



Energy audit of household electrical appliances used for thermal comfort in Jorhat City, Assam, India

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Abstract

The present study highlighted the energy-use of electrical appliances used for thermal comfort among 373 households in Jorhat City, Assam. Appliances were audit based on age, wattage, duration of use, and BEE star rating. Study revealed that immersion rod water heaters (75.00%) and ceiling fans (71.04%) were among the most commonly used appliances. A considerable proportion of appliances had been used for four to eight years. Fans and air coolers were generally lower-wattage appliances, whereas electric heaters with fans, immersion rods, air conditioners, and electric geysers showed higher wattage. Ceiling fans, stand/table fans, and air coolers were commonly used for four to eight hours per day. Air conditioners, electric geysers, and ceiling fans had comparatively higher representation of BEE star-rated models, while most other thermal comfort appliances were non-star-rated. It showed that there is a need for greater adoption of energy-efficient appliances and responsible usage practices to reduce household electricity consumption.

Keywords: Energy audit, thermal comfort, household electrical appliances, energy efficiency, electricity consumption, BEE star rating

Introduction

By 2050, approximately 85% of India's residential floor space is expected to be served by modern energy services such as cooling, clean cooking, lighting, and media access (GBPN, 2014). Energy conservation and sustainable development depend on energy auditing. The energy audit involves a detailed assessment to identified the amount of energy consumed by various sectors and shows different ways to save energy (Darshan *et al.*, 2022)^[4].

Bukarica and Tomšić (2017)^[2] identified energy efficiency as a key tactic to address three major energy related challenges: climate change, energy security and societal economic development. By 2027, India's electricity consumption is predicted to increase from 259TWh in 2016-17 (Ministry of Statistics & Program Implementation, 2018)^[6] to 533 TWh (Central Electricity Authority, 2017). Room air conditioners, refrigerators, fans, and colour televisions are the topmost four appliances that could consume the maximum electricity in 2030 (Brookings India, 2018)^[1].

The Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Govt, of India, established under energy conservation Act 2001, is responsible to promote energy conservation and improve energy efficiency in the country. It is also responsible for implementing the energy efficiency Standards and Labelling program in India. The objective of BEE energy efficiency labelling initiatives is to lower the energy consumption of appliances without diminishing the services.

Methodology

A descriptive household survey was conducted to audit the energy-use of electrical appliances used for thermal comfort in Jorhat City, Assam. A total of 373 households from all 19

municipal wards were selected for the study. Data were collected using a structured and pre-tested interview schedule and direct observation of household appliances. Data on appliance age, wattage, usage per hours, and BEE star rating was recorded. The data were coded and analysed using appropriate descriptive statistics, including frequency, percentage, and mean, to audit appliance energy-use patterns.

Results and Discussion

The age distribution of households according to electrical appliances for thermal comfort where shown in **Table 1**, where it was depicted that three fourth (75%) of the respondents households used water heater immersion rod, which was followed by 71.04 percent ceiling fan, 65 percent air cooler, 57.77 percent electric geyser, 32.43 percent air-conditioner, 27.34 percent stand fan/table fan, 26.31 percent electric heater-with fan and only 13.76 percent electric heaters of four years of age old appliances. Further study revealed that 53.94 percent households had electric heaters with fans followed by 49.18 percent air conditioners, 46.11 percent stand or table fans, 44.95 percent electric heaters, 29.16 percent air coolers, 28.88 percent electric geysers, 25 percent water heater immersion rods, and 24.39 percent ceiling fans, had been in use for four to eight years. A small percentage of respondent households used electrical cooking appliances more than eight years. Almost 41.28 percent households had electric heaters, followed by 26.54 percent stand and table fans, 19.73 percent electric heaters with fans, 18.37 percent air conditioners, 13.33 percent electric geysers, 5.83 percent air coolers, and 4.55 percent ceiling fans were found under this category.

Table 1: Distribution of respondent's household according to the age of electrical appliances used for thermal comfort

Sl. no	Particulars	Up to 4 years	4-8 years	Above 8 yrs	Total
1.	Ceiling Fan	265(71.04)	91(24.39)	17(4.55)	373
2.	Air cooler	78(65.00)	35(29.16)	7(5.83)	120
3.	Air-conditioner	60(32.43)	91(49.18)	34(18.37)	185
4.	Electric Heater-with fan	20(26.31)	41(53.94)	15(19.73)	76
5.	Electric Heater	15(13.76)	49(44.95)	45(41.28)	109
6.	Water heater Immersion rod	45(75.00)	15(25.00)	-	60
7.	Electric Geyser	78(57.77)	39(28.88)	18(13.33)	135
8.	Stand Fan/table fan	102(27.34)	172(46.11)	99(26.54)	373

The distribution of households by wattages of electrical appliances used for thermal comfort showed that cent percent of the respondent households used ceiling fan, air cooler, stand fan/table fan of power rating up to 500 W, which indicates comparatively low power consumption. Similarly, 49.62 percent electric geyser followed by 43.24 percent air conditioners, 41.66 percent water heater immersion rod, 28.44 percent electric heater and only (19.73%) electric heater-with-fan had power ratings between 550 and 1000 W.

