IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 8, Issue 1, January 2020

Analysis of Different Electrical Appliances by Comparing their Energy Consumption, Cost and Energy Saving

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Abstract: Now a day's electricity is very important part of human and technologies. Different types of electrical appliances like air conditioner, LED bulb, CLF bulb, fan, washing machine etc. are available in the market. They have different rating and energy consumption capacity. These electrical appliances divided into different categories according to power consumption, such as 1 star, 2 star, 3 star, 4 star and 5 star electrical appliances. In this paper, analysis of different electrical appliances with their energy consumption, calculate of unit's consumption and energy cost comparison of different star rating appliances. Discussion of energy saving using different star rating appliances. Also calculate of payback period for different appliances.

Keywords: Air conditioner; LED bulb; CFL bulb

I. INTRODUCTION

The government of India start Bureau of Energy Efficiency (BEE) on 1st march 2002 under the provision of the energy conservation act, 2001[1] [2].The mission of the bureau of energy efficiency is to developing policies & strategies of self -regulation & market demand. The primary objective of act 2001 is reducing energy intensity of the Indian economy [6].

Energy efficiency: Energy efficiency means using less energy to provide the same level of energy. Efficient energy use is achieved by efficient technology and process. It is therefore reduced human greenhouse gas emissions [3] [4].

Star rating [6]: The star rating is a measure of energy efficiency of an appliances, it is a five star points scale where higher the rating lower is the energy consumption and hence better saving. The bee star rating scheme is applied for air conditioner, Refrigerator, fan and many more appliances.

A) Air Conditioner: - The Air conditioner is device to process of removing heat and gives the cooling in the room. Now day's three types of AC are used: (a) split AC (b) window AC (c) inverter AC.

(a) Split Ac: A split air conditioning means that the condenser is separated from the indoor unit. Split air conditioner has two units, indoor and outdoor.

(b) Window Ac: Window AC is the simplest form of an air conditioning system. it is mounted on the window or wall. The evaporator side is in the room for cooling of the space and the condenser is outside for heat rejection.

(c) Inverter Ac: Inverter air conditioning adjusting their cooling capacity by adjusting the power supply frequency of their compressors. And adjust the speed of compressor to control the refrigerant (gas) flow rate. And it's consuming less current and power.

B) LED bulb: - A diode is an electrical component with two terminals which conduct the electricity only in one direction. An electric current pass, the diode emits a bright light around the small bulb [5].

C) CFL bulb: - in CFL bulb an electric current is driven through a tube containing argon and a small amount of mercury vapor. This generates invisible ultraviolet light that excites a fluorescent coating on the inside of the tube, which then emits visible light [5].

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II. STAR RATINGS AND EER VALUES [6]

The Energy Efficiency Ratio (EER) is the ratio of output cooling energy (in BTU) to input electrical energy (in watts). British thermal unit (BTU): - It is defined as the amount of heat needed to increase the temperature of 1 pound of water by 1 degree Fahrenheit.

Power consumption/hour of inverter and non-inverter AC

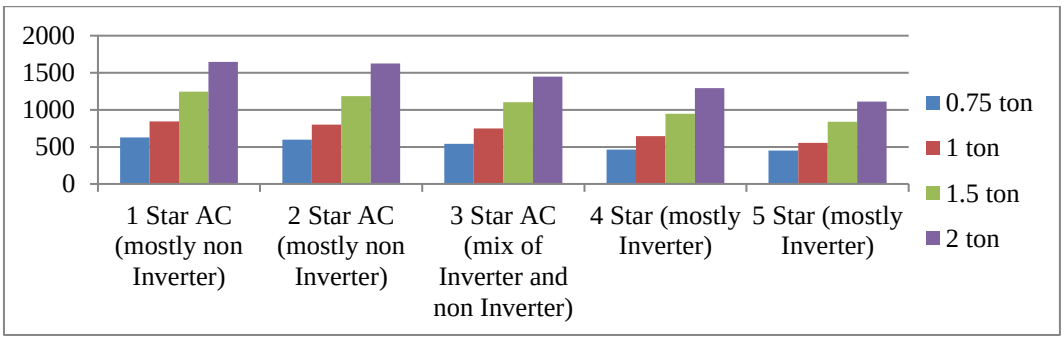

Fig 1. Energy Consumption Chart of AC

III. ENERGY SAVING, COST OF ENERGY AND PAYBACK PERIOD CALCULATION OF SPLIT AC

A. Calculation for split AC
Comparison of energy consumption and cost between the 5 star split AC with a 1 star split AC (1 ton)

