Knowledge to action – strategies for market adoption of super-efficient fans

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Abstract

The cooling sector, whether air conditioning, process cooling, or cold-chain has been somewhat of a climate change blind spot – partly due to its initially small share. However, over the last two decades it has been growing dramatically and is now approaching 7 % of all GHG emissions globally. The IEA estimates that there are currently 3.6 bn cooling appliances in the world and full access to cooling for those that need it is estimated to result in a total of 14 bn cooling appliances by 2050. Within the cooling sector the largest contributor now – and in the future – is air conditioning in buildings.

Whilst we need better buildings that can naturally and passively prevent heat gain, we also need better air conditioners, fans and coolers that have a lower climate impact such that the emissions impact of cooling can be flattened even as its adoption grows. Providing thermal comfort to the millions of people is critical during extreme heat conditions. About 35 % of the urban population living in slums and informal settlements cannot protect themselves from extreme heat and mostly depend on low-cost ceiling fans for thermal comfort under the intense heat – devices which are currently inefficient.

The paper will focus on informing novel strategies based on Knowledge to Action (KTA) framework that helped in transforming the market of super-efficient cooling appliances, mainly fans, across one of the largest real estate developers in India. The paper will focus on the case study from the real estate company "Lodha Developers" on how a multi-pronged strategy in a city inhabited by 1 million people by 2030 can be adopted for diffusion of energy efficient technologies. The proposed strategy consists of designing a mass awareness campaign, conducting in-person interviews, strategic partnerships and engagement with manufacturers and resident associations.

Introduction

As the Indian Meteorological Department reports, temperature patterns across the country are shifting, elongating summer conditions to nearly eight months a year and exacerbating the frequency and intensity of heatwaves (Kumar et al., 2006). The implications of this sustained climatic shift are profound, stretching beyond health risks to test the resilience of the nation's energy infrastructure.

Cooling solutions, predominantly air conditioners and fans, already account for about 60 % of the energy usage in residential buildings, with projections suggesting a steep climb in demand due to increasingly common heatwaves (De La Rue Du Can, Leventis, Shah, & McNeil, 2006). By 2037, the India Cooling Action Plan forecasts an elevenfold surge in India's cooling requirements, with building space cooling poised to register an eightfold increase from 2017 levels (Ozone Cell, Ministry of Environment, Forest & Climate Change, Government of India, 2019). This escalation could lead to an unsustainable strain on energy resources unless mitigated by a transition to more efficient technologies.

Fans, a ubiquitous and cost-effective means of providing thermal comfort, are instrumental in India's narrative of energy consumption. Accounting for roughly 30 % (41 TWh) of the total expected space cooling energy use (135 TWh), the nearly 450 million fans in operation are projected to double their energy consumption by 2037, highlighting a critical juncture for energy policy and consumer behavior (Ozone Cell, Ministry of Environment, Forest & Climate Change, Government of India, 2019). Addressing this impending challenge, fans have transcended their role as mere comfort appliances; they have become indispensable in homes across urban and rural landscapes, contributing to air circulation and living standards in over 95 % of Indian households, often with more than one fan per home (Agrawal et al., 2020).

This study embarks on a journey to explore and implement the Knowledge to Action (KTA) Framework (Graham et al., 2006), aiming to catalyze the market adoption of super-efficient Brushless DC (BLDC) fans, which emerge as a pivotal countermeasure to the escalating energy demand in Indian homes. By employing the KTA Framework, we aim to systematically dismantle the barriers to adopting energy-efficient technologies, transforming knowledge into actionable, sustainable practices within the Lodha Group's developments.

As we pave the way through this multifaceted challenge, the subsequent sections will delve into the methodologies adopted, informed by the robust KTA Framework, to enact a strategy that not only measures but motivates a significant shift in India's cooling sector towards energy efficiency and environmental stewardship.

