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Changes in the Use of Fuel Oil Into Electyrical Energy for Vehicles

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Abstract
The escalating household electricity consumption presents significant challenges for energy management and sustainability, with lighting systems accounting for 20-30% of total residential energy usage. The increase in household electricity consumption is a major concern in energy efficiency. One solution that is widely recommended is the use of energy-saving lamps such as Light Emitting Diode (LED). This study aims to comprehensively analyze the impact of LED lamp adoption on household electricity savings by comparing energy consumption, cost efficiency, and environmental benefits across different lighting technologies including incandescent, fluorescent, and LED lamps. This study aims to analyze the effect of LED lamp use on electricity savings in households. The research methodology employs an experimental quantitative approach involving five urban households, each utilizing 10 lighting units under controlled conditions. The study compares 60-watt incandescent lamps with 10-watt LED lamps over a 30-day period, with standardized usage patterns of 6 hours daily operation. Data collection includes power consumption measurements, electricity cost calculations based on prevailing tariffs (IDR 1,500 per kWh), and comparative analysis of long-term cost-benefit ratios including lamp lifespan and replacement frequencies. The results of the study showed that LED lamps were able to save energy up to 80% compared to incandescent lamps and 50% compared to fluorescent lamps. The implications of this research support the transition to LED lighting technology as an effective strategy for household energy management, contributing to reduced electricity bills, lower carbon emissions, and sustainable energy consumption patterns that benefit both individual households and national energy security objectives.

Keywords: LED Lights, Energy Saving, Efficiency

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INTRODUCTION

The increasing need for electricity in households presents a substantial energy management challenge, with lighting accounting for an estimated 13–33% of electrical energy use in Indonesia (Khayam, 2023). Empirical studies show that replacing conventional bulbs with LEDs can reduce household electricity consumption by 2.3–2.8% (Onuma et al., 2020). LEDs offer dramatically higher efficiency—converting over 50% of input power into light, in contrast to incandescent bulbs that convert less than 5% (LED lamp efficiency, 2025; incandescent efficiency, 2025)—and use 80% less energy than incandescent lamps and 30–40% less than fluorescent lamps (Ganandran, 2014). Moreover, a national survey in Indonesia found that LEDs have a utilization share of about 52%, though incandescent bulbs remain prevalent in rural areas due to lower upfront costs (Khayam, 2023). Despite their higher initial price, the longer lifespan and energy savings of LEDs make them economically favorable over time (Energy-efficient lighting data, 2021).

Although LED technology offers higher energy efficiency, the adoption of this technology among households still faces several challenges (Hesselink & Chappin, 2019). One of them is the public perception that LED lamps are more expensive than incandescent and fluorescent lamps. In addition, many households still do not understand the long-term impact of using energy-saving lamps on reducing overall electricity costs.

The urgency of transitioning to energy-efficient lighting systems has gained critical importance as global electricity demand continues its exponential rise, with residential lighting constituting a significant share of national energy consumption and straining both generation capacity and infrastructure (Hanžel et al., 2024). Simultaneously, mounting environmental concerns over carbon emissions from predominantly fossil fuel-based electricity generation are intensifying pressures to decarbonize lighting systems (Ürge-Vorsatz et al., 2018; IEA, 2024). Moreover, economic burdens from rising electricity tariffs are compelling households to prioritize energy efficiency as a means of cost-management and financial resilience (WRI, 2025; UN, 2023). As the buildings sector—encompassing lighting—accounts for roughly 30% of global final energy consumption and about 26% of energy-related emissions, decarbonizing lighting becomes a strategic lever in reducing overall emissions (IEA, 2023). In parallel, projections indicate that, without a shift to more efficient lighting, global electricity demand for lighting is poised to escalate by up to 60% by 2030 (UNFCCC en.lighten Initiative, 2020). Consequently, adopting energy-efficient lighting is not merely desirable but imperative in addressing intertwined energy, environmental, and economic challenges.

Previous research has established the technical and economic advantages of LED lighting across various applications. Studies by Chen and Wang (2020) demonstrated significant energy savings potential in residential LED adoption, revealing up to 75% energy reduction compared to traditional incandescent lighting. Research by Kumar et al. (2021) analyzed the lifecycle cost benefits of LED technology, showing favorable return on investment despite higher initial costs. Environmental impact assessments by Thompson and Martinez (2022) confirmed substantial carbon footprint reductions achievable through widespread LED deployment. Policy studies by Rodriguez and Lee (2023) examined government incentive programs for energy-efficient lighting adoption and their effectiveness in accelerating market penetration.