(a) 5 stars AC
This AC market price is 32,990 Rs
Cooling capacity = area of the room in square feet * 25 Btu = 110 *25 = 2750
Power consumption = 611 w/Hr = 0.611 unit (Kw/Hr)
Energy efficiency ratio = cooling capacity / power consumption = 2750/611= 4.5
If average use of Ac 8 hours per day, so Unit used per day = 0.611*8= 4.888 units /day
Assume the electricity rate is 5 Rs/unit
Energy consumption cost per hour = Consumed unit per hour * Electricity rate= 0.611*5 = 3,055 Rs/hour
Energy consumption cost per day = Consumed unit per day * electricity rate= 4.888*5 = 24.44 Rs/day
Units used per year = Consumed unit per hour*8(hours per day)*300(days per year)
= 0.611*8*300 = 1466.4 units used per year
Energy consumption cost per year = Consumed unit per year (assume 300 days Ac is on) * Electricity rate
= (0.611*8*300)*5 = 7332 Rs/year

(b) 1 star split AC
This AC market price is 21,000 Rs
Cooling capacity = Area of the room in square feet*25 Btu= 120*25 = 2750
Power consumption = 984 w/hr = 0.984 unit (kw/hr)
Energy efficiency ratio = Cooling capacity / Power consumption= 2750 / 984 = 2.79
If we used Ac for 8 hours per day, so Unit used per day = 0.984*8= 7.872 units /day
Energy consumption cost per hour = Consumed unit per hour * Electricity rate= 0.984*5 = 4.92 Rs/hour
Energy consumption cost per day = Consumed unit per day * Electricity rate= 7.872*5 = 39.36 Rs/day
Units used per year = Consumed unit per hour*8(hours per day)*300(days per year) = 0.984*8*300
= 2361.6 units used per year
Energy consumption cost per year = Consumed unit per year (assume 300 days ac is on) * electricity rate
= (0.984*8*300)*5 = 11808 Rs/year

➢ Results 5 star and 1 star AC
Fig 2and 3shows the percentage of units saved with using 5 star AC compare to 1 star split AC and amount saving using 5 star and 1star split AC respectively.

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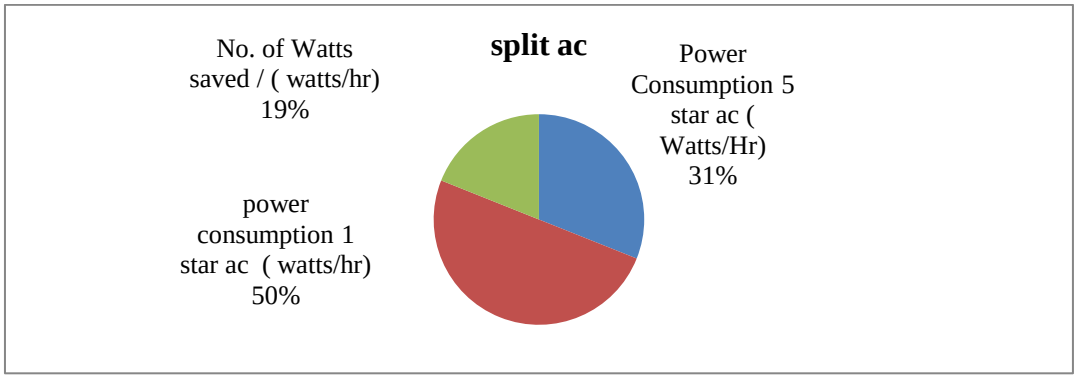