UNDERSTANDING THE KNOWLEDGE TO ACTION (KTA) FRAMEWORK

The Knowledge to Action (KTA) Framework is an evidence-based model developed by Graham et al., 2006 to translate research findings into practice. The framework is designed to bridge the gap between knowledge and action, consisting of two main components: the Knowledge Creation Funnel and the Action Cycle. The Knowledge Creation Funnel captures the process of knowledge synthesis, distillation, and representation, leading to the development of actionable messages and tools. The Action Cycle then guides the implementation of these tools through tailored interventions, promoting the adoption of best practices and overcoming barriers to change. In this study, we operationalize the KTA Framework to enhance the market adoption of super-efficient fans. Through rigorous knowledge synthesis, we identified the critical attributes of super-efficient fans and recognized the key barriers to their widespread adoption. In line with the KTA's Action Cycle, our intervention strategies were informed by this knowledge and focused on the real-world context of Indian residential developments. This involved customizing the dissemination of knowledge to address consumer behavior, economic constraints, and policy environments.

FAN OPERATION AND ENERGY PERFORMANCE

The primary function of a ceiling fan is to ensure air circulation. Fan blades rotate and push air downward, creating a breeze that moves across the skin of the people in the room and enhances the evaporative rate. This air movement can make the surroundings feel cooler, leading to improved thermal comfort for occupants.

Key factors affecting fan performance: The key metric of a fan's performance is the service value, which is the ratio of air delivery in cubic meters per minute and power consumption. It depends on two parameters:

1. **Air circulation and flow:** Ceiling fans come in various blade sizes such as 900 mm, 1,200 mm, 1,400 mm and others to suit different room sizes. The airflow and circulation differ depending on the blade size. The higher the fan sweep size, the higher is the airflow within the space. Airflow and circulation are also dependent parameters of blade design. With a rise in sweep size, service value is also expected to increase considering the proportional increase in airflow and circulation and the blade's sweep size.
2. **Power consumption:** Power consumption refers to the power consumed by a ceiling fan during one hour at full speed.

The Bureau of Energy Efficiency (BEE) launched a mandatory star labelling schedule for fans effective from 1 July 2022 to 31 December 2022 (see Table 1).

Methodology: Applying the Knowledge to Action Framework

Our study employed the Knowledge to Action (KTA) Framework as a guide to evaluate and promote the use of energy-efficient BLDC fans within the Lodha Group's managed facilities. The research methodology unfolded as follows:

- **Step 1: Knowledge Synthesis**: We conducted a comprehensive review of literature on energy consumption patterns in India and the role of cooling technologies, particularly focusing on ceiling fans' energy efficiency. The key literature referred for this paper included:
  - Awareness and Adoption of Energy Efficiency in Indian Homes: Insights from the India Residential Energy Consumption Survey (IRES) – *Agrawal et al., 2020*

Table 1. Star rating of ceiling fans and their service values.

Star rating*	Service value for blade sizes	
	1,200 mm and above	Less than 1,200 mm
1	4.0–4.5	3.1–3.6
2	4.0–5.0	3.6–4.1
3	5.0–5.5	4.1–4.6
4	5.5–6.0	4.6–5.1
5	6.0 and above	5.1 and above

**The fan performance is tested in conformance to ISO 374:1979.*

Table 2. Details of interviews.

Organisation	Job title of interviewed person	Interview Duration	Timeline
Atomberg	Senior Sales Representative	60 minutes	Sep-24
Versa Drive/ Superfans	Managing Director	60 minutes	Sep-24
Havells	Senior Sales Representative	60 minutes	Sep-24
Indo Fans	Senior Sales Representative	60 minutes	Sep-24
EESL	Head of International, Strategy, Appliances, Rooftop Solar and PE & A	60 minutes	Sep-24
Orient	Senior Sales Representative	60 minutes	Sep-24

