

Strategy to Save Electrical Energy Consumption as an Effort to Manage Electrical Energy at Tanadewa Resort and Spa Ubud Bali

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Article History

Received: 12.06.2024

Accepted: 30.06.2024

Published: 05.07.2024

Abstract: Bali Island, known as a tourism center, has a power capacity of 1,243.30 MW, with the highest use in 2020 of 980.89 MW. Thus, 262.41 MW of backup power is still available for Bali Island. Making sure the IKE value complies with the requirement and can search for energy-saving opportunities is the aim (PHE). The method compares the consumption of electrical energy (kWh/year) with the building area according to the hotel occupancy rate to get the IKE value. Then, analyze the electrical energy user system to look for energy-saving opportunities. The result is that the IKE value in 2019 was 222.56 kWh/m²/year, and in 2020 it was 170.29 kWh/m²/year. Energy-saving opportunities are obtained by adjusting the pattern of using air conditioners and lights and carrying out routine maintenance to increase the efficiency of water pumps. After the PHE was carried out, the IKE value in 2019 was 161.70 kWh/m²/year. Based on the IKE of air-conditioned buildings, electricity consumption in 2019 increased from slightly wasteful to quite efficient after the PHE. Savings on electricity bills in 2019 after PHE carried out amounted to Rp.203,806, 287.

Keywords: Energy Audit, Energy Saving, IKE, PHE, Energy Consumption.

Cite this article:

Sukadana, I. W., Sutama, I. W., Hernawan, I. K., Ariana, I. K. A., (2024). Strategy to Save Electrical Energy Consumption as an Effort to Manage Electrical Energy at Tanadewa Resort and Spa Ubud Bali. *ISAR Journal of Science and Technology*, 2(7), 7-15.

Introduction

Bali Island is one of Indonesia's islands that is famous for its tourism center. As a world tourist destination, many entrepreneurs work in lodgings such as hotels, villas, and resorts. According to Hotelmu.id website on Monday, March 23, 2020, the island of Bali has a total of 4,874 businesses in the hospitality sector. In operating hotel facilities, enough power is needed to run electrical loads such as pumps, hot water machines, air conditioning machines, and others (Upadhyay &. Currently, the power capacity of the electricity system in Bali is 1,243.30 MW, with the highest load in 2020 being 980.89 MW. Thus, Bali Island still has 262.41 MW of backup power available. Power usage may increase to the point that new power plants or energy-saving techniques are required. [1].

As an evaluation of whether the energy conservation carried out is under standards, it is necessary to conduct an energy audit to determine the Energy Consumption Intensity (IKE) at Tanadewa Resort and Spa Ubud [2], [3]. Suppose the results of the Energy Consumption Intensity (IKE) of electricity are not according to standards. In that case, it is necessary to carry out an Energy Saving Opportunity (PHE) strategy to manage electrical energy effectively and efficiently [4].

Methods

Energy Consumption Intensity

It compares energy and building area units in a certain period (SNI 6196:2011) [5]. Calculating Energy Consumption Intensity (IKE) is an index that can be an indicator of the energy use status of a hotel building ([6], [7] Energy Consumption Intensity (IKE) is calculated in units of kWh / m² per year with the following equation;

$$IKE = \frac{\text{electrical energy consumption (kWh/year)}}{(\text{occ rate} \times \text{area room}) + (\text{area non room})} \quad (1)$$

Lighting System

To determine the power requirements of the unity lamp, the area of the room used can be measured by the following equation:

$$\text{Electrical Power} = \frac{W_{total}}{A} \quad (2)$$

Where:

Electrical Power = Result Power/Room Area (watt/m²)

W_{total} = Power of All Lamps (watts)

A = Room Area

Air Conditioning System

To determine the performance of the appropriate air conditioner, it is necessary first to know the total area to be conditioned in square meters (m²). Then, calculate the air conditioning capacity according to the equation in units of BTU / h. British Thermal Unit (BTU) can reduce heat / cool the room in certain areas and conditions.

$$Kebutuhan\ BTU = \frac{L \times W \times H \times I \times E}{60} \quad (3)$$

Where:

L = Room Length (feet)

W = Room Width (feet)

H = Room Height (feet)

I = Insulated Room (10), Non Insulated Room (18)

E = Room Facing North (16), Facing East (17),

Facing South (18), Facing West (20).

