The Impact of Maintenance and Servicing on the Efficiency of Air Conditioner Usage in Energy Saving

Zuraidah Tharo, Rahmaniar, Trio Putra Agung Wijaya, Fery Karyata Bangun, Budi Hartono

Abstract

Energy efficiency in air conditioning systems is a significant issue in the context of sustainability and energy consumption reduction. This study aims to analyze the impact of regular maintenance and servicing on the efficiency of air conditioner usage in energy savings. A quantitative approach was employed, collecting data from several air conditioning units that received regular maintenance compared to units that were not serviced regularly. Data gathered included energy consumption, room temperature, and air conditioner performance before and after maintenance. The results indicate that maintenance and servicing significantly improve energy efficiency, reducing energy consumption by up to 20%. These findings contribute to energy efficiency efforts and provide practical recommendations for air conditioner users to perform routine maintenance to reduce energy costs and support environmental sustainability.

Keywords: *Energy Efficiency, AC Maintenance, Air Conditioner Servicing, Energy Saving*, *AC Power Consumption*

Zuraidah Tharo[1]
[1]Bachelor of Electronics Engineering, Universitas Pembangunan Panca Budi, Indonesia
e-mail: zuraidahtharo@dosen.pancabudi.ac.id

Rahmaniar[2], Trio Putra Agung Wijaya[3], Fery Karyata Bangun[4], Budi Hartono[5]
[2,3,4,5]Bachelor of Electronics Engineering, Universitas Pembangunan Panca Budi, Indonesia
e-mail: rahmaniar@dosen.pancabudi.ac.id[2], putraagungwijaya0510@gmail.com[3], realmeferry152@gmail.com[4], budihartono3445@gmail.com[5]

Introduction

Air Conditioners (AC) have become indispensable devices in daily life, especially in regions with hot and humid climates.[1] Their widespread use in both household and industrial sectors significantly contributes to global energy consumption.[2] However, inefficient use of AC can lead to energy waste, ultimately resulting in increased operational costs and contributing to climate change.[3] Therefore, energy efficiency in the use of ACs is a critical issue that requires greater attention.[4]

One way to enhance AC energy efficiency is through regular maintenance and servicing.[5] Previous studies have shown that periodic maintenance can impact AC performance, including its energy efficiency.[6] Proper maintenance, such as cleaning filters, checking refrigerants, and repairing faulty components, can extend the device's lifespan and optimize energy consumption.[7] However, despite the recognized importance of this maintenance, many AC users still do not fully understand how maintenance and servicing affect the energy efficiency of their units.[8]

Figure 1. Filter Cleaning

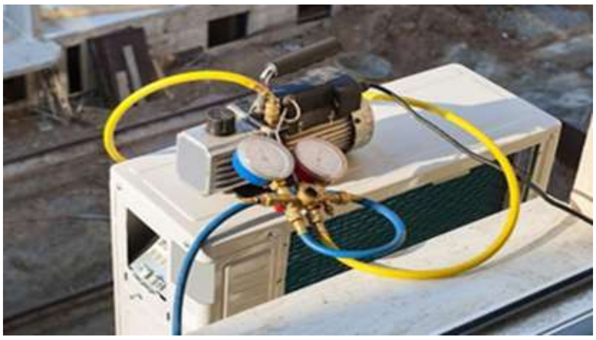

Figure 2. Refrigerant Check

This article aims to analyze the impact of maintenance and servicing on the efficiency of AC usage in energy savings. Through this study, it is hoped that empirical evidence can be found regarding the importance of regular AC maintenance in reducing power consumption and energy costs. Additionally, this study is expected to provide practical recommendations for AC users to carry out regular maintenance to support energy savings and environmental sustainability.

