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Energy Efficiency Analysis of Computing Equipment: A Case Study at the Faculty of Engineering, Udayana University

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ABSTRACT

Energy efficiency in universities is a crucial component of national and regional strategies to reduce energy consumption and environmental impact. This is supported by regulations such as Presidential Regulation No. 33/2023 and the Bali Governor's Circular Letter, as well as the Bali Clean Energy Program, which promotes the use of energy-saving devices and renewable energy in the education sector. This study employs a descriptive quantitative approach, conducting a comprehensive inventory and direct observation of 609 computing devices at the Faculty of Engineering, Udayana University, Jimbaran. Data analysis includes statistical descriptive methods and interviews to evaluate compliance with the Energy Star standard and alignment with existing energy policies. The inventory revealed that 74% (448 units) of the computing devices (desktops, laptops, printers, scanners) were Energy Star certified. However, a significant implementation gap was identified, as all network devices (routers and access points) and projectors (totaling 161 units) lacked energy efficiency certifications. The estimated annual energy consumption cost for these devices ranges from approximately Rp 106 million (under a 4-hour usage scenario) to Rp 218 million (under an 8–10 hour usage scenario). While adherence to energy efficiency standards is high for core computing equipment, there is a notable gap in policy implementation for peripheral devices like projectors and network infrastructure. The study recommends the proactive procurement of energy-efficient devices across all categories and the implementation of periodic energy audits to enhance sustainability efforts and achieve significant cost savings within the university.

Keywords: *energy efficiency, electronic devices, policy, Energy Star, Bali Clean Energy*

INTRODUCTION

Improving energy efficiency is the main agenda in overcoming the challenge of meeting increasing energy needs and reducing the environmental impact due to excess energy consumption (Bee et al., 2025; Erdogdu, Dayi, Yanik, Yildiz, & Ganji, 2025). The higher education sector, as one of the significant users of energy, has a strategic role in adopting energy-saving practices through the efficient management of electronic devices and technological infrastructure (Franco, Crisostomi, Leccese, Mugnani, & Suin, 2025; Quispe, Viveros Mira, Chamorro Díaz, Castrillón Mendoza, & Vidal Medina, 2025). Universities are not only a center for learning and research, but also as a model for implementing sustainable energy policies in society (Oh, Park, & Baek, 2025; Vettriselvan & Ramya, 2025).

Various national regulations, such as Presidential Regulation No. 33 of 2023 concerning Energy Conservation, provide a legal framework that supports the implementation of energy efficiency (Iavorschi, Milici, Ifrim, Ungureanu, & Bejenar, 2025; Oluokun, Akinsooto, Ogundipe, & Ikemba, 2025). At the regional level, Bali Governor Regulation Number 45 of 2019 concerning Bali Clean Energy, Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 14 of 2021 concerning the Implementation of Minimum Energy Performance Standards for Energy Utilization Equipment, which requires the use of energy-efficient labeled electrical devices in government agencies and educational institutions, in line with the Bali Clean Energy program which encourages the use of renewable

energy and reduces dependence on materials burn fossils. Although the policy already exists, the level of implementation in the university environment still needs to be studied in depth to identify opportunities and obstacles in the implementation of energy-saving devices (Marfo, Bondinuba, & Mewomo, 2025; Widyastomo, Simbiak, & Nion, 2025).

Several previous studies have addressed energy efficiency in educational and office settings (Chaer, Ozarisoy, Ismail, Salari, & Zhihui, 2025; Wu et al., 2025). For example, conducted an energy audit in a university setting and highlighted significant savings potential through equipment upgrades. Evaluated the impact of Energy Star-certified devices on reducing electricity consumption in office buildings, demonstrating a 15-20% reduction. Studied behavioral interventions to promote energy-saving habits among staff and students in a campus environment (Mesloub, Alghaseb, & Al-Sabhan, 2025). Additionally, analyzed the gap between energy policy and its implementation in public institutions, identifying lack of monitoring and budget as key barriers. However, few studies have focused specifically on computing equipment efficiency within Indonesian universities, particularly in the context of local energy regulations such as Bali Clean Energy (Aditya, Wijayanto, & Hakam, 2025; Afrianto, Salsabillah, & Hariyanto, 2025).

This research is urgent for several reasons. First, it supports national and regional energy conservation targets, including Indonesia's commitment to reducing greenhouse gas emissions (Putri, Karimi, Ridwan, & Muharja, 2025; Veza, Wiranegara, Ghazali, & Tirta, 2025). Second, universities, as large energy consumers, have a responsibility to lead by example in sustainable practices (Haldorai, Kim, & Phetvaroon, 2025; Panait, Ionescu, Hysa, & Blessinger, 2025). Third, rising electricity costs pose a financial burden on universities; improving energy efficiency can lead to significant budget savings (Franco et al., 2025; Mathew, Janet, Zik, & Isaac, 2025). Finally, there is a pressing need to assess the implementation of energy policies at the institutional level to ensure alignment with national and regional goals.

