Policy Brief: Evidence-based Cooling Strategies for a Warming World: Assessing Supply and Demand Conditions in the Indian Market for Energy Efficient Fans

September 2022

This paper evaluates the outcome of trials of super efficiency ceiling fans and assesses the benefits of their use from the perspective of both consumers and utilities. Based on willingness to pay exercises and market analysis it also explores routes to supplying at scale to the low-income segment of the market in India.

Key messages and recommendations

- Without additional policy intervention, India will likely see significant under-investment in energy efficient fans, particularly among households who pay subsidized electricity rates. This under-investment will "lock-in" energy inefficient cooling for decades. This will impose larger-than-necessary costs to households, distribution companies, and the environment.
- To incentivize efficient investments in harder-to-reach markets, policy makers need to find viable ways to reduce the cost of purchasing BLDC fans and other efficient appliances. Bulk procurement programs will be necessary, but not sufficient.
- This research finds that state governments and distribution companies could reduce their overall subsidy costs by providing technology incentives that increase BLDC fan adoption among low-income households. Researchers find that lowering BLDC fan prices by INR 1000 increased BLDC fan adoption by almost 65 percentage points. This INR 1000 subsidy could be offset by reductions in future electricity subsidy costs which are estimated to be on the order of INR 2000 per fan over a five-year time horizon.
- Policy makers have a number of tools they could use to reduce BLDC fan prices offered to low-income households such as : **Direct benefits** transfers for BPL households that offset part of the upfront cost of a BLDC fan; **On-bill financing programs** that allow households to pay off low-interest loans through higher electricity prices on their electricity bills; **Fan replacement or buyback programs** that offer BLDC fan rebates in exchange for an inefficient fan `trade-in'; **General sales tax** exemption for energy efficient fans
- More work is needed to assess the impacts that these alternative strategies would have on BLDC fan adoption and electricity consumption. This work should start now. In the absence of effective policy intervention, households will continue to purchase inefficient fans, locking in higher costs for consumers, the power sector, and the environment for decades to come

Background

Rising global temperatures pose a particular risk for vulnerable populations with limited access to cooling technologies. India faces the dual challenge of helping millions of at-risk households adapt to the heat, while at the same time reducing the local air pollution and greenhouse gas emissions generated by electricity production and managing the impacts on constrained power system infrastructure.

A new EEG working paper by a team of researchers from IIT Bombay and the University of California highlights the critical role that energy efficient fans could play in addressing India's cooling access challenges. Ceiling fans are, by far, the most common cooling appliance used by households in India. Ceiling fan sales now exceed 60 million annually. As incomes and temperatures rise, demand for fans is expected to increase.

The induction motor (IM) fans that currently dominate the Indian market consume 65-75W. Super-efficient Brushless Direct Current (BLDC) fans use between 28-35W. If future cooling demand increases could be met with these super-efficient fans,

the amount of electricity required to keep up with increasing demand for cooling would be dramatically reduced. However, the market penetration of energy efficient fans remains very low, despite energy efficiency labelling and procurement programs.