Water Pump Efficiency

Pump efficiency is the ratio between pump hydraulic power (Ph) and pump shaft power (Ps) [8]. Hydraulic power (Ph) is used to push water from one point to another. Shaft power (Ps) is the mechanical power used to rotate the pump impeller. Pump efficiency and motor efficiency can be calculated using the following equation:

Motor Input Power:

$$P_{in} = \frac{1,73 \times V \times I \times \cos \varphi}{1000} \quad (4)$$

Where:

P_{in} = Input Power (kW)

V = Average voltage between phases (V)

I = Average current of all three phases (A)

Cos = Power factor (0.90)

Load Factor:

$$LF = (V_{in} \times I_{in}) / (V_{np} \times I_{np}) \quad (5)$$

Where:

LF = Load Factor

V_{in} = Rated Voltage

I_{in} = Rated Current

V_{np} = Nameplate Voltage

I_{np} = Nameplate Flow

Motor Efficiency:

$$\eta_m = \frac{P_{np} (kW) \times LF}{P_{in} (kW)} \times 100 \% \quad (6)$$

Where:

η_m = Motor Efficiency (%)

P_{np} = Nameplate Power (kW)

LF = Load Factor

P_{in} = Input Power (kW)

Hydraulic Power Equation:

$$P_h = \frac{Q \times H \times g \times \rho}{1000} \quad (7)$$

Where:

P_h = Hydraulic Power (kW)

Q = Water Discharge (m³/s)

H = Head (m)

g = Velocity of Gravity (9.81 m/s²)

ρ = Density (1000 kg/m³)

Shaft Power Equation:

$$P_s = \eta_m \times P_{in} \quad (8)$$

Where:

η_m = Motor Efficiency On Nameplate (%)

P_{in} = Input Power (kW)

Pump Efficiency:

$$\eta_p = \frac{P_h (kW)}{P_s (kW)} \times 100 \% \quad (9)$$

Where:

η_p = Pump Efficiency (%)

P_h = Hydraulic Power (kW)

P_s = Shaft Power (kW)

By taking action to increase pump efficiency, it is expected to get savings following the equation below:

$$S = P_{in} \times t \times \left(1 - \frac{\eta_a}{\eta_o}\right) \quad (10)$$

Where:

S = Savings (kWh)

P_{in} = Input Power (kW)

t = Operating Time (hours)

A = Old Efficiency

O = New Efficiency

Water Heater Efficiency

Efficiency is the ratio between incoming and outgoing energy [9]. The incoming energy is the energy released by electric heaters. However, the energy that the fluid can absorb is the outgoing energy. So, in general, the efficiency of the water heater can be formulated as follows:

$$\eta = \frac{q_2}{q_1} \times 100 \% \quad (11)$$

$$q_1 = V \cdot I \cdot t$$

$$q_2 = m \cdot c \cdot \Delta T (T_{out} - T_{in})$$

Where:

η = Efficiency (%)

q_1 = Energy input (kW or kWh)

q_2 = energy out (kW or k.Joule/second)

V = Voltage

I = Current

t = Warm-up time

m = Mass of object (water = liter)

c = Density (density of water = 4187 j/kg)

ΔT = Temperature changes (°C)

Research Stage

After collecting the required data, the stages of research carried out are:

1. Calculate the energy consumption intensity (IKE) in hotels, and then the result is compared with the ASEAN-USAID IKE standard and the air-conditioned building IKE standard.
2. Calculate the lighting power of the room and then fit it to the standard.
3. Adjusting the capacity of the air conditioner according to the needs.
4. Calculate the efficiency of the water pump using the equation.

5. Calculate the efficiency of the water heater using the equation.

6. Write the saving strategy for each electric energy user system according to the analysis and observations in the field.

Results and Discussions

Hotel Building Area Data

Tanadewa Resort and Spa Ubud has a 5-storey building consisting of 30 rooms, four suite rooms, 13 offices, and 21 operational rooms. Outside the 5-storey building are seven villas and four buildings for Spa. The size of each room is obtained from the hotel floor plan and direct observation in the field.

