# Air-Conditioning for Green Universities

## Cost Management and Sustainability via HVAC Energy Savings

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**Abstract.** University is one of the highest energy consumptions among commercial buildings because the university has high load consumption. So, strategic management of energy saving in universities needs to be considered to reduce costs and energy consumption. Actually, there are many methods to save electricity consumption in university (community load system) from electrical sides and building design construction and human behaviors. Another thing is that energy consumption can be reduced by making green university. Some methods that can reduce energy in university are using conservation voltage reduction methods, utilizing IoT devices and smart technology instead of outdated electrical equipment, and installing renewable energy technology such as solar PV on campus. This paper reviews some methods that can save energy consumption and electricity bills as a background. The cost-effectiveness analysis was done by installing individual AC in universities. The experiment was done over 15 days with 8 h per day and energy savings can be found in 10,624 kWh with a cost-saving was 45,683 Baht for 15 days. The payback period was 1.6 years. According to these results, individual air-conditioning systems can be used instead of chiller systems in universities to save energy. This is the way of making the university become a green campus and sustainable.

**Keywords:** energy savings · strategic management · cost-effectiveness analysis · university energy consumption · chiller systems

## 1 Introduction

These days, energy-related issues, especially energy efficiency, have become a hot topic and a major concern. Energy efficiency refers to using less energy to provide the same service [1]. High energy efficiency can reduce energy consumption. That is why energy efficiency is essential to be considered as a major effort to reduce cost and energy consumption. University buildings are high energy consumption under the category of commercial buildings, due to their activities and population [2]. The major energy consumption takes place in buildings and environmental consequences in universities [3]. Environmental problems such as the emission of carbon dioxide contributing to global warming have become the main issue [4]. As a result, universities must take this issue seriously and implement energy management plans and strategies to achieve better


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energy efficiency, reducing the electricity bill. Many students, academic and administrative staff, researchers, and others work or study in universities; thereby, a large amount of energy is needed for operations, including student and staff dormitories, chiller systems, library, car parks, laboratories, sports areas, and offices, which looks like to "mini-city" [5]. Hence, the university requires a good energy management strategy to reduce costs and environmental impacts [6].

The potential for effective and efficient energy use is typically quite low due to outdated buildings and other sources of energy waste on the campus. As a result, it is critical to examine energy consumption patterns on the campus to figure out how to improve energy efficiency [7]. Due to the high energy consumption, energy-saving strategies have become essential to consider in most universities. Therefore, this paper will investigate an efficient energy-saving strategy.

According to Deshko and Shevchenko [8], energy certification is one of the most important measures to increase the energy efficiency of university buildings. According to the report, the university buildings are divided into different categories, and all require various methods for energy certification. Selection of determining factors, data collection and verification, distribution of the university buildings by types, adaptation and normalization of energy consumption data, development of an energy consumption and efficiency assessment scale, and finally, selection of the best optimal variant are the methodology chosen for the energy efficiency assessment. Faghihi et al. [9] investigated the relationship between the university buildings' energy savings and the funds required to implement these savings. Financing is found as the biggest obstacle for corporations in creating and implementing sustainable development projects. Energy efficiency and conservation were chosen as the two primary factors for enhancing sustainability. The study found that energy efficiency and conservation save money; however, the latter requires maintenance to extend the energy-saving methods because it deals with human behavior, which is not uniform. Finally, they created a dynamics model to understand better sustainability programs resulting in increased energy and financial savings.

In another study, Zhou et al. [10] revealed that private institutions consume more energy per student or building area than public universities due to better teaching and research settings. As a result, these universities have a lot of energy-saving potential. The study found five significant energy conservation strategies in the university buildings, including electricity sub-metering, renewable energy usage, and the installation of energy-saving appliances, among many others. At National Taiwan University, Guo [11] and Wei [11] investigated BIM technology (eQUEST) to undertake an energy consumption study and simulated the re-design of the civil engineering research building. After creating a verifiably accurate simulation, the consequences of changing the building's design were studied. Furthermore, during the design scheme optimization process, cost remains critical in reflecting the relationship between construction expenses and energy efficiency. In the future, the findings of this study may help building owners, designers, and developers make better and more complete decisions. BIM technology has the potential to eliminate design errors and increase overall design efficiency. BIM technology has the potential to eliminate design errors and improve overall design efficiency. The feasibility of the proposed strategy was also examined concerning cost changes and the economic benefits of energy efficiency.