  - Cooling the Growth of Air Conditioners Energy Consumption – *De La Rue Du Can, Leventis, Shah, & McNeil, 2006*
  - India Cooling Action Plan – *Ozone Cell, Ministry of Environment, Forest & Climate Change, Government of India, 2019*
  - In addition to this, paper utilised the literature and experiential knowledge gathered through working with Lodha Developers and insights from Gateway to India's Dymaxion – *Lodha, & RMI Net Zero Urban Accelerator, 2023.*

- **Step 2: Knowledge Exchange** Dialogue with Lodha Group stakeholders facilitated an exchange of insights and knowledge, fostering a shared understanding to guide informed decision making.
- **Step 3: Identifying Barriers**: Conversations with Lodha Group and fan manufacturers revealed barriers to BLDC fan adoption, such as cost concerns, preference for existing technology, and lack of credible information on BLDC fan benefits.
- **Step 4: Intervention Identification**: To build evidence-based confidence, we implemented experiments as described in step 5 as interventions to address these barriers, particularly focusing on the perceived risks associated with new technology adoption.
- **Step 5: Experimentation and Knowledge Adaptation:** To adapt our synthesized knowledge to a practical setting, we designed an experimental comparison within the Lodha Group's developments. This involved assessing the performance of different fan types in four separate, controlled-environment rooms available in a building constructed by the Lodha Group to evaluate their energy efficiency and operational benefits.

  Experimental Setup: The evaluation consisted of an experimental comparison conducted in four separate rooms, each outfitted with different types of fans to assess their performance under controlled conditions and are as follows:

  - 1st Room – Business As Usual (BAU): Served as the baseline, outfitted with 80 W fans to establish a control for energy consumption and airflow efficiency.
  - 2nd Room – 50 W Fan: Introduced as a more energy-efficient alternative to BAU fans, providing a comparative measure of energy savings.
  - 3rd Room – 26W BLDC Fan by Manufacturer 1: Tested for cutting-edge energy efficiency, these fans were assessed for their potential to significantly reduce energy usage.
  - 4th Room – 26W BLDC Fan by Manufacturer 2: Equipped with a different brand of 26 W BLDC fans to evaluate performance variations and affirm the consistency of BLDC technology benefits across manufacturers.
  - Each room's setup was meticulously isolated to ensure external factors like air infiltration did not skew the performance metrics, thus guaranteeing that any observed differences in operational efficiency were attributable to the fans themselves.

- **Step 6: Data Collection and Analysis**: We systematically recorded energy consumption data, enabling a comparative analysis across the different fan types and setups.
- **Step 7: Outcome Evaluation**: Our evaluation supported Lodha Group in informed decision making to retrofit existing facilities with BLDC fans, indicative of the research's direct impact on institutional practices.
- **Step 8: Sustaining Knowledge Use***:* To encourage long-term adoption, we outlined strategies for continued education on BLDC fan benefits, including potential partnerships with manufacturers to reduce costs and incentive programs to encourage resident uptake.
- **Limitations:** Though the experimentation rooms were controlled for external factors such as air infiltration to ensure a fair comparison, we did not follow a standardized test protocol due to the real-world application focus of the study.

Results

BARRIERS TO ADOPTION OF SE FANS: BASED ON DISCUSSION WITH LODHA GROUP AND FAN MANUFACTURES

Even after evidential benefits, the uptake of SE fans is limited. The barriers to the adoption of SE or BLDC fans in this context can be categorised into several key areas:

Table 3. Power and energy consumption of various ceiling fans (rated power 26 W, 50 W and 80 W).