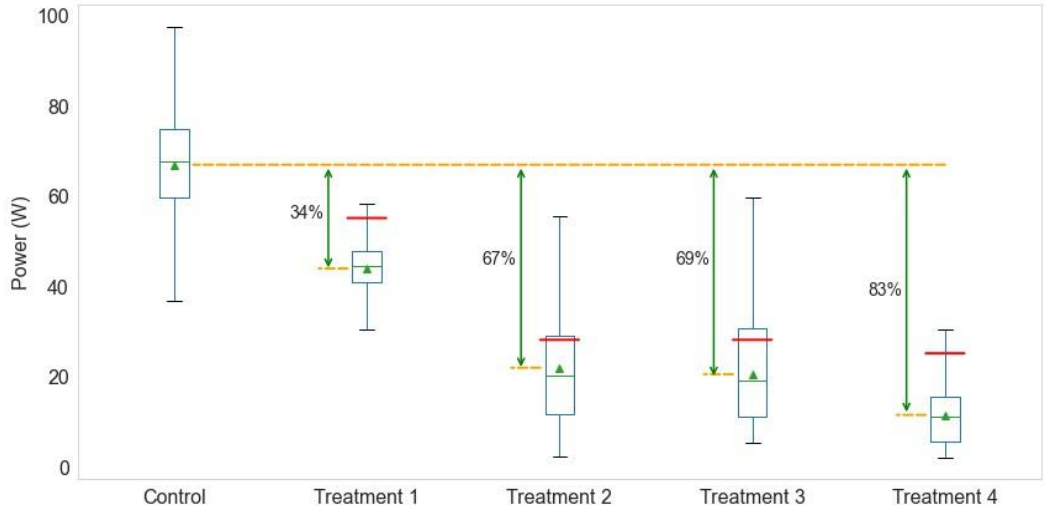
Findings

The IIT-UCB study provides a first-of-its kind- assessment of the demand potential for BLDC fans in rural and peri-urban market settings where access to sustainable cooling solutions is currently limited (or non-existent). There are five key findings:

1. BLDC fans perform well in settings characterized by supply-interruptions and voltage fluctuations

In a field trial designed to assess the real-world performance of BLDC fans, participating households were assigned to either a control group or a treatment group in which the household fans were replaced with an efficient BLDC fan. Fan usage was monitored at on minute intervals over a period of 11 months. Figure 1 shows that electricity savings per hour of use were 67-83% among households that received a BLDC fan (Treatment groups 2-4), relative to the group that used their standard fan.

Figure 1: Average Measured Power Draw of Standard versus BLDC Fans



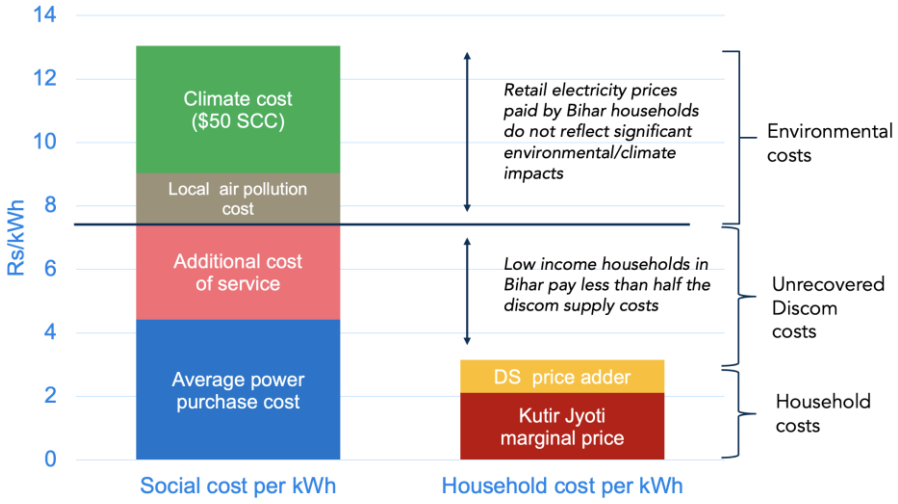
Notes: Horizontal red line markers indicate design power ratings of ceiling fans assigned to each group. Green triangle markers show average power consumption for each group. Box plots show the range of fan power consumption during operation across time. Percentages indicate differences in average fan power consumption between energy-efficient fans assigned to treatment groups and conventional fans in control group households.

2. BLDC fans are highly cost-effective from a social perspective

The returns on BLDC fan investments accrue primarily in the form of electricity savings. When the electricity inputs required to cool a home are reduced, households spend less on their electricity bills, distribution companies spend less on procurement and delivery costs, and emissions of harmful air pollution and greenhouse gas emissions are reduced.

In India, low-income households pay subsidized electricity prices that do not fully cover the cost of generating and supplying electricity. Figure 2 contrasts the full social marginal cost per kWh of electricity consumption (including variable generation costs, distribution costs, air pollution costs, and climate change costs) against the retail rates paid by low-income households in Bihar.