Sunday et al. [12], who did the walk-through energy audit method, revealed the potential for energy savings on Covenant University's selected buildings. Many cases exist where the loading of equipment and appliances on a building was relatively high, resulting in reconstructions that resulted in the buildings having more offices and laboratories than they were originally designed to accommodate, thereby increasing the load and energy demand on the building. Economic and environmental analysis showed that by replacing inefficient bulbs with LED bulbs and installing solar panels, over $81,000 could be saved annually with a payback time of fewer than 6 years. Shafie et al. [13] examined the energy consumption trend in Universiti Utara Malaysia to help the university achieve more efficient energy use across the whole. The initiatives include improving energy awareness, garnering senior management commitment, formulating energy-saving rules, and encouraging students, employees, and lecturers to conserve energy. However, human-related behaviors and activities are the key contributors to high energy consumption.

Kyaw [14] evaluated installing solar PV panels such as rooftop PV, ground mount PV, and floating PV systems in the Asian Institute of Technology, Thailand. Helioscope software was used to find the potential for installing the solar PV system. Techno-economic analysis was done for the three types of the system. Among all systems, the ground mount system can offset a huge amount of the energy consumed by 70% annually and give the cheapest energy cost as 2.1 THB/kWh with a payback period of 4.2 years.

## 2 Methodology

In this paper, one of the possible methods of energy saving will be described as analyzing the cost-effectiveness of replacing chiller systems with individual air conditioning systems in universities. In the case of a chiller air conditioning system, the cooling and heating rejection occurs at various locations, but in individual systems, both take place in the unit itself [15]. Step by step flowchart of the methodology can be seen in Fig. 1.

## 3 Results and Discusion

According to the flowchart of methodology, the following results can be evaluated in this paper.

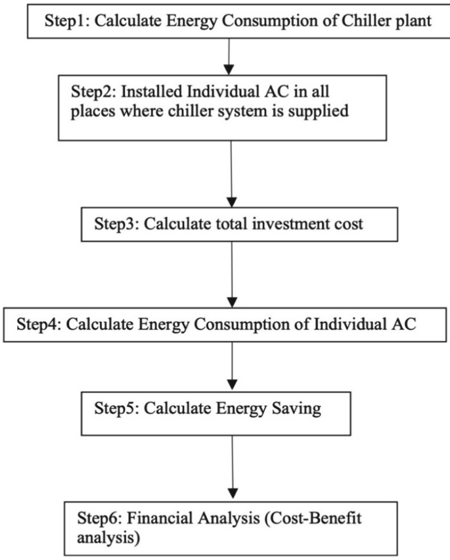


**Fig. 1.** Flowchart of the methodology

### 3.1 Various Types of Chiller Systems and Individual AC System

Typically, there are three types of chiller systems such as package chiller (1–30 Ton), screw type chiller (50–900 Ton), and centrifugal chiller (150–6000 Ton). There are several types of individual air conditioning systems: window, split, portable, package terminal, package air conditioner, single package rooftop systems, and variable refrigerant flow split systems. In this paper, the chiller systems currently used is a centrifugal chiller, and replaced that chiller to split type of individual air conditioning system.

### 3.2 Cost-Effectiveness Analysis

The data was collected from the university's office, and the energy consumption of the chiller plant was 92,921 kWh per month and 19,840 kWh per 15 days. Energy consumption of individual AC was 9,216 kWh for 15 days. The rate of electric charges was 4.3 Baht per unit. So, the cost will be calculated by multiplying energy consumption and per unit charges. The investment cost of chiller systems includes compressors, auxiliaries, distribution networks such as piping and insulation, and the installation cost of the chiller plant. The investment cost of an individual air-conditioning system includes the cost of indoor and outdoor units, installation cost, and VAT. Energy-saving and cost-saving can be calculated by subtracting the energy and cost of the chiller plant with individual air-conditioning. Finally, the payback period was evaluated total investment by total cost savings (Table 1).