Table 1. Building Area Data

Location	Room (m ²)	Non-Room (m ²)	AC (m ²)	No AC (m ²)
1st Floor	320	165	485	-
2nd Floor	320	510	716	114
3rd Floor	320	340,23	496,5	163,73
4th Floor	390	-	390	-
5th Floor	150	115	265	-
Villa	424,03	156,64	542,83	37,84
Total	1924,03	1286,87	2895,33	315,57

Hotel Electrical Energy Consumption

Data on the use of electrical energy consumption at Tanadewa Resort and Spa Ubud are electricity bills in 2019 and 2020, along with the occupancy percentage to facilitate observations on electrical energy consumption.

Table 2. Electricity Bill in 2019

Month	Room Occupied	kWh Total	Cost
January	0,00%	16.020	Rp. 19.722.287
February	0,00%	14.200	Rp. 17.443.571
Maret	0,00%	28.940	Rp. 35.878.383
April	14,96%	38.300	Rp. 47.693.526
Mei	26,92%	41.360	Rp. 51.476.194
June	69,57%	45.100	Rp. 56.124.775
July	91,11%	46.860	Rp. 58.175.619
Agustus	95,98%	50.400	Rp. 62.641.903
September	92,39%	53.300	Rp. 66.185.306
October	78,21%	55.600	Rp. 69.056.488
November	38,80%	46.480	Rp. 57.537.579
Desember	38,46%	44.180	Rp. 54.723.365
Total	45,53%	480.740	Rp. 596.658.997

Table 3. Electricity Bill in 2020

Month	Room Occupied	kWh Total	Cost
January	43,08%	46.320	Rp. 57.469.218
February	22,91%	38.040	Rp. 47.146.634
Maret	7,86%	24.840	Rp. 30.739.879
April	0,00%	6.400	Rp. 15.723.140
Mei	0,00%	7.720	Rp. 15.723.140
June	0,00%	7.060	Rp. 15.723.140
July	1,97%	7.940	Rp. 15.723.140
Agustus	3,76%	17.000	Rp. 21.066.729
September	1,45%	13.800	Rp. 17.090.370
October	3,42%	17.120	Rp. 21.294.601
November	5,90%	21.100	Rp. 26.262.202
Desember	26,24%	31.880	Rp. 39.626.871
Total	6,13%	239.220	Rp. 323.589.064

Energy Consumption Intensity (IKE)

From the data on electricity bills in 2019, a total kWh of 480,740 kWh / year was obtained with an average occupancy of 45.53%, and in 2020, a total kWh of 239,220 kWh / year was acquired with an average occupancy of 6.13%. Then, from the hotel building area data, the entire room area is 3210.90 m² with a room area of 1924.03 m² and a non-room area of 1286.87 m². Then, the value of Energy Consumption Intensity (IKE) can be determined as follows:

Energy Consumption Intensity in 2019:

$$IKE = \frac{480.740 \text{ kWh/tahun}}{(45,53\% \times 1924,03 \text{ m}^2) + (1286,87 \text{ m}^2)}$$

$$IKE = \frac{480.740 \text{ kWh/tahun}}{2162,96 \text{ m}^2}$$

$$IKE = 222,26 \text{ kWh/m}^2\text{/tahun}$$

Energy Consumption IntensityIn 2020:

$$IKE = \frac{239.220 \text{ kWh/tahun}}{(6,13\% \times 1924,03 \text{ m}^2) + (1286,87 \text{ m}^2)}$$

$$IKE = \frac{239,220 \text{ kWh/tahun}}{1404,81 \text{ m}^2}$$

$$IKE = 170,29 \text{ kWh/m}^2\text{/tahun}$$

Table 4. IKE ASEAN – USAID Standard

Building Type	IKE Standard	
	(kWh/m ² /month)	(kWh/m ² /year)
Office	20	240
Shopping Center	27,5	330
Hotel	25	300
Hospital	31,7	380

Based on the IKE ASEAN – USAID Standard table (4) for 300 kWh/m²/year hotel buildings, the consumption of electrical energy in 2019 and 2020 at Tanadewa Resort and Spa Ubud is in the category according to the standard.