Fig 2. Percentage of units save using 5 stars and 1 star split Ac

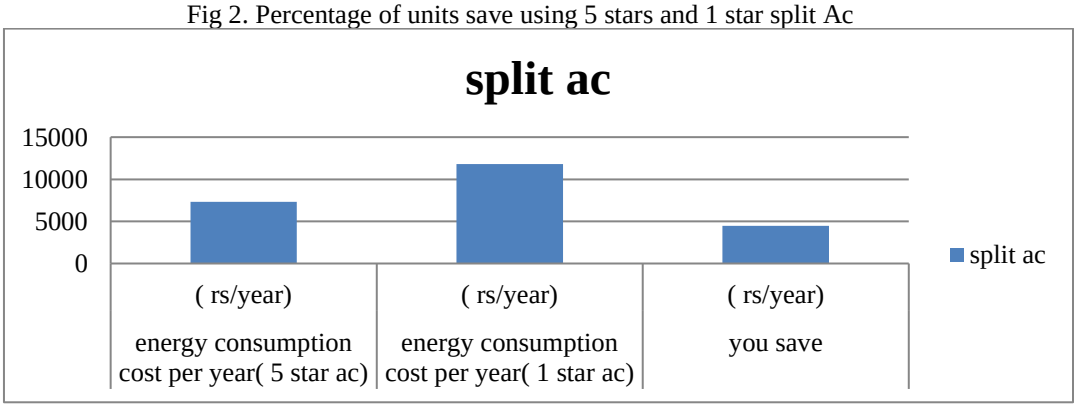

Fig:3. Saving of energy consumption cost per year for split AC

Saving energy consumption cost per year = 1 star Ac energy consumption cost per year – 5 star Ac energy consumption cost per year = 11808 -7332 = 4476 Rs/year cost saving
Saving unit consumption per day = 1 star type Ac unit consumed per day – 5 star type Ac unit consumed per day
= 7.872 – 4.888= 2.984 = 3 (approx) unit saved per Day
Saving unit consumption per year = 1 star type Ac unit consumed per year – 5 star type Ac unit consumed per year
= 2361.6 – 1466.4 = 895.2
The market price difference between both Ac = 5 stars Ac price – 1star Ac price= 32990 – 21000 = 11990 Rs
The Payback period of 5 stars Ac compared to 1 star Ac = Market price difference between both Ac / saving of energy consumption per year = 11990 / 4476= 2.67 years of Payback period

B. Energy saving, cost of energy and payback period calculation of window AC
Comparison of energy consumption and cost between 5 stars window Ac with a 1 star window Ac (1 ton)

(a) 5 stars window AC
This Ac market price is 27,000 Rs
Cooling capacity = Area of the room in square feet * 25 Btu = 110 * 25= 2750
Power consumption = 844 w/hr = 0.884 units (kw/hr)
Energy efficiency ratio = Cooling capacity / Power consumption= 2750/844= 3.25
If average use of AC 8 hours per day, so Unit used per day = 0.844*8= 6.752 units /day
Energy consumption cost per hour = Consumed unit per hour * Electricity rate= 0.844*5 = 4.22 Rs/hour
Energy consumption cost per day = Consumed unit per day * Electricity rate= 6.752*5 = 33.76 Rs/day
Units used per year = Consumed unit per hour*8(hours per day)*300(days per year)
= 0.844*8*300= 2025.6 units used per year
Energy consumption cost per year = Consumed unit per year (assume 300 days ac is on) * Electricity rate
= (0.844*8*300)*5 = 10128 Rs/year

(b) 1 star window A
This Ac market price is 21,000 Rs
Cooling capacity = Area of the room in square feet * 25 Btu = 110*25 = 2750
Power consumption = 1267 w/hr = 1.267 units (kw/hr)
Energy efficiency ratio = Cooling capacity / Power consumption= 2750/1267 = 2.17

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If we used Ac for 8 hours per day, so Unit used per day = 1.267*8= 10.136 units /day.
Energy consumption cost per hour = Consumed unit per hour * Electricity rate= 1.267*5 = 6.335 Rs/hour
Energy consumption cost per day = Consumed unit per day * Electricity rate= 10.136*5 = 50.68 Rs/day
Units used per year = Consumed unit per hour*8(hours per day)*300(days per year)
= 1.267*8*300 = 3040.8 units used per year
Energy consumption cost per year = Consumed unit per year (assume 300 days ac is on) * Electricity rate
= (1.267*8*300)*5 = 15204 Rs/year

➢ Results of 5 star and 1 star window AC

Fig 4 and 5 show the percentage of units saved with using 5 star AC compare to 1 star window AC and amount saving using 5 star and 1star window AC respectively.

