

# 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:  $13.14 \text{ kWh/year} \times \$0.15/\text{kWh} = \$1.97$

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 CO<sub>2</sub>.

**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.