Table 5. IKE Standards for Air-conditioned Buildings

Criterion	IKE Standard	
	(kWh/m ² /month)	(kWh/m ² /year)
Very Efficient	4,17 – 7,92	50,04 – 95,04
Efficient	7,92 – 12,08	95,04 – 144, 96
Quite Efficient	12,08 – 14,58	144,96 – 174,96
A bit extravagant	14,58 – 19,17	174,96 – 230,04
extravagant	19,17 – 23,75	230,04 – 285
Very extravagant	23,75 – 37,75	285 - 453

Based on the IKE Standard for air-conditioned buildings in Table (5), electrical energy consumption in 2019 is in the Somewhat Wasteful category. Electrical energy consumption in 2020 is in the Quite Efficient category. With these results, further analysis is needed, especially on electrical energy consumption in 2019, to get results close to Quite Efficient.

Energy Saving Opportunity Analysis

Based on the hotel's single-line diagram, the total installed load is 238,771 W. The load is divided into several systems: lighting, air conditioning, water pumps, and water heaters. The use of lighting and air conditioning systems is divided based on the room's function. The amount of electrical energy consumption can be seen in the table (6).

To find energy-saving opportunities at Tanadewa Resort and Spa, it is necessary to know the magnitude of the average electricity load usage in 2019. With a known electricity consumption of 480,738 kWh / year, the amount of electricity load used can be calculated as follows:

Average Electricity Load in 2019:

$$kWh = \frac{480.738 \text{ kWh/tahun}}{12} = 40.061,67 \text{ kWh}$$

$$kWh = \frac{40.061,67 \text{ kWh/bulan}}{30} = 1.335,39 \text{ kWh}$$

$$kWh = \frac{1.335,39 \text{ kWh/hari}}{24} = 55,64 \text{ kW}$$

$$Daya = \frac{55,64 \text{ kW}}{0,9} \times 1000 = 61.824 \text{ W}$$

Table 6. Electrical Energy Consumption

Electric Energy User System	Location	Daya (W)	Electricity Consumption Year 2019 (W)
Lighting	Room	9322	2.414
	Operasional	3699	958
	Office	846	219
Air Conditioning	Room	82.050	21.245
	Operasional	13.065	3.383
	Office	9.325	2.414
Air Pump	PumpRoom	27700	7.172
Water Heater	Room	15.000	3.884
	Villa	54000	13.982
Other Expenses		23746	6.153

Effective energy saving (PHE) opportunities can be created in the most significant electricity user systems, such as air conditioners. However, it does not rule out the possibility of obtaining Energy Saving Opportunities (PHE) from other electrical energy user systems. Such as lamps that can be reduced in usage hours and the efficiency of pumps or water heaters that can be sought. Energy Saving Opportunities based on engine performance.

Energy Saving Opportunities in Lighting

In determining the lighting power in a hotel room, a standard is needed so that the power needs of the lights are as required [10]. Hotel lighting power standards are listed in SNI 6197:2011.

Table 7. Hotel Lighting Power Standards

Room Functions	Maximum Lighting Force (W/m ²)
Reception and cashier room	12
Lobby	12
Function room	8
Meeting rooms	10
Dining area	9
Cafeteria	8
Bedroom	7
Hallway	5
Kitchen	10

The lighting power (W/m²) in room 1 complies with the standard, as per the lighting power standard in the table (7) in the bedroom category. The lighting power (W/m²) results for the additional rooms can be found in the following table using the same methodology:

$$Daya Listrik = \frac{W_{total}}{A}$$

$$Daya Listrik = \frac{178}{40}$$

$$Daya Listrik = 4,45 \text{ W/m}^2$$

Based on the lamp data table, LED lamps dominate more than TL lamps. It can be said that the specifications of the lamps used are good because LED lamps have a longer life. When viewed from the standard lighting power of the room, most of it is up to standard. It is just that the villas and workshops are not up to standard. In this case, it needs to be set for its use so that it does not need to be replaced. Then, other energy-saving opportunities can be found by observing the pattern of lamp use.