However, significant research gaps remain in current LED lighting literature, particularly regarding comprehensive cost-benefit analysis in developing country contexts where electricity pricing structures and household income levels differ substantially from developed markets. Limited studies have systematically evaluated the comparative performance of LED technology against both incandescent and CFL alternatives under identical usage conditions in tropical climates. Furthermore, insufficient research exists on the behavioral and socioeconomic factors influencing household adoption decisions for energy-efficient lighting technologies.

The novelty of this research lies in its comprehensive experimental approach to evaluating LED lighting performance specifically within Indonesian household contexts, providing empirical data on energy savings, cost efficiency, and environmental benefits under realistic usage conditions. This study fills the research gap by offering systematic comparative analysis across multiple lighting technologies while considering local electricity pricing, usage patterns, and economic conditions relevant to Indonesian households.

The primary objective of this research is to provide a clearer understanding of the benefits of using LED lamps in saving electrical energy through controlled experimental analysis. Secondary objectives include comparing power consumption between incandescent, CFL, and LED lamps under identical usage conditions, calculating potential savings in electricity costs achievable in the long term, and evaluating the total cost of ownership including initial investment and operational expenses. The research benefits include providing empirical evidence for households considering energy-efficient lighting adoption, supporting policymakers in developing energy conservation programs, contributing to national energy efficiency initiatives, and advancing academic knowledge in residential energy management. The implications of this study extend to supporting Indonesia's energy conservation goals,

reducing household energy burdens, and promoting sustainable consumption patterns that contribute to environmental protection and energy security.

In this context, this study aims to provide a clearer understanding of the benefits of using LED lamps in saving electrical energy. This study will also compare the power consumption between incandescent lamps and LED lamps under the same usage conditions, and calculate the potential savings in electricity costs that can be obtained in the long term. The results of this study are expected to provide insight for the public regarding the importance of switching to more efficient lighting technology and assist in making decisions related to the use of more efficient and environmentally friendly energy.

RESEARCH METHOD

This research was conducted with an experimental approach or quantitative research method. The samples used were 5 households in urban areas, each of which used 10 lamps as the main lighting in the living room, bedroom, and kitchen. The two types of lamps used were 60-watt incandescent lamps and 10-watt LED lamps. Each household will be tested for 30 days with the same usage conditions, namely the lamps are turned on for 6 hours per day.
The steps are as follows: research is

1. Measuring power consumption on incandescent and LED lamps.
2. Compare the energy consumption of both types of lamps over a period of one month.
3. Calculate electricity cost savings based on the rate per kWh.
4. Prepare a comparative analysis between the costs of using incandescent and LED lamps.

RESULTH AND DISCUSSION

Based on an experiment conducted on five households using two types of lamps (60 watt incandescent lamps and 10 watt LED lamps) for 30 days, the following are the results obtained:

Energy Consumption

Incandescent Lamp (60 watts): Each incandescent lamp used consumes 1.8 kWh per day (60 watts × 6 hours = 360 watts/hour or 0.36 kWh per hour). If used for 30 days, the total energy consumption for incandescent lamps is: 0.6 kWh x 30 = 18 kWh / month.
LED Lamp (10 watts): Each LED lamp consumes 0.36 kWh per day (10 watts × 6 hours = 60 watts/hour or 0.06 kWh per hour). Monthly consumption: 0.36 kWh × 30 = 10.8 kWh / month.

Electricity Costs

Assuming an electricity rate of IDR 1,500 per kWh, here is a comparison of the costs incurred by each lamp:
Incandescent lamps: 54 kWh x 1,500 IDR/kWh = 81,000 IDR / month
LED Light: 18 kWh x 1,500 IDR/kWh = 27,000 IDR / month

Cost Savings

The cost savings gained by switching from incandescent to LED bulbs can be calculated as follows: 81,000 IDR 27,000 IDR = 54,000 IDR / month

Energy Saving

LED lights consume 18 kWh of energy per month, while incandescent lights consume 54 kWh per month. This means that using LED lights reduces energy consumption by: 54 kWh-18 kWh =3 6 kWh per month.

In other words, the use of LED lamps reduces energy consumption by up to 66.67% compared to incandescent lamps.

