

CEILING FAN THE OVERLOOKED APPLIANCE IN ENERGY EFFICIENCY DISCUSSIONS

Prayas Energy Group
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CEILING FAN

The Overlooked Appliance in Energy Efficiency Discussions

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1. INTRODUCTION

Even though ceiling fans are probably the most common electrical appliance after electric lights in Indian households and offices, they are rarely mentioned in discussions of energy efficiency (EE). This omission results in the loss of an opportunity to realize significant savings in energy. Fans consume about 20% of the electricity in Indian households, and their numbers are growing rapidly. Production of all fans in India is about 40 million units per year. Subtracting 20% to reflect sales of table and pedestal fans, and 10% for exports, we get annual sales of about 29 million for ceiling fans within India.² These fan additions, in turn, require an addition of new generating capacity of about 2000 MW³ each year. With a growth of 10% per year in sales, we can expect that of all the ceiling fans in Indian households in 2020, about 70% will have been added just since 2009. Fans are rarely replaced, implying this new stock will have a long life. Therefore, it is important that this new stock be efficient. In this context, we decided to review the fan industry and market in order to determine the opportunities for improving their energy efficiency.

In this paper, we first describe the structure of the fan industry. Next, we look at how fans are marketed and the characteristics customers look for when purchasing fans. Then we discuss various technical options for improving EE of fans, and end with some suggestions for bringing about an improvement in EE of fans.

² Production data, level of exports, and share of ceiling fans is based on Indian Fan Manufacturers Association's estimates (IFMA, 2010). IFMA estimated size of the fan market in 2007 as 30 million units with a growth of 10% per year which would result in about 40 million units per year in 2010.

³ Assuming that only half the fans are running at the time of peak load, and accounting for T&D losses and average non-availability of generating units.

2. HISTORY OF FAN INDUSTRY⁴

Initially the fan industry in India was dominated by imports. With the ban on imports of fans after independence, domestic production picked up. The first manufacturing unit was set up by Jay Engineering (JE) in 1947 in Kolkata. It was followed by other manufacturers around Kolkata and the other metropolitan cities.

With the closure of the JE plant in Kolkata because of labor problems, JE's Hyderabad unit became the main manufacturing center for the company. Initially, all the components were manufactured in-house by JE. Over time, In order to reduce costs, JE started outsourcing components until only the assembly was being done in-house. Finally, JE started procuring completed fans manufactured to their specifications and branding them.

Starting in the mid-eighties, other brands emerged and JE's production declined resulting in excess capacity with the component manufacturers. These component manufacturers scouted around for new customers, and as a result the ceiling fan technology was out in the open in Hyderabad. Over time, in addition to the organized component manufacturers, there emerged a number of units in the unorganized sector each manufacturing one or two components such as CI castings, aluminum die castings, blades, stators, rotors etc, or providing single services such as machining. Several assembly units also came up and assembly work became a cottage industry. In this way a cluster of units for manufacturing fans developed in Hyderabad. In a similar way, clusters came up around Delhi, Kolkata, Bangalore, Pune, Varanasi, and in parts of Punjab and Haryana.

More recently, competition in the fan industry has increased, forcing manufacturers to look for additional ways to cut costs. Himachal Pradesh (HP) and Uttarakhand have offered tax holidays to attract industries to set up manufacturing units in these two states. Some of the entrepreneurs from the old clusters shifted their bases to these two states and some new entrepreneurs joined in. As a result, now there are a few hundred manufacturers in these two states who supply fans to all leading brands according to their designs and desired level of quality.

3. STRUCTURE OF THE INDIAN FAN INDUSTRY

Today the market is divided into three segments: (1) Eight leading brands - Bajaj; Crompton-Greaves; Havells; Khaitan; Orient; Ortem; Polar; and Usha - together have a market share of about 60%; (2) About a hundred lesser known brands in the organized sector have a market share of about 25%; and (3) A large number of very small manufacturers have the remaining market share of about 15%. A large fraction of the demand for fans for the organized sector is met by the clusters in HP and Uttarakhand.

⁴ The history of the development of the fan industry in India is based on the discussion in (NRCD, 2005).

4.4 Availability

Availability in the market of particular brands is related to the brand value. Generally, only the leading brands are prominently displayed in shops. In addition, lesser known brands such as GETCO, KETCO, National, and Zenith are displayed but not as prominently. Low cost brands are available but only on demand and these brands are rarely recommended even to price-conscious customers.