Table 8. Recommended Use of Lights

Location	On-Time		Day
	LWBP	WBP	
Room	2 jam	4 jam	Senin - Minggu
Operasional	2 jam	4 jam	Senin - Minggu
Office	8 jam	-	Senin - Jumat

Energy Saving Opportunities in Air Systems

To determine the hotel's capability for air conditioning when needed, the following calculations are required:

Determining the Capacity of AC Room 1:

Known:

Room Length (L) = 8 m (26 feet)

Room Width (W) = 5 m (16 feet)

Room Height (H) = 2,8 m (9 feet)

Uninsulated room (I) = 18

Facing East (E) = 17

$$Kebutuhan BTU = \frac{L \times W \times H \times I \times E}{60}$$

$$Kebutuhan BTU = \frac{26 \times 16 \times 9 \times 18 \times 17}{60}$$

$$Kebutuhan BTU = 19.094 \text{ BTU/h}$$

Table 9. Convert BTU/h to PK

BTU/h	PK
5.000	1/2
7.000	3/4
9.000	1
12.000	1,5
18.000	2
24.000	2,5
27.000	3
45.000	5

Based on table (4.14) of BTU/h to PK conversion, the air conditioning capacity in room 1 is close to 2 PK. With the results of field observations for the installed AC capacity in room 1 of 2

PK, it can be said that the air conditioning capacity is following the needs.

Based on the calculation of BTU/h needs for each hotel room, it can be seen that the air conditioning capacity is following the needs. It can be said that the selection of air conditioning at Tanadewa Resort and Spa Ubud is good.

Savings can be made, namely in operational and office space. When viewed from the working room air conditioning pattern, the AC flame clock on WBP can be eliminated. The room's heat has decreased since the sun has set at 18.00-22.00. For office space, savings can be made by turning on the air conditioner before noon between 11.00 and noon. Then turn off the air conditioner during break hours in the canteen and turn off the air conditioner at 17.00 in the afternoon because the sun is no longer hot.

Table 10. Recommended Use of Air Conditioning

Location	On-Time		Day
	LWBP	WBP	
Operational	Nine jam	-	Senin - Minggu
Office	6 jam	-	Senin - Jumat

Energy Saving Opportunities at Water Pumps

To determine the hotel's capability for air conditioning when needed [11].

Table 11. Pump Measurement Results

Pump	V(in)			I(in)		
	R (V)	S (V)	T (V)	R (A)	S (A)	T (A)
Booster Pump	382	382	381	7,8	12	11,7
	382	379	381	8,1	7,8	6,3
	384	379	382	13,1	14,5	10,8
Fillter Pump	385	381	381	2,3	2,6	2
	381	382	381	2,2	2,2	2,6
Irrigation Pump	221	-	-	5	-	-
	219	-	-	5	-	-
Heat Pump	232	-	-	2,3	-	-
	231	-	-	2,5	-	-
Return Heat Pump	382	381	380	1,3	1,3	1,3
	380	379	382	1,3	1,2	1,3

Based on the measurement results in Table (11), it can be seen that the Booster Pump, Filter Pump, and Return Heat Pump use 3-phase electricity. So, the average voltage and current are used in each pump unit to determine the pump's efficiency. With nameplate data and measurement results on the pump, the pump efficiency can be calculated, and in the same way, other calculation results can be seen in the table (12).

Calculating Booster Pump Input Power 1:

$$P_{in} = (1,73 \times V \times I \times \cos \phi) / (1000)$$

$$P_{in} = (1,73 \times 381,7 \times 10,5 \times 0,9) / (1000)$$

$$P_{in} = 6,25 \text{ kW}$$

Calculating Booster Pump Load Factor 1:

$$LF = (V_{in} \times I_{in}) / (V_{np} \times I_{np})$$

$$LF = (381,7 \text{ V} \times 10,5 \text{ A}) / (380 \text{ V} \times 4,5 \text{ A})$$

$$LF = 2,34$$

Calculating Booster Pump Motor Efficiency 1:

$$\eta_m = (P_{np} \text{ (kW)} \times LF) / (P_{in} \text{ (kW)}) \times 100 \%$$

$$\eta_m = (2,20 \text{ kW} \times 2,34) / (6,25 \text{ kW}) \times 100 \%$$

$$\eta_m = 82,53 \%$$

Calculating the Hydraulic Power of Booster Pump 1:

$$P_h = (Q \times H \times \rho \times g) / (1000)$$

$$P_h = (10 \text{ [m] } ^3 / \text{h} \times 48,3 \text{ m} \times 1000 \text{ kg/m}^3 \times 9,81 \text{ m/s}^2) / (1000)$$

$$= (0,002778 \text{ m}^3 / \text{s} \times 48,3 \text{ m} \times 1000 \text{ kg/m}^3 \times 9,81 \text{ m/s}^2) / (1000)$$

$$P_h = 1,32 \text{ kW}$$

Calculating Booster Pump Shaft Power 1:

$$P_s = P_{in} \text{ (kW)} \times \eta_m$$

$$P_s = 6,25 \text{ kW} \times 85,9 \%$$

$$P_s = 5,37 \text{ kW}$$

Calculating Booster Pump Efficiency Pump 1:

$$\eta_p = (P_h \text{ (kW)}) / (P_s \text{ (kW)})$$

$$\eta_p = (1,32 \text{ kW}) / (5,37 \text{ kW})$$

$$\eta_p = 24,53 \%$$

Table 12. Pump Efficiency Calculation Results

Pump	P _{in} (kW)	P _h (kW)	P _s (kW)	η _m (%)	η _p (%)
Booster Pump	6,25	1,32	5,37	82,53	24,53
	4,39	1,32	3,77	82,53	34,89
	7,62	1,32	6,54	82,53	20,12
Fillter Pump	1,37	0,87	1,15	80,39	66,78
	1,39	0,87	1,17	80,39	66,99
Irrigation Pump	1,72	0,67	1,30	64,15	52,04
	1,71	0,67	1,28	64,15	52,52
Heat Pump	0,83	0,30	0,53	58,57	56,40
	0,90	0,30	0,58	58,57	52,11
Return Heat Pump	0,77	0,21	0,49	61,90	42,86
	0,75	0,21	0,48	61,90	44,07

It can be seen that the decrease in pump efficiency is in the booster pump, irrigation pump, heat pump, and return heat pump. It could happen because of the heavy work of the pump to transfer water throughout the hotel building, compared to the filter pump, which has a reasonably close working distance.

Table 13. Recommended actions for decreasing pump efficiency

Pump Efficiency Criteria (η_p)	Action
$\eta_p > 60\%$	The pump is still good. No action is required.
$\eta_p = 55\% - 60\%$	Impeller resetting, cleaning
$\eta_p = 50\% - 55\%$	Reconditioning, impeller repair, and readjustment
$\eta_p < 50\%$	Total overhaul of the impeller or overall pump replacement

To get the amount of PHE if the efficiency below the nameplate standard is increased again, it is necessary to do calculations by comparing the old efficiency with the efficiency of the nameplate. This method can be calculated as follows:

Calculating the kWh savings on booster pump 1:

$$S = P_i \times t \times (1 - (\eta_a)/(\eta_o))$$

$$S = 6,25 \text{ kW} \times 1 \text{ hour} \times (1 - (24,53)/(68,7))$$

$$S = 4,02 \text{ kWh}$$

Table 14. Electricity Savings On Water Pump Efficiency

Description	Nameplate		η_m (%)	η_p (%)	S_{np} (kWh)
	η_m (%)	η_p (%)			
Booster Pump	85,9	68,7	82,53	24,53	4,02
	85,9	68,7	82,53	34,89	2,16
	85,9	68,7	82,53	20,12	5,38
Fillter Pump	84,2	67,5	80,39	66,78	0,01
	84,2	67,5	80,39	66,99	0,01
Irrigation Pump	75,2	60	64,15	52,04	0,34
	75,2	60	64,15	52,52	0,33
Heat Pump	63,9	60	58,57	56,40	0,10
	63,9	60	58,57	52,11	0,17
Return Heat Pump	64,0	58,0	61,90	42,86	0,20
	64,0	58,0	61,90	44,07	0,18

Because the pump lives alternately, the PHE calculation will use the average data on each pump function. For example, for a booster pump with savings in unit 1 of 4.04 kWh, unit 2 of 2.16 kWh, and unit 3 of 5.38 kWh, the average yield is 3.85 kWh. In the same way for other pumps using the average yield, the total savings amounted to 4.36 kWh.