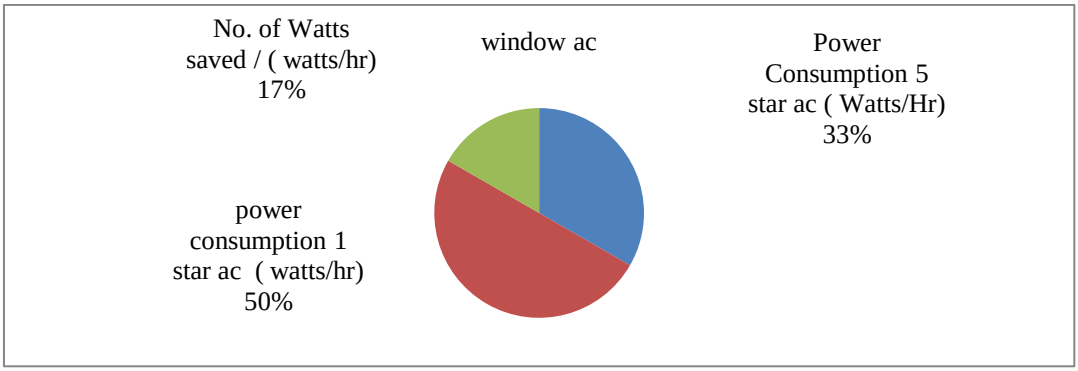

Fig 4: percentage of units save using 5 stars and 1 star window ac

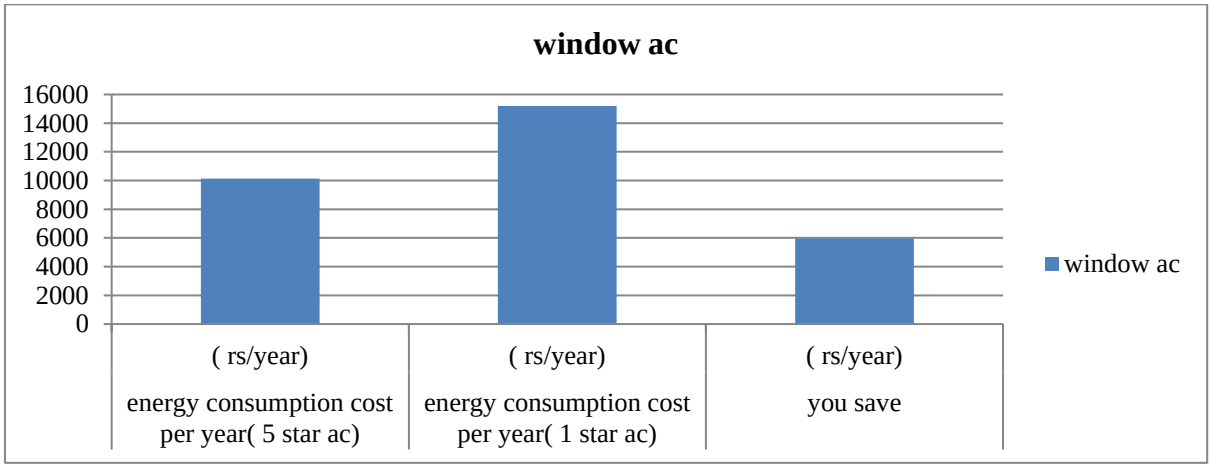

Fig 5. Saving of energy consumption cost per year for window AC

➢ After comparison of both AC

Saving of energy consumption cost per year = 1star Ac energy consumption cost per year – 5 stars Ac energy consumption cost per year = 15204 -10128 = 5076 Rs/year cost saving
Saving of unit consumption per day = 1 star type Ac unit consumed per day – 5 stars type Ac unit consumed per day = 10.136 – 6.752 = 3.384 units saved per day
Saving of units consumption per year = 1 star type Ac unit consumed per year – 5 stars type Ac unit consumed per year = 3040.8 – 2025.6= 1015.2
The Market price difference between both Ac = 5 stars Ac price – 1 star Ac= 26700 – 21500 = 5200 Rs
The Payback period of 5 star AC compared to 1 star window AC = Market price difference between both AC / saving energy consumption per year= 5200 / 5076 = 1.02 year of Payback period.

C. LED bulb and CFL bulb

Fig 6 shows lumens v_s watts comparison chart of LED bulb and CFL bulb.

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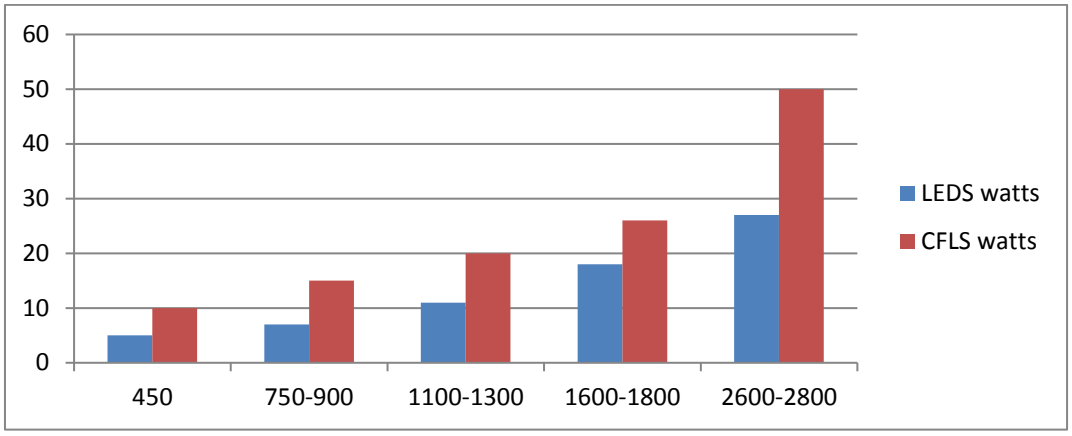

Fig 6. Lumens Vs Watts comparison of LED bulb and CFL bulb

D. Energy saving, cost of energy and payback period calculation of LED bulb

➢ Comparison of energy consumption and cost between LED bulb and CFL bulb

