UT	10080116398	On	501	Basement 1	Lightning & Electrical Equipments
46	SR	M06.00224	On	39200	Basement 1	Lightning & Electrical Equipments
47	AC	1512011249089	On	827	Basement 1	HVAC
48	UT	1512011249136	On	161	Basement 1	Lightning & Electrical Equipments
49	UT	1512011249050	On	2725	Basement 1	Lightning & Electrical Equipments
50	UT	1504231063837	On	1742	Basement 1	HVAC
51	UT	1504231063860	On	682	Basement 1	HVAC
52	UT	1504231063843	On	292	Basement 1	HVAC
53	AC	1504231063868	On	2523	Basement 1	HVAC
54	AC	1504231063857	On	52800	Basement 1	HVAC
55	AC	1504231063841	On	52500	Basement 1	HVAC
56	AC	1504231063858	On	80640	Basement 1	HVAC
57	UT	1504231063847	On	15050	Basement 1	Lift
58	AC	1512011249117	On	39360	Basement 1	HVAC
59	UT	1512011249097	On	1115	Basement 2	Lightning & Electrical Equipments
60	TN	5133030	On	145	Basement 2	Lightning & Electrical Equipments
61	UT	2236026	On	967	Outside	Lightning & Electrical Equipments
62	UT	076414	On	944	Outside	Lightning & Electrical Equipments
63	UT	1512011249066	On	0	Outside	Lightning & Electrical Equipments
64	UT	1512011249105	On	7200	Outside	Plumbing
65	TN	16011170	On	190	Outside	Lightning & Electrical Equipments
66	UT	114090914140	On	350	Ruang Lift	Lift
67	UT	1504231063851	On	3586	STP	Lightning & Electrical Equipments
68	UT	16011216	On	237	Outside	Lightning & Electrical Equipments
69	TN	1606231126464	On	441	Outside	Lightning & Electrical Equipments
70	UT	3917093253	On	266	Outside	Lightning & Electrical Equipments
71	TN	00000046	On	14459	5	Lightning & Electrical Equipments
72	EL	1606231126434	On	650	Outside	Lightning & Electrical Equipments
73	TN	3917093550	On	73	2	Lightning & Electrical Equipments
74	TN	1512011249043	On	1358	Basement 1	Lightning & Electrical Equipments
75	EL	1606231126614	On	1020	16	Lightning & Electrical Equipments
76	UT	3918070467	On	180	Outside	Lightning & Electrical Equipments
77	UT	1512011249111	On	133	Outside	Lightning & Electrical Equipments
78	TN	20113061	On	2953	Outside	Lightning & Electrical Equipments
79	TN	20150648	On	69	2	Lightning & Electrical Equipments
80	TN	3921030561	On	491	Outside	Lightning & Electrical Equipments
81	TN	3921030709	On	44	2	Lightning & Electrical Equipments
82	UT	151201124901	On	617	8	Lightning & Electrical Equipments
83	UT	14090914164	On	470	12	Lightning & Electrical Equipments
84	UT	1512011249067	On	653	14	Lightning & Electrical Equipments
85	TN	20113077	On	5683	Outside	Lightning & Electrical Equipments
86	UT	20113070	On	1142	Basement 2	Lightning & Electrical Equipments
87	TN	1512011249059	On	285	1	Lightning & Electrical Equipments
88	TN	19274310	On	125	1	Lightning & Electrical Equipments
89	TN	21140762	On	2176	17	Lightning & Electrical Equipments
90	TN	21140725	On	1259	Outside	Lightning & Electrical Equipments
91	EL	12080859	On	456	2	Lightning & Electrical Equipments



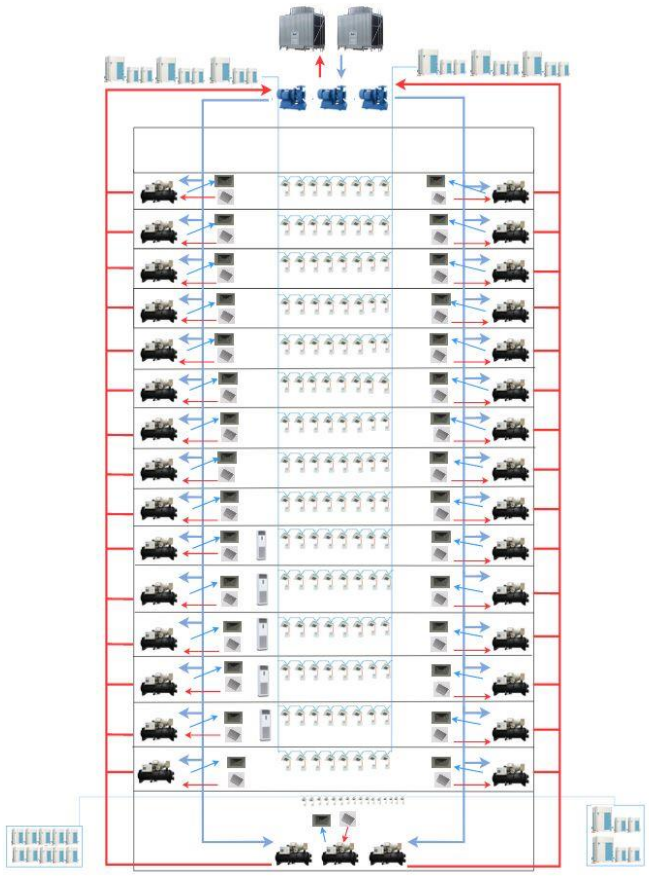
GRAPH II. Percentage Energy Distribution

By the following graphs It can be seen that the energy distribution for HVAC is the largest, based on this, the authors will make potential savings from the HVAC side.