This study offers novelty by focusing specifically on computing and network equipment within an Indonesian university context, using a case study approach to evaluate compliance with Energy Star standards and local energy policies. Unlike previous studies, this research combines device-level inventory analysis with policy evaluation, providing a practical framework for monitoring and improving energy efficiency in higher education institutions. It also introduces a dual-scenario energy consumption model (8–24 hours and 4–24 hours) to estimate potential savings, which has not been widely applied in similar contexts.

This research focuses on the inventory of computing devices on campus as well as the evaluation of conformity to the Energy Star efficiency standard. The findings obtained are expected to be a reference for the development of more effective energy management policies and support environmental sustainability efforts in the higher education sector.

METHOD

This research was carried out within the Faculty of Engineering, Udayana University Jimbaran. The implementation of this research started from November 2022 to April 2023. This research was conducted with a descriptive quantitative approach with direct observation techniques. Data was collected from all computing and network equipment at the Faculty of Engineering Jimbaran. Each piece of equipment is listed by type (desktop, laptop, printer, scanner, projector, router and access point), number of units, and Energy Star label status. The

analysis was carried out statistically descriptive and interviews, then the results were compared with provisions in national and regional policies.

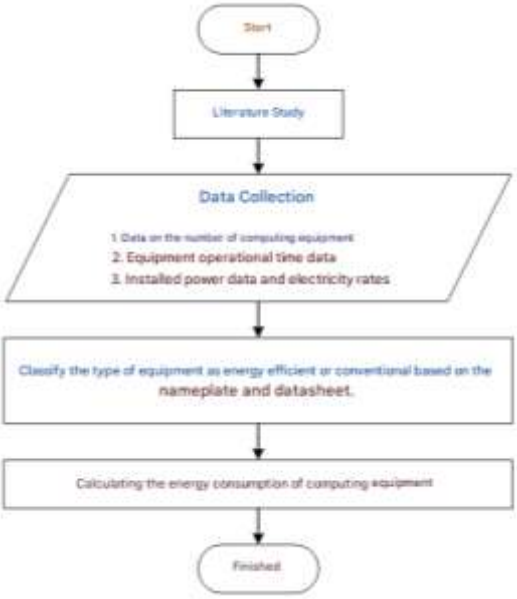

Figure 1. Research Stage Flow Chart
Source: Research Documentation (2023)

RESULTS AND DISCUSSION

Computer Equipment, Faculty of Engineering, Udayana University. In Table 1, you can see the existing data of Computing Equipment contained in the Building/Study Program of the Faculty of Engineering Jimbaran, including Desktop/PC, Laptop, Printer, Scanner, LCD Projector, Router and Access Point.

Table 1. Existing Data of Building Computing Devices/Study Programs, Faculty of Engineering, Jimbaran

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Jimbaran's Faculty of Engineering	Desktop/PC	343	339	4
	Laptop	22	21	1
	Printers	86	85	1
	Scanners	3	3	0
	LCD projector	66	0	66
	Router	27	0	27
	Access Points	62	0	62
Total		**609**	**448**	**161**

Source: Primary Data, Direct Observation and Inventory (2023)

A. Existing Conditions of the Architectural Engineering Study Program

Table 2. Data of Computing Devices of the Architecture Study Program

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Architecture	Desktop/PC	44	44	0
	Laptop	5	5	0
	Printers	8	0	0
	Scanners	0	0	0
	LCD projector	2	0	2
	Router	27	0	3
	Access Points	3	0	11
Total		73	57	**16**

Source: Primary Data, Direct Observation and Inventory (2023)

B. Existing Conditions of the Electrical Engineering Study Program

Table 3. Data of Computing Devices of the Electrical Engineering Study Program

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Teknik Elektro	Desktop/PC	44	0	0
	Laptop	0	1	0
	Printers	8	2	0
	Scanners	1	0	0
	LCD projector	9	0	2
	Router	3	0	3
	Access Points	3	0	11
Total		86	3	**16**

Source: Primary Data, Direct Observation and Inventory (2023)

C. Existing Conditions of Industrial Engineering Study Program

Table 4. Data on Computing Devices for Industrial Engineering Study Program

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Industrial Engineering	Desktop/PC	0	0	0
	Laptop	1	1	0
	Printers	2	2	0
	Scanners	0	0	0
	LCD projector	7	0	7
	Router	0	0	0
	Access Points	1	0	1
Total		11	3	8

Source: Primary Data, Direct Observation and Inventory (2023)