(a) LED bulb

Luminous flux = 810, Power consumption = 9 watts, Life span hour = 25000 hours
Price per bulb = 200 Rs.
Lumens per watt = Luminous flux / Power consumption= 810 / 9 = 90
If use of LED light bulb is 8 hours per day, so Unit used per day = 0.009*8= 0.072 unit /day
Energy consumption cost per hour = Consumed unit per hour * Electricity rate= 0.009*5 = 0.045 Rs/hour
Energy consumption cost per day = Consumed unit per day * Electricity rate= 0.072*5 = 0.36 Rs/day
Units used per year = Consumed unit per hour*8(hours per day)*300(days per year) = 0.009*8*300
= 21.6 units used per year
Energy consumption cost per year = Consumed unit per year (assume 300 days led light bulb is on) * Electricity rate= (0.009*8*300)*5 = 108 Rs/year

(b) CFL bulb

Luminous flux = 810, Power consumption = 15 watts, Life span hour = 20000 hours, Price per bulb = 120 Rs
If use of CFL bulb is 8 hours per day, so Unit used per day = 0.015*8 = 0.12 unit /day
Energy consumption cost per hour = Consumed unit per hour * Electricity rate= 0.015*5 = 0.075 Rs/hour
Energy consumption cost per day = Consumed unit per day * Electricity rate= 0.12*5 = 0.6 Rs/day
Units used per year = Consumed unit per hour*8(hours per day)*300(days per year) = 0.015*8*300
= 36 units used per year
Energy consumption cost per year = Consumed units per year (assume 300 days CFL is on) * Electricity rate
= (0.015*8*300)*5 = 180 Rs/year