Room No.	Rated power	Measurements	Speed 1	Speed 2	Speed 3	Speed 4	Speed 5
1	26 W	Power, W	5.8	8.3	15	21.1	25.9
		Energy, Wh (24 hours)	139.2	199.2	360	506.4	621.6
2	26 W	Power, W	5.8	8.3	15	21.1	25.9
		Energy, Wh (24 hours)	139.2	199.2	360	506.4	621.6
3	50 W	Power, W	20.8	37.3	37.4	63.1	61.1
		Energy, Wh (24 hours)	499.2	895.2	897.6	1,514.4	1,466.4
4	80 W	Power, W	15.1	27.7	44.6	53.6	82.5
		Energy, Wh (24 hours)	362.4	664.8	1,070.4	1,286.4	1,980

- **Voluntary Labelling Program** – The BEE star labelling program for ceiling fans is still at the voluntary stage and doesn't ensure full-scale enforcement of the program.
- **Cost**: BLDC fans typically have a higher upfront cost than conventional fans due to the advanced technology they use. This can deter potential buyers, especially in cost-sensitive markets as there is a cost increment of around 40 % compared with a 50 W fan.
- **Awareness**: Many consumers including the Lodha Group were unaware of the actual benefits of BLDC fans, such as energy efficiency and quiet operation, as mostly there are no unbiased studies claiming the benefits. In addition, some consumers perceive BLDC fans as more complex to install or operate than traditional fans as there is a disconnection from the regulators required in most cases.
- **Resistance to change**: People often resist changing their habits, including their purchase habits. If they have been using traditional fans for many years, they may be reluctant to switch to a new type of fan.
- **Availability**: BLDC fans may not be as readily available as traditional fans in some markets. Limited availability in local stores due to less demand also hinders their adoption.
- **Long replacement cycles**: Fans are not frequently replaced appliances. Therefore, even if a consumer is aware of and interested in BLDC fans, they may not have the opportunity to purchase one until their existing fan needs to be replaced.

RESULTS FROM FAN ENERGY MONITORING EXPERIMENT

The most advanced technology currently available is the brushless direct current (BLDC) fan, noted for its low energy consumption, with some models using just 24 watts. A fan energy monitoring experiment was conducted at the residential units being developed in Palava by Lodha developers to evaluate the energy efficiency and energy consumption of ceiling fans with power ratings of 26 W, 50 W, and 80 W. These fans were tested at different speeds, from the lowest to the highest setting, and measurements of power and energy use were recorded continuously over a full day. The findings are summarised in Table 2.

The power consumed by a super-efficient (SE) BLDC ceiling fan at the lowest speed is 5.8 W, which is at least three times more efficient than 50 W and 80 W ceiling fans at the lowest rates. The same trend is observed at the top speed. As shown in Figure 2, 26 W BLDC fan consumes hourly energy of less than 6 Wh at the lowest speed, while an 80 W conventional fan consumes 15 Wh. This could potentially lead to 66 % energy savings and associated operational cost reduction. Similarly, an SE 26 W BLDC fan consumes hourly energy of 25.6 Wh at top speed compared with an 80W conventional ceiling fan consuming 82.5 Wh.[1]

Assuming the usual set speed for fans at 'speed 4' and 24-hour operations, the energy consumption was estimated for 10 years in Figure 2.

An SE 26 W BLDC fan would consume three times less energy cumulatively in 10 years, which is approximately equivalent to 2,000 units, resulting in cost savings of approximately ₹20,000 (calculated at ₹10/kWh on average).

LIFE CYCLE COST OF A CEILING FAN

The life cycle cost (LCC), also known as whole life costing, is a method to determine the total cost of ownership of a product or service. It includes all the costs associated with the product or service over its entire life cycle, from initial acquisition and installation to its use, maintenance and final disposal. **The main components of LCC typically include the following:**

- **Acquisition costs**: These are associated with purchasing the product or service and could include the product cost and other costs associated with installation or initial setup.
- **Operating costs**: These are associated with using the product or service and could include energy, maintenance, repair, and other costs associated with the daily use of the product.
- **Maintenance and repair costs**: These are associated with keeping the product or service in good working order and could include regular maintenance and repairs over the product's life.
- **End-of-life costs**: These are associated with disposing of the product or service at the end of its useful life and could include costs associated with decommissioning, disposal or recycling.

In the case of a ceiling fan, the overall lifespan is at least 12 to 15 years, with minimal or no maintenance or repair costs

1. Air delivery and RPM were not measured during the measurements. This will be further assessed in the second phase of the experiment in the second year of the accelerator.