Figure 2: Household costs, distribution company costs, and the environmental costs of electricity consumption

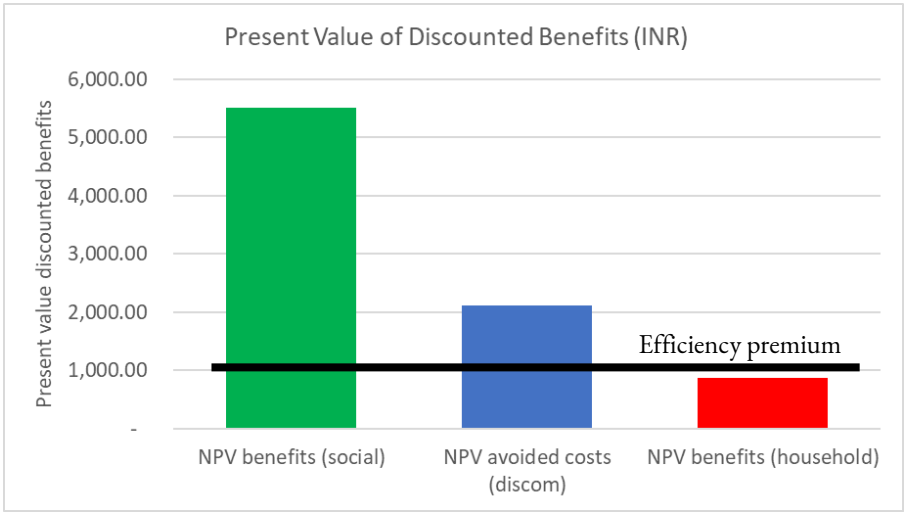


Notes: BPL households are either unmetered (with a marginal price of Rs 0), or on one of two subsidized rates (i.e. Kutir Jyoti or DS). See paper for details on the calibration of the social marginal cost of electricity consumption.

Researchers estimate the present value of discounted savings from replacing a standard fan with a BLDC fan from a variety of perspectives. Figure 3 compares these benefits estimates under one set of assumptions from the perspective of society (green), the distribution company (blue), and a low-income household (red).1

- From a social perspective, the present discounted value of avoided energy supply costs and avoided environmental impacts easily offsets the energy efficiency "premium" (i.e., the difference between the cost of a typical induction motor fan and a cost of an efficient BLDC fan).
- From the distribution company's perspective, the present discounted value of the reductions in residual costs (i.e., supply costs not recovered in revenues collected from households) also exceed the additional technology cost. In other words, BLDC fans appear to be are cost effective investments.

Figure 3: Discounted Monetized Value of Savings from BLDC Fan Adoption



[1] The paper evaluates the net present value of a BLDC fan investment using a range of plausible assumptions and parameter values.

Notes: Net present value estimates of discounted benefits from fan adoption conservatively assume a fan life of 5 years, an efficiency improvement of 35W, and a fan utilization rate of 7 hours per day. Private savings are discounted at 30%. Social savings are discounted at 15%.

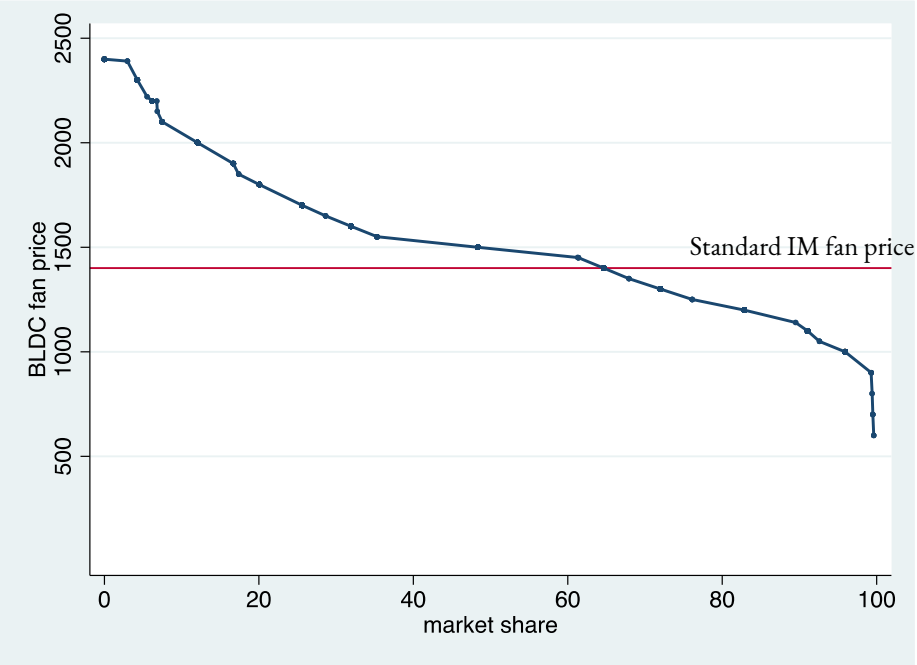
3. BLDC fans are not cost-effective for low-income households paying subsidized electricity prices.

