

Energy Savings Analysis: LED vs. Incandescent Bulbs with Cost-Benefit Analysis

1. Introduction

Lighting accounts for a significant portion of electricity consumption in residential and commercial buildings. The choice of lighting technology, therefore, has a substantial impact on energy bills and environmental footprint. This report conducts a detailed cost-benefit analysis comparing traditional Incandescent bulbs with modern Light Emitting Diode (LED) bulbs, highlighting the energy savings and financial advantages of switching to LEDs.

2. Technical Specifications of Bulbs

To perform a fair comparison, we need to select representative bulbs from each technology category that provide similar light output (measured in Lumens).

Assumptions for Comparison:

3. Energy Consumption & Cost Analysis (Per Bulb)

This section calculates the energy consumption and associated costs for a single bulb over its lifetime, and over a standardized period.

3.1. Daily Usage Assumption: Let's assume an average daily usage of 4 hours per bulb.

3.2. Energy Consumption Calculation:

a. Incandescent Bulb (60W):

kWh/day

Annual Energy (kWh): $0.24 \text{ kWh/day} \times 365 \text{ days/year} = 87.6 \text{ kWh/year}$

Lifetime Energy (kWh): $(60 \text{ W} \times 1,000 \text{ hours}) / 1000 = 60 \text{ kWh}$ (Note: Lifetime is 1,000 hours)

b. LED Bulb (9W):

Daily Energy (kWh): $(9 \text{ W} \times 4 \text{ hours/day}) / 1000 = 0.036 \text{ kWh/day}$

Annual Energy (kWh): $0.036 \text{ kWh/day} \times 365 \text{ days/year} = 13.14 \text{ kWh/year}$

Lifetime Energy (kWh): $(9 \text{ W} \times 15,000 \text{ hours}) / 1000 = 135 \text{ kWh}$ (Note: Lifetime is 15,000 hours)

3.3. Electricity Cost Calculation:

a. Incandescent Bulb (60W):

Daily Cost: $0.24 \text{ kWh/day} \times \$0.15/\text{kWh} = \$0.036$

Annual Cost: $87.6 \text{ kWh/year} \times \$0.15/\text{kWh} = \$13.14$

Lifetime Cost: $60 \text{ kWh} \times \$0.15/\text{kWh} = \9.00

b. LED Bulb (9W):

Daily Cost: $0.036 \text{ kWh/day} \times \$0.15/\text{kWh} = \$0.0054$

Annual Cost: $13.4 \text{ kWh/year} \times \$0.15/\text{kWh} = \$1.97$

Lifetime Cost: $135 \text{ kWh} \times \$0.15/\text{kWh} = \20.25

4. Cost-Benefit Analysis (Total Cost of Ownership)

To provide a fair comparison, we need to calculate the total cost of ownership over a standardized period or the equivalent lifespan of one LED bulb.

Standardized Period for Comparison: The lifespan of one LED bulb, which is 15,000 hours.

4.1. Incandescent Bulb Costs over 15,000 Hours:

Number of Incandescent Bulbs needed: $15,000 \text{ hours (LED lifetime)} / 1,000 \text{ hours (Incandescent lifetime)} = 15 \text{ bulbs}$

Total Purchase Cost (Incandescent): $15 \text{ bulbs} \times \$1.50/\text{bulb} = \$22.50$

Total Electricity Cost (Incandescent): $(60 \text{ W} \times 15,000 \text{ hours}) / 1000 \times \$0.15/\text{kWh} = 900 \text{ kWh} \times \$0.15/\text{kWh} = \$135.00$

Total Cost of Ownership (Incandescent): Purchase Cost + Electricity Cost = $\$22.50 + \$135.00 = \$157.50$

4.2. LED Bulb Costs over 15,000 Hours:

Number of LED Bulbs needed: $15,000 \text{ hours (LED lifetime)} / 15,000 \text{ hours (LED lifetime)} = 1 \text{ bulb}$

Total Purchase Cost (LED): $1 \text{ bulb} \times \$4.00/\text{bulb} = \4.00

Total Electricity Cost (LEDs): $(9 \text{ W} \times 15,000 \text{ hours}) / 1000 \times \$0.15/\text{kWh} = 135 \text{ kWh} \times \$0.15/\text{kWh} = \$20.25$

5. Environmental Impact

Switching to LEDs also offers significant environmental benefits:

Reduced Carbon Emissions: Lower electricity consumption directly translates to fewer greenhouse gas emissions from power plants. Saving 765 kWh over 15,000 hours per bulb means avoiding a substantial amount of CO₂.

Less Waste: The significantly longer lifespan of LEDs means fewer bulbs ending up in landfills, reducing waste generation.

No Hazardous Materials: Unlike CFLs (compact fluorescent lamps) which contain mercury, LEDs are generally free of hazardous materials, making disposal safer.

Reduced Heat Output: LEDs produce much less heat than incandescent bulbs, which can reduce cooling loads in air-conditioned spaces, leading to additional indirect energy savings.

6. Conclusion and Recommendation

The analysis clearly demonstrates the overwhelming advantages of LED bulbs over traditional incandescent bulbs. While LEDs have a higher upfront purchase price, their drastically lower power consumption and significantly longer lifespan result in substantial long-term financial

Summary of Benefits:

Energy Savings: 85% less energy consumed.

Cost Savings: Over \$133 saved per bulb over its lifetime compared to incandescents.

Extended Lifespan: 15 times longer life, reducing replacement frequency and maintenance.

Rapid Payback: The initial investment in an LED bulb is recouped in just a few months through electricity savings.