4.5 Consumer Priorities

Sales personnel say that the amount of air flow a fan creates is a major criterion for selection of fans by customers, and therefore, salespersons also base their purchase recommendations on the air flow of a fan. The BIS standard for ceiling fans specifies minimum performance requirements. For ceiling fans with a sweep of 1200 mm, it requires: (1) that the minimum air delivery be 200 m³/min; (2) that the minimum service value⁷ be 4.0; (3) that the maximum power input be 50 W, but allows an increase upto 55 W if the service value is maintained. It is interesting that the specifications for a 5 Star fan established by BEE also requires that the service value be 4.0 or higher. However, the minimum air delivery required is slightly higher at 210 m³/min.

The power consumption of standard designs from most leading brands is about 70-80W at full speed. Most of the leading brands also have Energy Saver models which consume around 50W at full speed. However, there is a perception among sales staff that Energy Saver models rotate at a lower speed and move less air and thus are not good for consumers. Even though these models are sold at a premium price about Rs. 100 to Rs. 200 above standard models, there is very little marketing of these models by the retail sales staff. Furthermore, very few of the retail sales persons are aware of the BEE label and energy efficient fans.

IFMA had proposed to BIS for an additional grade of fans having higher air delivery but much lower service value than given in the standard to cater to market demand. However, BIS has deferred the consideration of the proposal because: (1) It could not be established conclusively that consumers wanted such fans; and (2) a more recent proposal from IFMA suggested that the additional grade have the same air delivery as the standard but much lower service values (BIS, 2007: Clause 0.3).

It is important that the air flow used for setting performance standards is consistent with the air flow desired by consumers. This will ensure that energy savings do not result in inadequate service for consumers. One confounding factor regarding fans is that the power consumption by a fan is greatly affected by the speed at which the fan rotates.⁸ Therefore, in order to accurately determine power consumption and energy savings for fans, it is important to know two things: (1) consumer preferences for levels of air flow and some idea of the typical air flow that people require from fans; and (2) how the

⁷ Service Value is calculated by dividing the air delivery of the fan in m³/min by the electrical power input in Watts.

⁸ The variable component of power consumption varies with the cube of the fan speed. However, because the fixed component of consumption is often not known, it is not possible to give a mathematical expression for the aggregate power consumption.

power consumption of a fan varies with the air flow level (or speed) setting. Unfortunately, neither one of these data sets are available.

While there is little interest in the efficiency of fans, customers are showing considerable interest in cosmetic features such as color and shape of the fan. Most major manufacturers are responding to this demand and have a line of decorative fans with a wide choice of colors, blade-designs, and number of blades. Some decorative models also combine a light with the fan.

5. SPEED REGULATORS

Regulation of fan speed can be done using one of three technologies:

1. Variable resistance in the line
2. Variable capacitance in the line
3. Electronic control using triacs or similar electronic devices.

Traditionally, the speed was controlled by using a resistor in the line whose value could be changed in steps. Resistive control leads to loss of energy because of I^2R losses and is rarely used in new installations but it is still seen in use in old installations. Variable capacitance is the most commonly used regulator for new installations. Generally, fans are sold without regulators and variable capacitor type regulators are installed in the switchboards by the builder. Electronic control generally based on triacs causes harmonics because of the “chopping up” of the sinusoidal input voltage. However, electronic controls allow continuously variable speed control which is not available with resistive and capacitive regulators.

6. OPTIONS FOR INCREASING EFFICIENCY OF FANS

We now look at the various technical options available for improving the EE of fans. We break up our investigation into two parts. First, we look at the options for the current design of fans based on induction motors. Next, we look at options that look at other innovative designs for fans using different technologies.

6.1 Current Designs

Fans with Induction motors can be made more efficient through three actions: (1) increasing the height of the stator and rotor stack (more iron); (2) by making the wires thicker (more copper); and (3) by using a smaller (lower value) capacitor to reduce the top speed of the fan. Using these methods, the power consumption of a fan can be brought down to about 45W at full speed for fans with a sweep of 1200mm. For further reductions in power consumption, alternative technologies need to be looked at which we describe next.

6.2 Future Technologies

Fan manufacturers are beginning to explore the use of brushless DC (BLDC) motors in ceiling fans. BLDC motors are actually permanent magnet synchronous AC motors that are driven by an inverter that is synchronized to the motor. In this configuration, the combination of motor and inverter displays characteristics at the DC input to the inverter which are the same as DC motors. Thus they are called brushless DC motors. Because there are no currents flowing in the rotor of a BLDC motor, there are no rotor losses. In addition, the rotor of a BLDC fan is lighter and thus will have lower inertia. These two features make BLDC fans more efficient. It is expected that with BLDC technology, the power consumption of ceiling fans can ultimately be reduced to about 35W per fan at full speed, about half of the power consumption of a standard fan today.