The red bar in Figure 3 represents the estimated present value of future electricity savings captured by low-income households in Bihar who choose a BLDC fan over a standard fan. Because these households pay a subsidized electricity price, they capture only a fraction of the benefits. For most households, these benefits will not offset the additional investment cost. These basic cost-benefit comparisons suggest that adoption rates of BLDC fans will likely be very low among low-income households.

4. BLDC fan demand among low-income households is much higher at lower prices.

Working closely with shop owners serving lower income markets in Bihar, we randomized BLDC fan prices across more than 1,700 transaction settings. Offered prices varied from as low as INR 1200 to the current EESL procurement price of INR 2399. Figure 4 shows how demand for fans varied with offered price points.

Figure 4: Observed Demand for BLDC Fans



Notes: This graph summarizes how demand for BLDC fans increases as the fan offer price decreases. A standard 75W induction motor fan sells in local markets at prices between INR 1200-1450.

Demand for the BLDC fan current price, INR 2399, was very low. Less than 3 percent of households were willing to purchase the fan at this price. However, at lower BLDC fan price points, adoption rates increased significantly. With an INR 1000 discount, the adoption increases to 65%.

Our estimates of the reductions in electricity subsidy payments that accrue when a low-income customer chooses a BLDC fan exceed INR 2000 over a five-year time horizon (see Figure 3). Taken together, these research findings suggest that the technology subsidy required to significantly increase BLDC fan adoption today could be quickly recovered via reductions in future electricity price subsidy obligations.

5. Strategic partnerships with local distribution/sales networks can overcome last-mile supply chain challenges.

To implement this study, researchers partnered with a well-established network of village organizations that support hundreds of female-owned and operated shops in Bihar. With some training and support, a group of shop owners were able to procure, market, distribute, and sell these energy efficient fans in their shops. If BLDC fan prices could be reduced to levels that support local demand, this network of local shops seems well positioned to meet this demand.

Policy Implications

Without additional policy intervention, India will see significant under-investment in energy efficient fans, particularly among households who pay subsidized electricity rates. This under-investment will "lock-in" energy inefficient cooling for decades. This will impose larger-than-necessary costs to households, distribution companies, and the environment.

To incentivize efficient investments in harder-to-reach markets, policy makers need to find viable ways to reduce the cost of purchasing BLDC fans and other efficient appliances. Bulk procurement programs will be necessary, but not sufficient.

This research finds that state governments and discoms could reduce their overall subsidy costs by providing technology incentives that increase BLDC fan adoption among low-income households. Researchers find that lowering BLDC fan prices by INR 1000 increased BLDC fan adoption by almost 65 percentage points. This INR 1000 subsidy could be quickly offset by reductions in future electricity subsidy costs which are estimated to be on the order of INR 2000 per fan over a five-year time horizon.

Policy makers have a number of tools they could use to reduce BLDC fan prices offered to low-income households. These include:

- **Direct benefits** transfers for BPL households that offset part of the upfront cost of a BLDC fan.
- **On-bill financing programs** that allow households to pay off low-interest loans through higher electricity prices on their electricity bills.
- **Fan replacement or buyback programs** that offer BLDC fan rebates in exchange for an inefficient fan `trade-in'.
- **General sales tax** exemption for energy efficient fans.

More work is needed to assess the impacts that these alternative strategies would have on BLDC fan adoption and electricity consumption. This work should start now. In the absence of effective policy intervention, households will continue to purchase inefficient fans, locking in higher costs for consumers, the power sector, and the environment for decades to come.

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