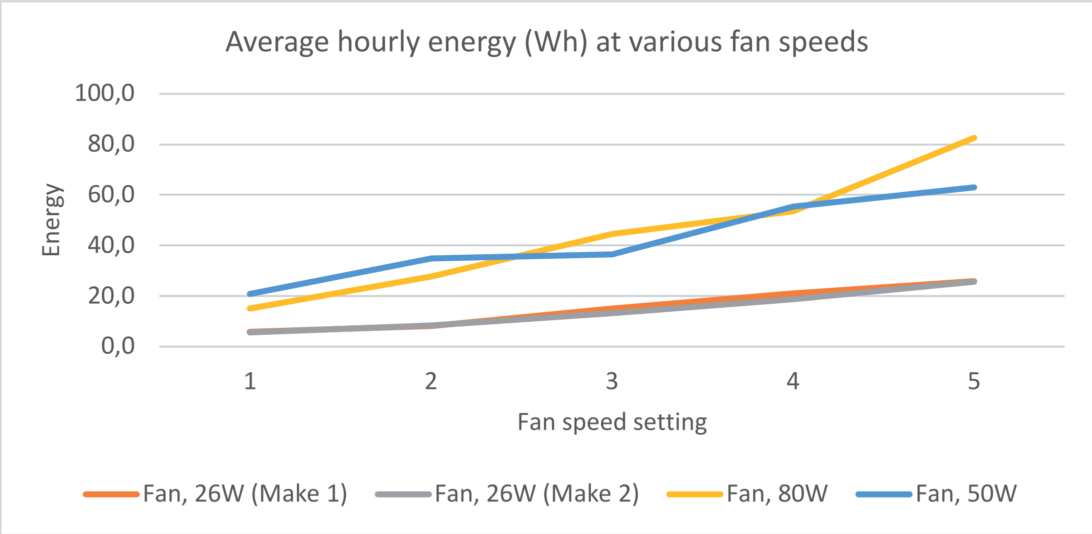

Figure 1. Energy consumption pattern on different fan speed settings.

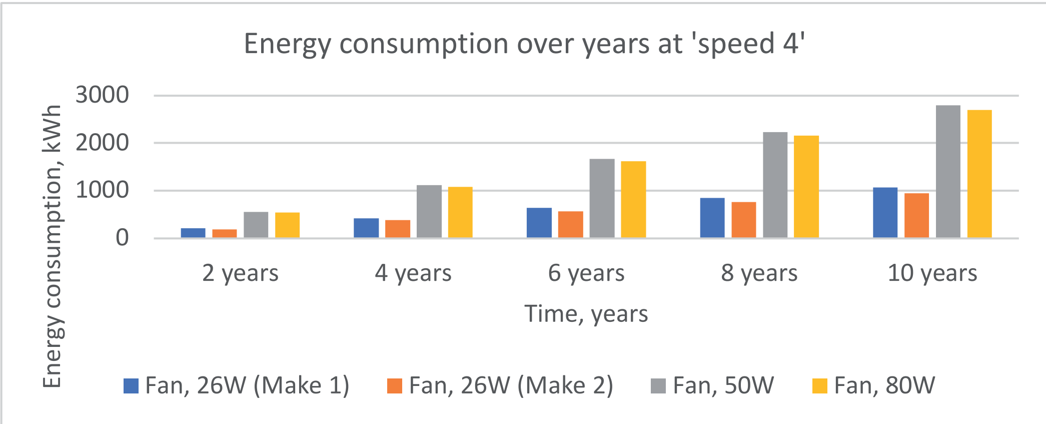

Figure 2. Cumulative energy consumption projections.

involved. Therefore, the only relevant components are the acquisition cost or capex and operating costs, that is, energy consumption in case of fans. The following assumptions are made to estimate the lifecycle energy savings and costs: **Operational hours**: 16; **Operational speed**: 5; **Lifespan of fan**: 10 years.