A majority (80.26%) of the respondent's households used electric heater-with-fan, 71.55 percent water heater immersion rod, 58.33 percent water heater immersion rod, 56.75 percent air conditioners, and 50.37 percent electric geyser of power ratings above 1000 W, indicating their high energy requirements. The results showed that despite air conditioners and heating appliances typically run at higher wattage levels and contribute to higher household electricity consumption whereas fans and air coolers are low-wattage appliances.

Table 2: Distribution of respondent's household according to wattage of electrical appliances used for thermal comfort

Sl. no	Particulars	Up to 500 W	550-1000W	Above 1000 W	Total
1.	Ceiling Fan	373(100)	-	-	373
2.	Air cooler	120(100)	-	-	120
3.	Air-conditioner	-	80(43.24)	105(56.75)	185
4.	Electric Heater-with fan	-	15(19.73)	61(80.26)	76
5.	Electric Heater	-	31(28.44)	78(71.55)	109
6.	water heater Immersion Rod	-	25(41.66)	35(58.33)	60
7.	Electric Geyser	-	67(49.62)	68(50.37)	135
8.	Stand Fan/table fan	373(100)	-	-	373

The use of electrical appliances for thermal comfort revealed that all the respondent's (100%) who have immersion rod water heaters in their homes and majority of them (82.96%) had electric geysers, 40.54 percent air conditioners, 15.78 percent electric heaters with fans, and 10.09 percent electric heaters used for less than one hour/day reflecting their short-duration of use. In contrast, 89.90 percent households were used electric heaters, followed by 84.21 percent electric heaters with fans, 59.45

percent air conditioners, 55.83 percent air coolers, 30.83 percent ceiling fans, 30.83 percent stand fans/ table fans, and 17.03 percent electric geysers up to four hour/day. It was observed that more than two-thirds (69.16%) of ceiling fans were used for four to eight hour/day, followed by (58.98%) stand/table fans and 44.16 percent used air coolers also used for four to eight hour/day. Only 10.18 percent of stand/table fans were used for more than eight hour/day during summer seasons.

Table 3: Distribution of respondent's household according to usage (hour/day) of electrical appliances used for thermal comfort

Sl. no	Particulars	< 1 hour / day	1 – 4 hours / day	4 – 8 hours / day	> 8 hours / day	Total
1.	Ceiling Fan	-	115(30.83)	258(69.16)	-	373
2.	Air cooler	-	67(55.83)	53(44.16)	-	120
3.	Air-conditioner	75(40.54)	110(59.45)	-	-	185
4.	Electric Heater-with fan	12(15.78)	64(84.21)	-	-	76
5.	Electric Heater	11(10.09)	98(89.90)	-	-	109
6.	water heater Immersion rod	60(100)	-	-	-	60
7.	Electric Geyser	112(82.96)	23(17.03)	-	-	135
8.	Stand Fan/table fan	-	115(30.83)	220(58.98)	38(10.18)	373

BEE star rating of electrical appliances used for thermal comfort is presented in the table 4, it was observed that more than one-fourth of (30.83%) of the respondent households had ceiling fans of 3 stars, followed by 28.15 percent 5 stars, 20.91 percent 4 stars, 12.06 percent 1 star, and 8.04 percent 2 stars. More than half (54.59%) households had air conditioners of 5 stars followed by 29.72 percent 4 stars, 5.94 percent 3 stars, and only 9.72 percent had no stars. Further investigation depicted that under 5 star

(51.85%) electrical appliances was electric geyser followed by 3 stars (25.92%) and (11.11%) in both 4 star and no star respectively. The respondents with cent percent households had stand/table fans, water heater immersion rods, electric heaters, air coolers, and electric heaters with fans were no star. The results showed that BEE star-rated air conditioners, electric geysers, and ceiling fans were more widely used but majority of the electrical thermal comfort appliances were not having any BEE star rating.

Table 4: Distribution of respondent's household according to star rating of electrical appliances used for thermal comfort

Sl. no	Particulars	No Star	1 Star	2 Star	3 Star	4 Star	5 Star	Total
1.	Ceiling Fan	-	45 (12.06)	30 (8.04)	115 (30.83)	78 (20.91)	105 (28.15)	373
2.	Air cooler	120 (100)	-	-	-	-	-	120
3.	Air-conditioner	18 (9.72)	-	-	11 (5.94)	55 (29.72)	101 (54.59)	185
4.	Electric Heater-with fan	76 (100)	-	-	-	-	-	76
5.	Electric Heater	109 (100)	-	-	-	-	-	109
6.	Water heater immersion rod	60 (100)	-	-	-	-	-	60
7.	Electric Geyser	15 (11.11)	-	-	35 (25.92)	15 (11.11)	70 (51.85)	135
8.	Stand Fan/table fan	373 (100)	-	-	-	-	-	373

Conclusion

The energy audit of the electrical thermal comfort revealed considerable variation in the age, wattage, usage duration, and BEE star ratings of the appliances. High-wattage appliances such as electric heaters, immersion rods, air conditioners, and electric geysers can contribute substantially to household electricity consumption. The majority of non-star-rated appliances also indicates scope for improving energy efficiency. Adoption of energy-efficient appliances, timely replacement of older appliances, and responsible usage practices can help reduce household electricity consumption and promote sustainable energy use.

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