**Table 1.** Cost-effectiveness analysis

| | Chiller plant system | Individual AC |
|---|---|---|
| Operating hours (hr) | 8 | 8 |
| Operating days | 15 | 15 |
| kWh/month | 92,921 for 24 h | - |
| Baht/month | 399,560 for 24 h | - |
| kWh/15days | 19,840 | 9,216 |
| Baht/15days | 85,312 | 39,629 |
| Total investment cost (Baht) | 4,927,414 | 1,808,064 |
| Energy-saving (kWh) | - | 10,624 for 15 days |
| Cost-saving (Baht) | - | 45,683 for 15 days |
| Cost-saving (Baht/year) | - | 1,111,620 for 1 yr |
| Payback period (years) | - | 1.6 |

## 4 Conclusion

The results show that the installation of individual AC is more reliable than using a chiller plant when the load consumption is less. Chiller plant has high installation and maintenance costs. Moreover, technologies are improving nowadays, and individual AC has become compact and popular for commercial. Individual AC can adjust the temperature that the consumer wants, and they are environmentally friendly. If the users want to reduce their electricity bills, they can switch on the smart saver embedded as one of the individual air conditioning system's features. However, the chiller plant has a lifetime advantage, which can endure for approximately 10 years. The main idea of this paper is the energy-saving of HVAC systems in universities to make them sustainable and green campuses. There are many ways still left to implement to save energy in university. The study's results show that a decentralized system's energy consumption is lower than a centralized system, with a payback period of 1.6 years.

For the future study, by using the advanced home monitoring systems and IoTs, the whole building consumption can be monitored in real-time to know which appliances consume the higher energy. Inefficient and old appliances should be replaced with new appliances that have better efficiency. The upfront cost for this type of transformation is higher in some cases, but it can save a lot of energy and electricity bills in the long term. Moreover, smart communication technologies can be controlled via mobile or website through internet connections. Therefore, energy consumption can be reduced, and the organization can save energy costs. Furthermore, according to these findings, the research team will provide information on a university's specific operational needs to the manufacturers' research and development teams and provide information to entrepreneurship centers of the universities to initiate start-up businesses linked with green initiatives. Also, the information will be used by the management team for future purchasing or classroom design stages.

## References


1. Napp, T., Shah, N., Fisk, D., & Clark, D. (2012). What's energy efficiency and how much can it help cut emissions. *The Guardian, 5*.
2. Bakar, N. N. A. et al. (2014). Sustainable energy management practices and its effect on EEI: A study on university buildings. *Journal of Modern Science and Technology, 2*(1), 1–2.
3. Petersen, J. E., Shunturov, V., Janda, K., Platt, G., & Weinberger, K. (2007). Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education.*
4. Tang, F. E. (2012). An energy consumption study for a Malaysian university. *World Academy of Science, Engineering and Technology, 68*, 1757–1763.
5. Choong, W. W., Chong, Y. F., & Low, S. T. (2012). Implementation of energy management key practices in Malaysian universities. *International Journal of Emerging Sciences, 2*(3), 455.
6. Alshuwaikhat, H. M., & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: Assessment of the current campus environmental management practices. *Journal of Cleaner Production, 16*(16), 1777–1785.
7. Chung, M. H., & Rhee, E. K. (2014). Potential opportunities for energy conservation in existing buildings on university campus: A field survey in Korea. *Energy and Buildings, 78*, 176–182.
8. Deshko, V. I., Shevchenko, O. M., & Farenyk, G. G. (2012). University campuses energy performance estimation in Ukraine based on measurable approach.
9. Faghihi, V., Hessami, A. R., & Ford, D. N. (2015). Sustainable campus improvement program design using energy efficiency and conservation. *Journal of Cleaner Production, 107*, 400–409.
10. Zhou, X., Yan, J., Zhu, J., & Cai, P. (2013). Survey of energy consumption and energy conservation measures for colleges and universities in Guangdong province. *Energy and Buildings, 66*, 112–118.
11. Guo, S. J., & Wei, T. (2016). Cost-effective energy saving measures based on BIM technology: Case study at National Taiwan University. *Energy and Buildings, 127*, 433–441.
12. Oyedepo, S. O., Anifowose, E. G., Obembe, E. O., & Khanmohamadi, S. (2021). Energy-saving strategies on university campus buildings: Covenant University as case study. In *Energy services fundamentals and financing* (pp. 131–154). Elsevier.
13. Shafie, S. M., Nu'man, A. H., & Yusuf, N. (2021). Strategy in energy efficiency management: University campus. *International Journal of Energy Economics and Policy, 11*(5), 310.
14. Kyaw, P. M. (2021). A study of solar PV based electricity system for ait.
15. Bhatia, A. Overview of Chiller Compressors. www.cedengineering.com. https://www.cedengineering.com/course-provider/a-bhatia.