Energy Saving Opportunities in Water Heaters

Tanadewa Resort and Spa Ubud uses a Water Heat Pump and Electric Water Heater as water heaters to meet its hot water needs. Heat pumps are used on the 5th-floor building, while Electric

Water heaters are used in villa buildings, spas, and pool bars. The following are the nameplates of the Heat Pump and Electric Water Heater used at Tanadewa Resort and Spa:

The efficiency can be calculated based on the measurement results of the Electric Water Heater in villa 1 in the table (15). In the same way, other efficiency calculation results can be seen in the table (15).

Calculating the input power of Electric Water Heater Villa 1:

$$P_{in} = V \cdot I \cdot t$$

$$P_{in} = 231 \text{ V} \cdot 5,3 \text{ A} \cdot 1 \text{ hour}$$

$$P_{in} = 1,10 \text{ kWh}$$

Calculating the Output Power of Electric Water Heater Villa 1:

$$P_{out} = m \cdot c \cdot \Delta T (T_2 - T_1)$$

$$P_{out} = 150 \text{ liter} \cdot 4179 \cdot \Delta T (65^\circ\text{C} - 26^\circ\text{C})$$

$$P_{out} = 150 \text{ liter} \cdot 4179 \text{ J/kg}^\circ\text{C} \cdot 39^\circ\text{C}$$

$$P_{out} = 24.447.150 \text{ Joule}$$

$$P_{out} = 0,68 \text{ kWh}$$

Calculating the Efficiency of Electric Water Heater Villa 1:

$$\eta = \frac{P_{out} (\text{kWh})}{P_{in} (\text{kWh})} \times 100 \%$$

$$\eta = \frac{0,68 \text{ kWh}}{1,10 \text{ kWh}} \times 100 \%$$

$$\eta = 61,63 \%$$

In the Electric Water Heater efficiency table, it can be seen that some units have decreased compared to the efficiency on the nameplate. Increased efficiency can be achieved by regular unit maintenance and cleaning of the elements. In addition, some things can be done to save on the hotel water heating system as follows:

1. Schedule regular maintenance to avoid wasting electrical energy in the event of unknown machine failure that can reduce efficiency.
2. Ensure the automatic breaker works correctly to avoid continuous heating resulting in a waste of electrical energy.
3. Ensure that the materials used for hot pipes, channels, and covers have been in good condition.
4. Prevent the formation of crust accumulation in heating tubes that block the process of heating water.
5. Setting the hot water temperature for guest rooms is usually sufficient at approximately 60°C .

To get PHE results on increasing the efficiency of the Electric Water Heater, it is necessary to do calculations by comparing the old efficiency with the efficiency of the nameplate.

Savings on increased efficiency of Electric Water Heater Villa 1:

$$S = P_i \times t \times (1 - \frac{\eta_a}{\eta_o})$$

$$S = 1,10 \text{ kW} \times 1 \text{ hour} \times (1 - \frac{61,63}{91})$$

$$S = 0,36 \text{ kWh}$$

Table 15. Electricity Savings On Water Heater Efficiency

Location	Nameplate	P in (kWh)	η (%)	S (kWh)
	η (%)			
Villa 1	91	1,10	61,63	0,36
Villa 2	91	1,09	56,26	0,42
Villa 3	91	1,04	55,41	0,41
Villa 4	91	1,08	55,37	0,42
Villa 5	91	1,06	58,11	0,38
Villa 6	91	1,09	58,12	0,39
Villa 7	91	1,08	55,13	0,43
SPA 1	91	1,08	53,74	0,44
SPA 2	91	1,07	62,28	0,34
SPA 3	91	1,10	57,27	0,41
Salon SPA	91	1,04	55,41	0,41
Pool Bar	91	1,10	54,32	0,44
Total Savings				4,48

Table 16. Electrical Energy Consumption After PHE

Electrical Energy Users	Location	Electricity Consumption 2019		
		Daya (W)	LWBP/ Tahun	WBP/ Tahun
Lighting	Room	2.414	1.564	3.128
	Operasional	958	621	1.241
	Office	219	379	-
Air Conditioning	Room	21.245	137.666	27.533
	Operasional	3.383	9.864	-
	Office	2.414	4.694	-
Air Pump	PumpRoom	7.172	15.084	3.017
Water Heater	Room	3.884	25.167	5.033
	Villa	13.982	55.755	11.151
Other Expenses		6.153	39.872	7.974
Total		61.824	290.665	59.078