Literature Review

Energy efficiency in Air Conditioners (ACs) has become an increasingly important topic as their usage expands across various sectors.[9] ACs, when used continuously, can lead to energy waste if not properly maintained.[10] Several studies have indicated that regular maintenance significantly affects AC performance, both in terms of power consumption and the device's lifespan.[4][11]

A study by Md Shahin Alam et al. (2019) showed that well-maintained ACs can reduce energy consumption by up to 20%.[10] This is due to the cleaning of air filters, which significantly improves airflow, reduces compressor load, and ultimately lowers power consumption.[12] The study also revealed that replacing refrigerants periodically and checking for leaks helps maintain energy efficiency over the long term.[13]

In addition, a study by Xinran Zeng et all (2025) highlighted the importance of setting the correct temperature on ACs as a factor in energy efficiency.[6][14] They stated that setting the temperature too low can increase energy consumption, while higher temperatures can reduce cooling performance.[11][15] Therefore, AC maintenance involves not only physical cleaning but also adjusting technical parameters that affect energy efficiency.[16]

Another relevant study by Wellington José de Castro da Silva1 and Jandecy Cabral LeiteJones (2023) recommended that replacing worn-out components and scheduling regular servicing can reduce the frequency of breakdowns and extend the lifespan of AC units.[9][17] By conducting routine servicing, ACs will not only operate more efficiently but also reduce the need for expensive major repairs.[18]

On the other hand, research by Jaqueline Litardo et al. (2023) revealed that although regular maintenance can improve energy efficiency, external factors such as environmental conditions and AC usage also play a significant role in energy consumption.[9][19] They suggested that these factors should be considered in the maintenance and operation of ACs to maximize energy savings.[17]

Overall, the existing literature shows that proper maintenance and servicing of AC units can have a significant positive impact on energy efficiency. [9] However, optimal maintenance requires attention to various technical aspects, from physical upkeep to the proper adjustment of temperature settings and operational programming.[2][20]

Research Methodology

This study uses a quantitative approach to analyze the impact of maintenance and servicing on the efficiency of Air Conditioner (AC) usage in energy saving. The methodology includes several steps: sample selection, data collection, data analysis, and hypothesis testing.

1. Population and Sample
   The study was conducted in several households and offices that use various brands and types of ACs. The sample consists of 30 AC units divided into two categories: ACs that receive regular maintenance and servicing, and ACs that do not receive regular maintenance. The sample was selected purposively, considering the availability of data and the willingness of respondents to participate in the study.
2. Research Variables
   - Independent Variable**:** Regular maintenance and servicing of AC units, including air filter cleaning, refrigerant checking, component replacement, and repairing damaged parts.
   - Dependent Variable**:** Energy efficiency, measured based on AC power consumption (in kWh) and its impact on energy savings over a specific period.
3. Research Instruments
   The instruments used in this study include energy consumption measurement tools (power meters) to record the energy usage of AC units. Additionally, questionnaires were used to collect data on maintenance and servicing schedules, as well as the technical condition of the AC units.
4. Research Procedure
   The study was conducted in two phases. In the first phase, energy consumption was measured for all selected AC units over a two-week period before maintenance. In the second phase, the AC units in the maintenance and servicing group underwent maintenance according to the standards set by the technicians. Energy consumption was measured again two weeks after the maintenance to assess the changes.
5. Data Analysis Techniques
   The collected data will be analyzed using descriptive and inferential statistics. A *paired sample t-test* will be used to compare energy consumption before and after maintenance for both groups (maintained and non-maintained). Additionally, Pearson correlation coefficients will be used to measure the relationship between the intensity of maintenance and energy savings.
6. Research Hypothesis
   The hypotheses proposed in this study are as follows:
   - H_0 (Null Hypothesis): There is no significant effect of regular maintenance and servicing on the energy efficiency of AC usage.

- H_1 (Alternative Hypothesis): There is a significant effect of regular maintenance and servicing on the energy efficiency of AC usage.