D. Existing Conditions of Information Technology Study Program

Table 5. Data on Computing Devices of the Information Technology Study Program

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Information Technology	Desktop/PC	90	90	0
	Laptop	3	3	0
	Printers	11	11	0
	Scanners	1	1	0
	LCD projector	16	0	16
	Router	2	0	2
	Access Points	15	0	13
Total		138	105	33

Source: Primary Data, Direct Observation and Inventory (2023)

E. Existing Conditions of the Mechanical Engineering Study Program

Table 6. Computing Device Data of the Mechanical Engineering Study Program

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Mechanical Engineering	Desktop/PC	62	59	0
	Laptop	0	0	0
	Printers	9	9	0
	Scanners	0	0	0
	LCD projector	7	0	7
	Router	7	0	7
	Access Points	15	0	15
Total		100	105	32

Source: Primary Data, Direct Observation and Inventory (2023)

F. Existing Conditions of Civil Engineering Study Program

Table 7. Data of Computing Devices of the Civil Engineering Study Program

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Civil Engineering	Desktop/PC	51	51	0
	Laptop	7	6	1
	Printers	17	16	1
	Scanners	1	1	0
	LCD projector	23	0	23
	Router	10	0	10
	Access Points	11	0	11
Total		120	74	46

Source: Primary Data, Direct Observation and Inventory (2023)

G. Existing Condition of the Dean of the Faculty of Engineering UNUD

Table 8. Data of Computing Devices of the Dean of the Faculty of Engineering UNUD

Study Program/Building	Device Type	Total	Energy Star (EPA)	
			Already	Not yet
Dekanat FT	Desktop/PC	34	34	0
	Laptop	6	6	0
	Printers	31	31	0
	Scanners	0	1	0
	LCD projector	2	0	2
	Router	2	0	2
	Access Points	6	0	6
Total		81	71	10

Source: Primary Data, Direct Observation and Inventory (2023)

Electrical Energy Consumption The calculation of electrical load consumption is used to determine the cost of using electrical energy. This is an equation to calculate electrical energy consumption per day:

$$Energy\ Use\ (kWh) = \frac{Power\ x\ Usage\ Period}{1000} \quad (1)$$

To find out the cost of using electrical energy, it can be calculated using this equation:

$$Usage\ Cost\ (Rp) = W(kWh) \times Electricity\ Base\ Cost \quad (2)$$

The following is a table of data on the overall electrical energy consumption of Buildings/Study Programs within the Faculty of Engineering Jimbaran with an on-turn time of 8 – 24 hours.

Table 9. Electrical Energy Consumption in Buildings/Study Programs of the Faculty of Engineering Jimbaran

No	Building / Study Program	Total Power (W)	Ignition Time (Hours)	Used Energy (kWh)
1	Architecture	13.099	9 – 24	120
2	Electrical Engineering	16.481	9 – 24	150
3	Industrial Engineering	2.415	9 – 24	22
4	Mechanical Engineering	9.273	10 – 24	98
5	Information Technology	23.550	8 – 24	191
6	Civil Engineering	23.334	8 – 24	192
7	Dean of the Faculty	18.060	8 – 24	146
	Total	106.213	—	919

Source: Primary Data, Direct Observation and Inventory (2023)

Based on Table 9. The total power of the Building/Study Program within the Faculty of Engineering Jimbaran is obtained a total power of 106,213 Watts, then with different time lights starting from 8-24 hours, based on the type of equipment (Desktop/PC, Laptop, Printer,

Scanner, LCD Projector operates for 8-10 hours and Access Point and Router operate for 24 hours) per day. In addition, the operational time in each building/study program is different. The determination of the operational time range of 8 to 24 hours was obtained based on information collected through interviews with employees in each building/study program at the Faculty of Engineering Jimbaran, Udayana University.

Furthermore, the total electrical energy used per kWh in one day is 919 kWh with the basic electricity tariff for transformer power capacity of 105 kVA and 197 kVA for the S-2 category is Rp 900/kWh. Therefore, the consumption cost of using electrical energy in computing equipment based on the results of existing data is as follows in the table of 10 Energy used in 1 Day, 22 Days and 12 Months (8 – 24 Hours).