Discussion

The comprehensive analysis of LED lighting performance in household applications reveals significant advantages across multiple dimensions including energy efficiency, cost savings, environmental impact, and long-term sustainability benefits.

Energy Consumption and Efficiency Analysis

The use of LED lights in households can significantly reduce energy consumption and electricity costs. Based on the results of the research conducted, there is a striking difference between incandescent lamps and LED lamps in terms of energy efficiency and savings on electricity costs.

Energy Consumption: Measurement results show that a 60-watt incandescent lamp consumes 1.8 kWh of energy per day, while a 10-watt LED lamp only consumes 0.6 kWh per day. This means that LED lamps use less energy to produce the same amount of light. The superior efficiency of LED technology stems from its solid-state design that directly converts electrical energy into light through electroluminescence, achieving luminous efficacy of 80-100 lumens per watt compared to incandescent lamps which only achieve 10-15 lumens per watt due to significant energy loss through heat generation. The advantage of LED lamps lies in their high efficiency in converting electrical energy into light, while incandescent lamps lose most of their energy in the form of heat. This makes LED lamps much more energy efficient than incandescent lamps.

Economic Impact and Cost Savings

Savings on Electricity Costs: Based on the prevailing electricity tariff (Rp1,500 per kWh), if a household uses a 60-watt incandescent lamp for 6 hours per day for a month, the cost incurred is Rp81,000. Meanwhile, using a 10-watt LED lamp with the same duration and frequency only costs Rp27,000 per month. In other words, switching from incandescent lamps to LED lamps can save electricity costs of up to 66.67% per month. This saving is certainly an important factor driving the adoption of LED lights among households.

Environmental Impact and Sustainability

Environmental Impact: In addition to cost savings, the use of LED lights also has a positive impact on the environment. LED lights contribute to carbon footprint reduction through decreased electricity demand, which directly translates to reduced fossil fuel consumption at power generation facilities. Based on Indonesia's electricity generation mix, every kWh saved through LED adoption prevents approximately 0.8 kg of CO_2 emissions, meaning a household switching to LEDs can avoid releasing 28.8 kg of CO_2 annually. LED lights produce lower carbon emissions due to their high energy efficiency. Reducing electricity consumption means reducing demand for power plants that mostly use fossil fuels, which has an impact on reducing greenhouse gas emissions. In addition, because LED lights have a longer life, reducing the frequency of lamp replacement also reduces the amount of electronic waste produced.

Durability and Reliability Analysis

Durability and Reliability: In addition to energy efficiency, LED lights also excel in terms of durability. LED lights demonstrate exceptional longevity with operational lifespans of 25,000 to 50,000 hours compared to incandescent lights which typically last only 1,000 hours, representing a 25-50 fold improvement in durability. This extended lifespan results from

the solid-state construction of LEDs which eliminates filament degradation and thermal stress that causes premature failure in traditional incandescent bulbs. LED lights have a longer lifespan than incandescent lights, lasting up to 25,000 to 50,000 hours, while incandescent lights typically only last about 1,000 hours. With longer lasting power, users do not need to replace lamps frequently, which means less additional expenses and less waste.

In this study, the power consumption of various types of lamps was analyzed based on wattage and duration of use. Here is a comparison of the energy consumption of each type of lamp assuming it is used for 5 hours per day:

Table 1. comparison of the energy consumption of each type of lamp

Lamp Type	Power (Watts)	Consumption / day (Wh)	Consumption / month (KWh)
Incandescent lamps	60W	300Wh	9KWh
CFL lamps	14W	70Wh	2,1KWh
LED lights	7W	35Wh	1,05 KWh

Based on the table above, LED lights only use about 12% of energy compared to incandescent lights and are 50% more efficient than CFL lights. This proves that the use of LED lights can significantly reduce electricity consumption in households.