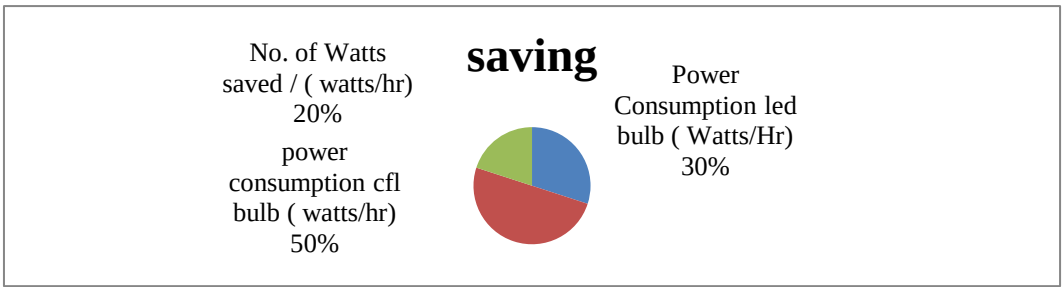

Fig 7. Percentage of units saved compared LED bulb and CFL bulb

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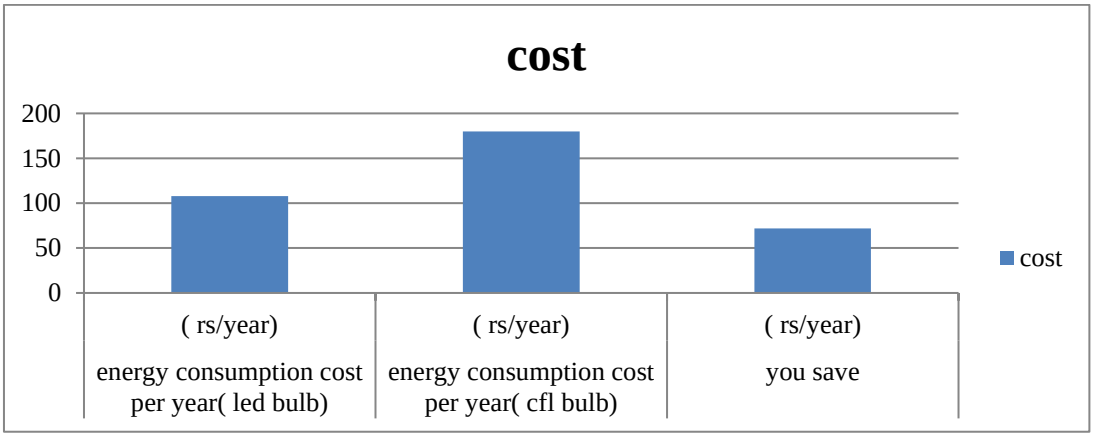

Fig8. Saving of energy consumption cost per year

➢ After comparison of both bulbs

Saving energy consumption cost per year = LED bulb energy consumption cost per year – CFL bulb energy consumption cost per year = 180 -108= 72 Rs/year cost saving

Saving unit consumption per year = LED bulb unit consumed per year – CFL bulb unit consumed per year
= 36 – 21.6 = 14.4 units saved per year

The Market price difference between both bulb = LED bulb price – CFL bulb price = 200 – 120 = 80 Rs.

The Payback period of led bulb compared to CFL bulb = market price difference between both bulbs / saving energy consumption per year = 80 / 72= 1.11 years of Payback period

IV. CONCLUSION

In this paper study of energy saving, cost of energy saving and payback period of 5 star split AC, 1 star split AC, 5 star window AC, 1 star window AC, LED bulb and CLF have carried out. Results shows that there is a saving of energy and shorter payback period using higher star rating AC compare to low star rating AC. Similarly LED bulb save energy compare to LED and it is also note that payback period is also very shorter. It is always better to use energy efficient equipment's to save energy and environment.

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