Figure 3 shows cumulative cost of fan operations for the next 10 years. The 26 W BLDC fan payback period was approximately 10 months against the 80 W model and 22 months (1 year 10 months) against the 50 W model.

Impact of the experiment

The application of the Knowledge to Action (KTA) Framework has facilitated a significant advancement towards energy-efficient cooling solutions through the adoption of Brushless DC (BLDC) fans, signifying a successful strategy for market adoption.

- **Data-Driven Decision Making:** The informed decision to retrofit 2,000 fans, at a cost of 4.4 million INR, was guided by solid empirical evidence gathered from the energy monitoring experiment. This strategic choice reflects the importance of data in achieving energy conservation objectives and serves as an inspiration for similar initiatives in other organizations.
- **Energy Conservation Impact**: The retrofitting initiative is estimated to yield annual energy savings of over 160 MWh, thereby setting a new standard in the industry for energy-efficient practices.

Discussion and Insights

In India, with a stock of more than 450 million ceiling fans and an annual sale of around 40 million fans, tackling the obstacles mentioned above becomes necessary. It requires a comprehensive strategy that encompasses educating consumers, expanding information on the availability of products, and highlighting the sustained advantages of energy efficiency.

From this case study, it can be seen how Knowledge to Action (KTA) framework played crucial role as it demonstrated how knowledge i.e. the data from the fan energy monitoring experiment was directly translated into actionable strategies i.e. the retrofitting decision by Lodha developers. It showcases the application of KTA principles through:

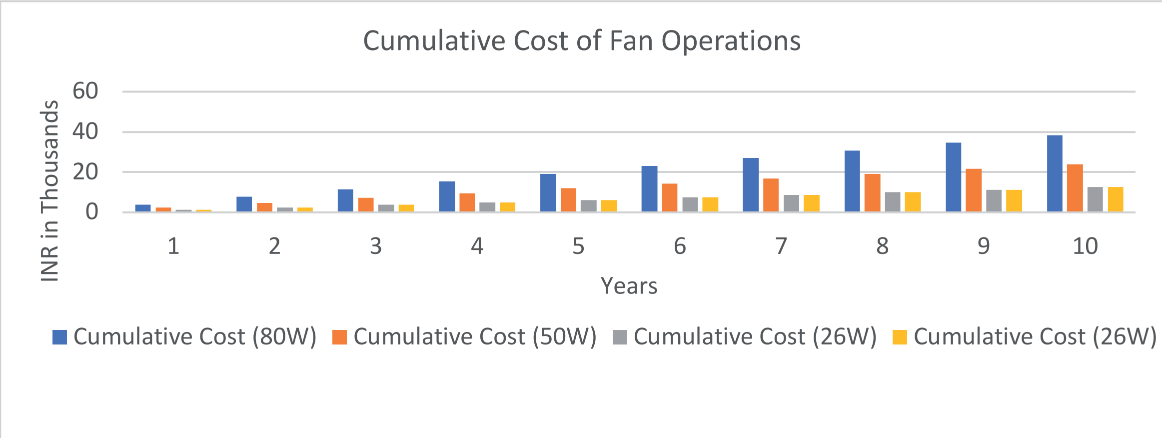

Figure 3. Cumulative amount of savings over 10 years.

Table 4. Life cycle cost analysis of ceiling fans.