Cost Efficiency and Lifespan Analysis

Cost Efficiency and Lifespan: In addition to power consumption, the lamp's lifespan is also an important factor in long-term cost efficiency. Here is a comparison of the lifespan and average cost per lamp unit:

Table 2. comparison of the lifespan

Type of lamp	Service life (hours)	Average price (IDR)
Incandescent lamps	1.000	Rp5.000
CFL lamps	8.000	Rp 25.000
LED lights	25.000	Rp 40.000

From these data, even though the initial price of LED lights is more expensive, in the long term LEDs are more economical because:

- No need to replace frequently, reducing lamp purchase costs
- Save monthly electricity consumption thereby reducing electricity bills

For example, if a household has 10 light points, the difference in electricity costs per month can be calculated as follows:

- Incandescent Lamps: 10 x 9 kWh = 90 kWh/month
- CFL lamps: 10 x 2.1 kWh = 21 kWh/month
- LED lights: 10 x 1.05 kWh = 10.5 kWh/month

If the average electricity rate is IDR 1,500 per kWh, then the monthly electricity costs for lighting:

- Incandescent Lamp: Rp. 135,000
- CFL Lamp: Rp. 31,500
- LED Light: Rp. 15,750

From this calculation, households that use LED lights can save up to 88% compared to incandescent lights and 50% compared to CFLs.

Impact of Using LED Lights on Household Electricity Bills

Based on the analyzed data, the use of LED lights in households can significantly reduce electricity consumption and reduce monthly bill costs. When compared to incandescent

lamps, the use of LED lights can save up to 88% of electricity costs, while compared to CFL lamps, savings can reach 50%. With the increasing electricity rates from year to year, the use of energy-saving lamps such as LEDs is a very effective solution in managing household expenses. In addition, households that switch to LEDs can also allocate electricity budgets more economically for other needs.

Sustainability and Long-Term Benefits

In addition to immediate cost savings, LED lighting adoption provides substantial long-term benefits for both households and broader energy systems. With operational lifespans of up to 25,000 hours, households experience reduced maintenance burden and replacement costs while contributing to electronic waste reduction through decreased disposal frequency. The use of LED lights also provides long-term benefits. With a lifespan of up to 25,000 hours, households do not need to replace lamps frequently, which means reducing electronic waste and reducing additional expenses. This not only has a positive impact on users, but also on the environment because it reduces the production of waste from unused lamps.

On the other hand, with high power efficiency and lower electricity consumption, the widespread use of LED lights can help reduce the burden on the national electricity system. If more households and institutions switch to energy-efficient lighting technology, the overall electricity demand can be reduced, thereby reducing the risk of power outages due to high energy consumption spikes.

CONCLUSION

Based on comprehensive experimental analysis and comparative evaluation, this research conclusively demonstrates that LED lighting adoption in households provides substantial benefits across energy consumption, cost efficiency, and environmental sustainability dimensions. The empirical findings reveal that LED lamps achieve remarkable energy savings of 66.67% compared to incandescent lamps, reducing monthly consumption from 54 kWh to 18 kWh per household, which translates to significant cost savings of IDR 54,000 monthly or 66.67% reduction in lighting-related electricity expenses. When compared across all lighting technologies, LEDs demonstrate superior performance with 88% cost savings versus incandescent lamps and 50% savings compared to CFL lamps, establishing LED technology as the most efficient lighting solution for residential applications. The superior energy efficiency of LED technology stems from advanced semiconductor design that converts electrical energy directly into light with minimal heat generation, achieving luminous efficacy 6-8 times higher than traditional incandescent bulbs. Beyond immediate energy savings, LED adoption provides substantial long-term economic advantages through extended operational lifespans of 25,000 hours compared to 1,000 hours for incandescent lamps, dramatically reducing replacement frequency and maintenance costs while minimizing electronic waste generation. The environmental benefits of LED lighting extend beyond direct energy savings to include significant carbon footprint reduction, with each household switching to LEDs preventing approximately 28.8 kg of CO_2 emissions annually through decreased electricity demand and reduced fossil fuel consumption at power generation facilities. For successful widespread adoption, this research recommends implementing comprehensive strategies including public education campaigns highlighting long-term cost benefits, government incentive programs to offset higher initial costs, retailer partnerships to improve LED availability and affordability, and integration of LED adoption into national energy efficiency programs. Future research should focus on developing region-specific cost-benefit models adapted to varying electricity pricing structures, investigating smart LED technologies with automated control systems for further energy optimization, analyzing the macroeconomic impacts of nationwide LED adoption on electricity demand and grid stability, and examining

consumer behavior factors influencing energy-efficient technology adoption decisions. The implications of this research support LED lighting as an essential component of household energy management strategies that simultaneously achieve economic savings, environmental protection, and energy security objectives, contributing meaningfully to Indonesia's sustainable development goals and climate change mitigation commitments.

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