7. DSM PROGRAMS FOR FANS

Given the energy saving potential of a super-efficient fan for a small increase in the cost, it makes sense to try to implement a DSM program for fans. In a companion paper (Prayas, 2010), we have described the benefits of national level programs and have also shown that a program based on super-efficient fans is a very good candidate for a national program. As discussed there, an upstream program for ceiling fans could start with BEE or a committee of stakeholders negotiating with manufacturers about the incentive that would be required for a super-efficient fan. We suggest that the committee not specify any particular technology but instead specify a performance level.

Table 1 gives some indicative numbers for the savings that could be achieved in 2020 if all new fans installed from now until 2020 were of the super-efficient type. Here we have assumed that a standard fan today consumes 75W at full speed while a super-efficient fan using current technology would consume 45W, and we have assumed that on average the power saving would be only half of the full-speed saving to account for reduced saving as speed of the fan is reduced. Even when assuming savings of 15 W only at an additional cost of Rs. 50 per super-efficient fan, as the data from the utility perspective in the table shows, the payback period for the additional investment is shorter than one year. Given the very long life of fans over which savings would continue to occur, the benefits are much greater than the costs making the use of such super-efficient fans clearly a very economically attractive option. As technology evolves and BLDC fans become widely available, the energy savings will be even higher. Even if the incentive may need to be somewhat higher in that case, the economics could still be very attractive.

Table 1-A : Potential Savings from National Fan Program in 2020

Power Savings per Fan (W)	15	W
Usage	1350	hours/yr
Energy Saved per Fan	20.25	kWh/yr
Power purchase cost saved per fan per year	60.75	Rs/yr/fan
Fan additions 2010-2020	537	million
Energy Saved at Bus-Bar in Year 2020	13603	GWh
Fraction of fans on during summer peak hours	50%	
Reduction in Summer Peak Capacity Reqmt in 2020	5930	MW

Table 1-B : Utility Perspective

Incentive Paid to Manufacturers @ Rs.50/fan	2687	crores
Avoided Power Purchase Costs @ Rs. 3/kWh in one year	4080	crores
Avoided Power Purchase Costs @ Rs. 3/kWh over lives of all fans	61200	crores

8. CONCLUSIONS AND ACTION POINTS

Ceiling fans are one of the big consumers of electricity in Indian households. With the rapid growth in the number of fans that is projected for the near future, it is important that attention is focused on improving the EE of fans. A national level DSM program for fans makes eminent sense. Upstream incentives of about Rs. 50 per super-efficient fan to manufacturers can result in very rapid introduction of super-efficient fans. As technology evolves and super-efficient fans such BLDC fans become widely available, the energy savings will be even higher. Furthermore, fortunately the structure of the fan industry where almost all the fans are manufactured by small manufacturers in industrial clusters means that small manufacturers will be integrated in the development of this new technology and no separate efforts are required to bring along small manufacturers.

In order to have more accurate estimates of the savings from super-efficient fans some additional data is required. First, we need better data on consumer preferences about the air-flow that they require from fans. Second, data is required about how power consumption varies with changes in the air-flow from fans.

9. REFERENCES

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10. ANNEXURE

COST STRUCTURE FOR CEILING FANS⁹

Table A-1: Indicative Costs for Ceiling Fan with 1200 mm Sweep Using Good Quality Materials

Item	Quantity	Cost (Rs.)
Material Costs		445
Silicon Stampings	1.1 kg	
Copper Wire for Winding	0.3 kg	
Shaft	1 No.	
End-Shields (Castings)	2.2 kg	
Bearings	2 No.	
Rotor Die-Casting	1 No.	
Canopies	2 No.	
Capacitor	1 No.	
Fan Blades	3 No.	
Labor incl. Painting		45
Packing		35
TOTAL COST		525

Source: The list of materials and quantities is from (NRCD, 2005). The costs were independently updated.

Table A-2: Estimate of Manufacturer's Realization for Ceiling Fan with 1200 mm Sweep Using Good Quality Materials

Activity	Cost (Rs.)	Realization (Rs.)
MRP		1375
Discount to Consumer	125	
Distributor & Retailer Margins	150	
Taxes	220	
Excise Duty		
VAT		
Octroi		
Transportation	35	
Manufacturers Fixed Cost	200	
TOTAL ADDITIONAL COSTS	730	
REALIZATION BY MANUFACTURER		645

⁹ All costs shown in this Annexure are based on a small and informal survey in Mumbai, and some discussions with manufacturers, and are meant to give a rough idea of the costs. More accurate estimates of costs would require a much more detailed and widespread survey.