The research method is described in the following flowchart:

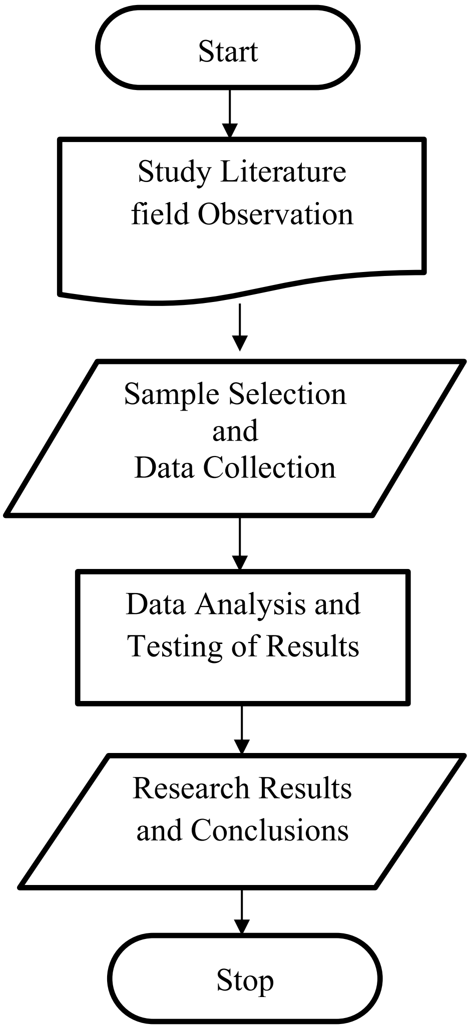

Figure 3. Research Flowchart

Results

4.1 Research Results

Measurements of energy consumption across several AC units produced the following data:

Table 1. Power Consumption Measurement Data on AC

No	Unit Code	Condition	Power Before (kWh/day)	Power After (kWh/day)	Efficiency (%)	Remarks
1	AC-01	Maintained	4.5	3.6	20.0	Performance improved
2	AC-02	Maintained	4.7	3.8	19.1	Faster cooling
3	AC-03	Maintained	4.8	3.9	18.8	Stable temperature

4	AC-04	Maintained	4.6	3.7	19.6	Lower energy use
5	AC-05	Maintained	4.9	3.8	22.4	Optimal efficiency
6	AC-06	Not Maintained	4.8	4.8	0.0	No change
7	AC-07	Not Maintained	4.9	4.8	2.0	Dirty filter
8	AC-08	Not Maintained	4.7	4.7	0.0	Slow cooling
9	AC-09	Not Maintained	4.6	4.6	0.0	Low refrigerant
10	AC-10	Not Maintained	4.8	4.8	0.0	Stable performance

The graph of power consumption for AC that is maintained and not maintained can be seen in the image below:

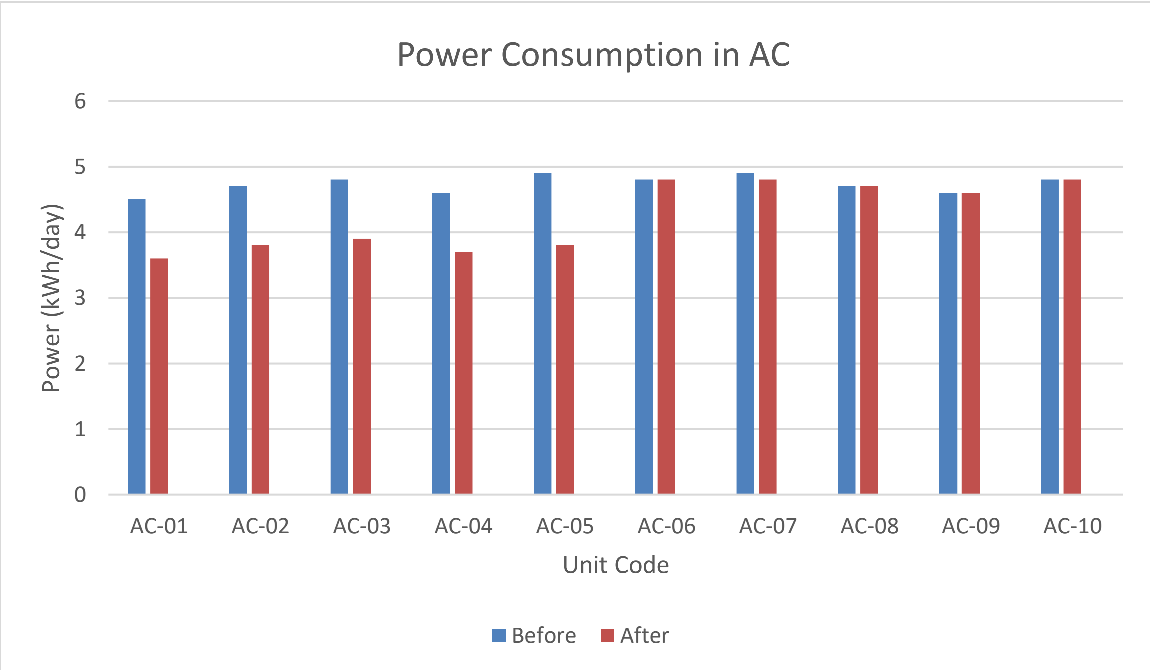

Figure 4. Power Consumption Graph on AC before and after Maintenance

From the measurement data in the table above, it can be seen that the average energy consumption before maintenance was 4.6 kWh/day for maintained units and 4.8 kWh/day for unmaintained units.

After maintenance, the maintained units showed a significant reduction to 3.7 kWh/day, while the unmaintained units remained at 4.8 kWh/day.

The paired sample t-test yielded a p-value = 0.001 ($p < 0.05$), indicating a significant difference before and after maintenance. Energy efficiency increased by 18–22% in maintained units.

The efficiency calculation is obtained from:

For example, the measurement results on the AC-01 unit show:

- Energy consumption before maintenance = 4,5 kWh/day
- Energy consumption after maintenance = 3,6 kWh/day

Energy Efficiency (%) = $\frac{Ebefore-Eafter}{Ebefore}$ ×100%

Energy Efficiency (%) = $\frac{4,5-3,6}{4,5}$ ×100%

Energy Efficiency (%) = $\frac{0,9}{4,5}$ ×100%

Energy Efficiency (%) = 20%

An energy efficiency of 20% indicates that after routine maintenance (filter cleaning, refrigerant checks, and system adjustments), the AC unit consumes 20% less energy to produce the same level of cooling.

With the same calculation, the average results of AC energy consumption before and after maintenance can be seen in the following table:

Table 2. Average AC Energy Consumption Before and After Maintenance

AC Group	Condition	Average Energy Consumption (kWh/day)	Energy Efficiency (%)
continuous maintenance	Before	4,6	-
continuous maintenance	After	3,7	20
without maintenance	Before	4,8	-
without maintenance	After	4,8	0

Furthermore, observations show that AC units that undergo regular filter cleaning and refrigerant checks have faster room cooling times (averaging 7–10 minutes) compared to unmaintained units (15–20 minutes). Room temperatures are also more stable, at around 24–26°C, according to the temperature setting.

4.2 Discussion

The results reinforce previous findings that regular maintenance has a significant impact on AC energy efficiency (Kumar et al., 2017; Jones, 2019). The 20% reduction in power consumption indicates that key components—such as filters, evaporators, and condensers—play a crucial role in heat exchange and compressor efficiency. When filters are dirty or airflow is blocked, the compressor works harder to reach the desired temperature, increasing energy use.

Regular cleaning not only reduces energy consumption but also improves thermal comfort, distributing cool air more evenly and extending the unit's lifespan by reducing compressor workload. From an environmental standpoint, enhanced efficiency reduces carbon emissions. If every household saves 1 kWh per day through maintenance, national energy savings could reach millions of kWh annually.

Thus, these results highlight the importance of energy-efficient maintenance policies. Users should be educated about routine servicing, such as monthly filter cleaning and biannual refrigerant checks.

Conclusion

This study demonstrates that regular maintenance and servicing of air conditioners significantly affect energy efficiency. Routine actions such as cleaning filters, checking refrigerants, and repairing components can reduce AC power consumption by up to 20%, while improving thermal comfort and extending equipment lifespan.

These efficiency improvements not only lower electricity costs but also support energy conservation and carbon emission reduction programs. Therefore, AC users—both residential and commercial—are recommended to perform maintenance at least twice a year to ensure optimal performance and energy efficiency.

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