The Building uses the following HVAC system for cooling:

- AC Central in the form of a cooling tower and two water cooling package units (WCPUs) on each floor as main cooling system.
- AC variable refrigerant volume (VRV) as additional cooling per floor .
- AC Split and portable as additional cooling per room.

The HVAC System is depicted in the following graphic:



GRAPH III. HVAC System in Building X

From this series of systems, the building does not yet use an automation system for HVAC consumption efficiency, for this reason an automation system is needed for HVAC energy efficiency.

Installation of BAS (Building Automation System) can optimize HVAC systems, which can account for a large portion of a building's energy consumption. By monitoring temperature and humidity levels and adjusting HVAC systems accordingly, BAS can reduce energy waste and improve comfort for occupants.

GRAPH IV. BAS Diagram

According to wide engineering there are typically 4 levels to a BAS system:

- Level 1: Supervisor
- Level 2: Network Controller
- Level 3: Field Controller
- Level 4: Sensor/Edge

Level 1, the Supervisor, is the software and user interface portion of the BAS where the end user can view the different devices being controlled and monitored. Level 2 contains the network controller, All information being collected and transmitted by Levels 3 and 4 then translates and transmits to Level 1. Level 3 consists of the BAS's field controllers and input/output devices. The field controllers are your local equipment controllers such as a an AHU controller, etc. Level 4, are sensors. These are occupancy sensors, thermostats, CO2 sensors, etc. The sensors are connected back to the field controllers and send local data back to make decisions on whether to adjust settings or maintain.

In Tropical country energy saving BAS implementation saving energy in range 10-25 % (King, 2017). Researchers and Building Management assume that BAS installation could saving 20% due to partial load system automation. Cost effieciency simulation is conducted before after BAS Installation:

TABLE 5. Cost Per Year before BAS Installation

No.	Equipment	Qty	Kwh	Operational Hours	Cost per Kwh (IDR)	Cost per Day (IDR)	Workdays per years	Cost Per year (IDR)
1	AC Portable Server	6	5	15	1038	467,100	260	121,446,000
2	Cooling Tower	2	5.5	15	1038	171,270	260	44,530,200
3	AC WCPU	34	20	15	1038	10,587,600	260	2,752,776,000
4	AC VRV	36	7.77	15	1038	4,355,240	260	1,132,362,504
5	Motor CWP	3	2.89	15	1038	134,992	260	35,097,894
					Total	15,716,202		4,086,212,598

TABLE 6. Cost Per Year after BAS Installation

No.	Equipment	Qty	Kwh	Cost Per Kwh	Hours Full Load	Full Load	Cost Full Load	Hours Partial Load	Partial Load	Cost Partial Load	Cost Per Day	Workdays	Cost Per year (IDR)
1	AC Portable Server	6	5	1038	12	80%	298944	3	20%	18,684	317,628	260	82,583,280
2	Cooling Tower	2	5.5	1038	12	80%	109612.8	3	20%	6,851	116,464	260	30,280,536
3	AC WCPU	34	20	1038	12	80%	6776064	3	20%	423,504	7,199,568	260	1,871,887,680
4	AC VRV	36	7.77	1038	12	80%	2787353.856	3	20%	174,210	2,961,563	260	770,006,503
5	Motor CWP	3	2.89	1038	12	80%	86394.816	3	20%	5,400	91,794	260	23,866,568
						Total	10,058,369.47			628,648	10,687,018		2,778,624,567

By those cost simulation BAS installation could saving IDR 1,307,588,031 yearly.

V. CONCLUSION

Energy consumption in Building X mostly distribute to HVAC (53%). This is the first priority for conducted efficiency. implementing BAS is a profitable decision for Building.

From this research, apart from HVAC equipment, the implementation of energy efficiency also needs to be considered, especially for lighting and electronic equipment. Apart from implementing energy efficiency, the author also suggests assessing the feasibility of producing your own energy, such as designing solar panels to achieve comprehensive energy efficiency.

REFERENCES

[1]. Bağcı, Barış. "Energy saving potential for a high-rise office building." *Intelligent Buildings International*, vol. 1, no. 2, 2009, pp. 156–163, https://doi.org/10.3763/inbi.2009.0025.

[2]. Oyedepo, Sunday. "Efficient Energy Utilization as a tool for sustainable development in Nigeria." *International Journal of Energy and Environmental Engineering*, vol. 3, no. 1, 2012, p. 11, https://doi.org/10.1186/2251-6832-3-11.

[3]. *Building Automation and Control Systems (Bacs)*, https://doi.org/10.3403/bseniso16484.

[4]. Moran, Paul, et al. "Sustainable Energy Efficiency Retrofits as residenial buildings move towards nearly Zero energy building (NZEB) standards." *Energy and Buildings*, vol. 211, 2020, p. 109816, https://doi.org/10.1016/j.enbuild.2020.109816.
[5]. Prasanna, Venkatesh S, et al. "Benefits of smart buildings." *Smart Buildings Digitalization*, 2021, pp. 77–84, https://doi.org/10.1201/9781003201069-6.
[6]. Singh, Kishen, and Gokul Rajendran. "Energy efficiency in HVAC and refrigeration systems." *Energy Audit and Management*, 2022, pp. 79–108, https://doi.org/10.1201/9781003203810-3.
[7]. Wardhana, Alex Sandria, and Eko Swi Damarwan. "Identification of energy saving potential through energy audit at pt. ABC." *Jurnal Edukasi Elektro*, vol. 7, no. 1, 2023, pp. 63–74, https://doi.org/10.21831/jee.v7i1.61657.