Type of Fan	80W Fan	50W Fan	26W Fan
No. of fans	1	1	1
Average daily operational hours	16	16	16
No. of operational months	10	10	10
Total yearly operational hours	4,800	4,800	4,800
Annual energy consumption (kWh)	384	240	124.8
Average electricity unit usage rate	10	10	10
Annual price to consumer	3,840	2,400	1,248
Fan cost	1,300	1,600	2,200
Annual savings from BLDC fan compared with 80 W (kWh) fan			2,592
Payback period (Years)			0.849
Annual savings from BLDC fan compared with 50 W (kWh) fan			1,152
Payback period (Years)			1.9

- Identifying a specific need or problem based on synthesized knowledge i.e. unavailability of unbiased information on comparative assessment of fans performance in the real-world settings.
- Adapting this knowledge to a local context i.e. conducting the experiment at Lodha's site and informing them the site-specific benefits for developments managed by Lodha Group).
- Enabling implementation of an intervention i.e. retrofitting fans informed by the synthesized knowledge.
- Monitoring and evaluating the intervention's impact on energy consumption and planning for its sustainability and expansion in future Lodha developments.

Based on these learnings, the research team proposed to Lodha group a market adoption strategy, rooted in the Knowledge to Action (KTA) Framework, specifically aims to tackle the identified barriers to the adoption of SE fans. Here's how Lodha group addresses each barrier:

- **Cost**: Recognizing the higher upfront cost of BLDC fans as a significant deterrent, Lodha group's strategy includes engaging with manufacturers to explore cost-reduction opportunities and advocating for policy incentives that can lower prices for end-users. Furthermore, by demonstrating the long-term savings and payback period, we aim to make a compelling case for the economic viability of SE fans.
- **Awareness**: To combat the lack of awareness, we have initiated comprehensive awareness campaigns, leveraging various media platforms to educate consumers on the benefits of BLDC fans, including their energy efficiency and quiet operation. These campaigns also demystify the technology, making it more accessible to the average consumer.
- **Resistance to Change**: Understanding the natural resistance to adopting new technologies, our approach includes creating experience centers where consumers can directly interact with and learn about the benefits of BLDC fans first hand. By addressing misconceptions and showcasing the ease of use and installation, we aim to mitigate this barrier.
- **Availability**: To improve the availability of BLDC fans, we are working with local retailers to increase stock levels and ensure a wider distribution network. By demonstrating consumer demand through our awareness campaigns, we encourage retailers to prioritize stocking SE fans.

- **Long Replacement Cycles**: Acknowledging that fans are not frequently replaced, our strategy includes targeting new constructions and renovations where the opportunity to choose energy-efficient options is higher. Additionally, we are working with fan manufacturers to propose buy-back or exchange programs to encourage consumers to replace older, less efficient fans with BLDC models.

Future Opportunities for Action: Scaling Sustainable Solutions

The Knowledge to Action (KTA) Framework has been instrumental in translating this success into a scalable model for broader market transformation. Building upon our initial accomplishments, we aim to extend the reach and impact of our initiatives:

- **Scaling Awareness Campaigns**: The Lodha group will initiate wider-reaching awareness campaigns to educate the general public about the economic and environmental benefits of BLDC fans. These campaigns will highlight the real-world impact and savings potential, capitalizing on the success stories from our pilot program.
- **Behavioral Engagement Strategies**: By harnessing insights from behavioural science, our future strategies will address the perceived barriers to BLDC fan adoption head-on. We will tailor our approach to emphasize long-term savings, environmental impact, and the intrinsic value of adopting sustainable technologies.
- **Forging Strategic Partnerships**: Collaborative efforts with manufacturers, retailers, and policymakers will be vital in ensuring the widespread availability and affordability of BLDC fans. Our goal is to make sustainable options not just an alternative but the preferred choice in the market.

Conclusion

The application of the Knowledge to Action (KTA) Framework within the framework of this project has highlighted the potential for energy-efficient technology adoption in the real estate sector. Through a data-driven approach, informed decisions were made to retrofit 2,000 fans, leading to a significant reduction in energy consumption by more than 160 MWh annually. This initiative exemplifies the practical application of research insights to achieve measurable outcomes in energy conservation.

This study reflects the KTA Framework's utility in facilitating strategic decision-making and guiding institutional efforts toward sustainability. By systematically applying lessons learned from the pilot program and integrating a robust evaluation methodology, the project contributes to sustainable development practices that extend beyond individual case studies to broader industry applications.

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