Table 10. Energy used in 1 Day, 22 Days and 12 Months (8 – 24 Hours)

No	Building / Study Program	Energy Used/Day (kWh)	Basic Electricity Tariff (IDR)	Total Daily Cost 1 Day (IDR)	Total Monthly Fee 22 Days (IDR)	Total Annual Fee 12 Months (IDR)
1	Architecture	120	900	108.000	2.376.000	28.512.000
2	Electrical Engineering	150	900	135.000	2.970.000	35.640.000
3	Industrial Engineering	22	900	19.800	435.600	5.227.200
4	Mechanical Engineering	98	900	88.200	1.940.400	23.284.800
5	Information Technology	191	900	171.900	3.781.800	45.381.600
6	Civil Engineering	192	900	172.800	3.801.600	45.619.200
7	Dekanat FT	146	900	131.400	2.890.800	34.689.600
Total		**919**	**900**	**827.100**	**18.196.200**	**218.354.400**

Source: Primary Data, Direct Observation and Inventory (2023)

Based on table 10. that the total cost (Rp) of electricity paid based on the results of table calculations at the Building/Study Program of the Faculty of Engineering Jimbaran, Udayana University, is for 1 day of Rp 827,100, for 22 days of Rp 18,196,200, and for 1 year of Rp 218,354,400. However, if it is assumed for reality that the use of computing equipment does not fully work based on the on-time in Table 9. because the use of relatively random equipment to be used, such as: Desktop/PC, Laptop, Printer, Scanner, and LCD Projector does not fully work actively, because this equipment works based on the user (User) of the equipment, if it is assumed that this equipment works actively for 4 hours, the results of electrical energy consumption are obtained as follows:

Table 11. Results of Assumption of Electrical Energy Consumption (4 – 24 hours) in the Building/Study Program of the Faculty of Engineering Jimbaran

No	Building / Study Program	Total Power (W)	Ignition Time (Hours)	Used Energy (kWh)
1	Architecture	13.099	9 – 24	120
2	Electrical Engineering	16.481	9 – 24	150

3	Industrial Engineering	2.415	9 – 24	22
4	Mechanical Engineering	9.273	10 – 24	98
5	Information Technology	23.550	8 – 24	191
6	Civil Engineering	23.334	8 – 24	192
7	Dekanat FT	18.060	8 – 24	146
	Total	**106.213**		**919**

Source: Primary Data, Direct Observation and Inventory (2023)

Based on Table 11. The results of the Assumption of Electrical Energy Consumption working for 4-24 hours were obtained The total power of the Building/Study Program within the Faculty of Engineering Jimbaran was obtained a total power of 106,213 Watts, then based on the type of equipment (Desktop/PC, Laptop, Printer, Scanner, LCD Projector operates for 4 hours and Access Point and Router operating for 24 hours) per day obtained a daily energy consumption of 450 kWh.

Furthermore, the calculation of electrical energy consumption using the basic electricity tariff for the transformer power capacity of 105 kVA and 197 kVA for the S-2 category is Rp 900/kWh will be calculated using the formula of equation 2 and carried out in Microsoft excel software. Therefore, the consumption cost of using electrical energy in computing equipment based on the results of existing data is as follows in the table of 11 Energy used in 1 Day, 22 Days and 12 Months (4 – 24 Hours) as follows.

Table 12. Energy used in 1 Day, 22 Days and 12 Months (4 – 24 Hours)

No	Building / Study Program	Energy Used/Day (kWh)	Basic Electricity Tariff (IDR)	Total Daily Cost 1 Day (IDR)	Total Monthly Fee 22 Days (IDR)	Total Annual Fee 12 Months (IDR)
1	Architecture	120	900	108.000	2.376.000	28.512.000
2	Electrical Engineering	150	900	135.000	2.970.000	35.640.000
3	Industrial Engineering	22	900	19.800	435.600	5.227.200
4	Mechanical Engineering	98	900	88.200	1.940.400	23.284.800
5	Information Technology	191	900	171.900	3.781.800	45.381.600
6	Civil Engineering	192	900	172.800	3.801.600	45.619.200
7	Dekanat FT	146	900	131.400	2.890.800	34.689.600
	Total	**450**	**900**	**405.000**	**8.910.000**	**106.920.000**

Source: Primary Data, Direct Observation and Inventory (2023)

Based on table 10. that the total cost (Rp) of electricity paid based on the results of table calculations at the Building/Study Program of the Faculty of Engineering Jimbaran, Udayana University, is for 1 day of Rp 405,000, for 22 days of Rp 8,910,000, and for 1 year of Rp 106,920,000.

CONCLUSION

Based on the electrical energy consumption data of computing devices at the Faculty of Engineering Jimbaran, Udayana University, the total power usage is estimated at 106,213 Watts, resulting in 919 kWh per day. Under an 8–10 hour daily operation for desktops, laptops, printers, scanners, and LCD projectors—with network devices running 24 hours—the electricity cost is approximately Rp 827,100 per day, Rp 18,196,200 per 22 working days, and Rp 218,354,400 annually. If the core devices operate only 4 hours daily while the network devices remain operational 24 hours, the daily consumption cost drops to about Rp 405,000, amounting to Rp 8,910,000 per 22 days and Rp 106,920,000 annually. Future research could explore the impact of energy-saving policies or behavioral interventions on reducing operational hours and their effectiveness in lowering energy consumption and costs across university computing infrastructure.

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