For the LWBP tariff, a fee of Rp. 1035.78/kWh is charged while WBP is charged at Rp. 1553.67/kWh, then the electricity bill can be calculated as follows:

2019 Electricity Bill After PHE:

$$LWBP = 290.665 \text{ kWh} \times 1.035,78 \text{ Rp/kWh} = \text{Rp. } 301.064.994$$

$$WBP = 59.078 \text{ kWh} \times 1.553,67 \text{ Rp/kWh} = \text{Rp. } 91.787.716$$

$$\text{Total} = \text{Rp. } 301.064.994 + \text{Rp. } 91.787.71 = \text{Rp. } 392.852.710$$

Energy Consumption Intensity (IKE) Hotel After PHE

The total electrical energy consumption after PHE [12] in 2019 was 349,743 kWh / year. With the same average occupancy and area, the value of Energy Consumption Intensity (IKE) in 2019 can be determined as follows:

$$IKE = \frac{349.743 \text{ kWh/tahun}}{(45,53\% \times 1924,03 \text{ m}^2) + (1286,87 \text{ m}^2)}$$

$$IKE = 161,70 \text{ kWh/m}^2/\text{tahun}$$

Table 17. Electricity consumption before and after PHE

kWh/tahun	Electricity Bill	IKE	Category
Sebelum PHE			
480.740	Rp. 596.658.997	222,56	Extrava gant
Setelah PHE			
349.743	Rp. 392.852.710	161,70	Quite Efficien t

Calculating Electrical Energy Consumption After PHE

To calculate the amount of electrical energy consumption, it is necessary to pay attention to LWBP (Outside Peak Load Time) and WBP (Peak Load Time). LWBP usage is measured from 22.00 – 18.00 (20 hours), and WBP usage is measured from 18.00 – 22.00 (4 hours). In this calculation, usage patterns will be used according to the recommendations in Table (4.13) and Table (4.21). For PHE based on increased efficiency, it will be subtracted by the result of savings, for example, calculating electricity consumption at a water pump after PHE:

$$Konsumsi Listrik = \frac{7.172 \text{ W} \times 0,9 \times 1}{1000} = 6,45 \text{ kWh}$$

$$6,45 \text{ kWh} - 4,36 \text{ kWh (PHE Pompa Air)} = 2,09 \text{ kWh}$$

$$LWBP = 2,09 \text{ kWh} \times 20 \text{ j} = 41,90 \text{ kWh}$$

$$WBP = 2,09 \text{ kWh} \times 4 \text{ jam} = 8,38 \text{ kWh}$$

$$LWBP = 41,90 \text{ kWh} \times 30 \text{ hari} = 1.256,99 \text{ kWh}$$

$$WBP = 8,38 \text{ kWh} \times 30 \text{ hari} = 251,40 \text{ kWh}$$

$$LWBP = 1.256,99 \text{ kWh} \times 12 \text{ bulan} = 15.084 \text{ kWh}$$

$$WBP = 251,40 \text{ kWh} \times 12 \text{ bulan} = 3.017 \text{ kWh/tahun}$$

Conclusions

Based on the results of calculations and analysis that have been carried out, several things can be concluded as follows:

1. The IKE value is obtained by comparing electrical energy consumption (kWh / year) and the building area according to hotel occupancy levels. The IKE value at Tanadewa Resort And Spa Ubud in 2019 was 222.26 kWh/m²/year, and in 2020 is 170 kWh/m²/year. These results follow IKE ASEAN-USAID standards on hotel building types. Based on the IKE standard for air-conditioned buildings, electricity consumption in 2019 was somewhat wasteful, and in 2020, it was pretty efficient.
2. Energy Saving Opportunities (PHE) at Tanadewa Resort and Spa Ubud are obtained from analyzing each electrical energy user system. Savings on electricity bills in 2019 after PHE amounted to Rp. 203,806,287. For the IKE value of Air-conditioned Buildings in 2019 after PHE has increased from the Somewhat Wasteful category to Quite Efficient.

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