Reducing Household Electricity Consumption Through Behaviourally Informed Nudges in Electricity Bills

Selected Proposal for Mission LiFE Global Call for Ideas

Acknowledgements:

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Abstract

For India to meet its 2070 net-zero target, emissions from electricity generation will need to be reduced. Electricity consumption accounts for the largest share of carbon footprints at the household level; there are also large inequities within this sector, with wealthier households causing seven times more emissions than poorer households. Changes in everyday habits to reduce electricity wastage and curtail overall usage, as well as investments in and maintenance of energy-efficient devices, can reduce household electricity consumption. Our research aims to reduce the electricity consumption of high-income households in Indian cities by incorporating behavioural nudges into electricity bills. We will test the efficacy of five categories of nudges through an online experiment. These nudges include 1) signing commitments to conserve energy, 2) setting electricity consumption goals, 3) information provision, 4) providing different types of feedback, and 5) rewards. Signing a commitment to conserve units of electricity could either be done privately or publicly. Goals can be either ambitious or modest. Information provision can range from providing details on changes in electricity usage from a baseline level to tips on saving energy. It is important to provide feedback that is prompt and tailored to households' previous consumption patterns. Rewards can be of a high or low quantum, and in the form of direct monetary incentives or rebates. Based on the results of this online experiment, we will collaborate with power utility companies to present redesigned and reframed electricity bills to households in order to curtail consumption in the long run.

The project will span five stages:

1. Designing eight different nudges under the five broad intervention areas to reduce electricity consumption;
2. Running an online experiment to identify (a) which of these nudges are most effective for our target population, and (b) which underlying behaviours are easy to change –- usage habits, maintenance of appliances, or purchase of energy-efficient appliances;
3. Selecting the most promising nudges and running on-the-ground pilots in selected cities, in collaboration with power utility companies;
4. Refining interventions based on findings from the pilot; and
5. Creating a scale-up plan for a wider rollout.

Problem Statement

Carbon emissions linked to electricity/power generation are significant in India due to the country's over-reliance on coal-based power. In 2021, one-third of India's total greenhouse gas emissions were caused by coal, which accounts for 74% of the country's electrical production (Lee et al., 2021). India's ability to meet its commitment to achieving net zero emissions by 2070 and reducing the Emissions Intensity of its GDP by 45 per cent by 2030 from the 2005 level (PIB Delhi, 2022) will be contingent on reducing electricity consumption.

Electricity consumption also accounts for the largest share of carbon footprints at the household level, ranging from 26% in low-income households to 36% among the wealthy (Lee et al., 2021; Shukla et al., 2022). Household carbon footprints vary depending on several factors, such as household size, income level, and lifestyle choices. High-income households in India have higher footprints than low-income households due to their higher consumption of energy-intensive products and services such as air travel, luxury cars, and high-end electronics. Per capita, carbon emissions in India also vary significantly within and between urban and rural areas: residents of megacities such as Mumbai (1.76 ton CO2/capita), Kolkata (1.56 ton CO2/capita), Bangalore (1.13 ton CO2/capita), Chennai (1.11 ton CO2/capita), and New Delhi (0.98 ton CO2/capita) have a carbon footprint far above the national average (0.56 ton CO2/capita) (Lee et al., 2021). The mean carbon footprint of low-income Indians (0.19 ton/year) is far lower than that of wealthier Indians (1.32 ton/year) (Lee et al., 2021). Given these large inequalities in per-capita emissions, and given that, simultaneously, it is the poorest people who suffer most from climate change – it is vital that any proposed behaviour-change interventions primarily target high-consuming groups.

India's electricity consumption and related emissions in households are expected to rise significantly in coming years due to population growth, urbanisation, and economic development. The International Energy Agency (India Energy Outlook 2021 – Analysis, 2021) predicts that India's electricity demand will more than double by 2040, with the country's electricity demand projected to grow at an average annual rate of almost 5%. The residential sector is expected to be the largest contributor to this growth in electricity consumption, accounting for around 40% of the total projected increase. The number of air-conditioning units in India is expected to grow from 15 million in 2011 to over 1 billion by 2050. Meeting this growing demand will require significant investments in electricity generation and distribution infrastructure, as well as in energy-efficiency measures to reduce environmental impacts.

Our daily behaviours and choices play a significant role in driving electricity consumption. Leaving appliances plugged in when not in use, using incandescent

light bulbs, keeping electronics on for long periods, overheating or overcooling homes, and using appliances inefficiently are some common behaviours causing excess emissions. These behaviours can be driven by habits, convenience, a desire for comfort, forgetfulness, or lack of awareness of the collective impact of seemingly trivial choices. The effort of many behaviours aimed at reducing energy consumption – such as turning off appliances while not in use – is low (Karlin et al., 2012). Residential energy demand can be significantly reduced through "structural" investments, including upgrades to energy-efficient household appliances and retrofits to existing appliances (Kasser, 2017; Suárez-Varela et al., 2016). By addressing these behaviours through education, incentives, and regulatory measures, households can be nudged towards lower electricity consumption as part of a sustainable future.

The monthly electricity bill is the most frequent point of contact between electricity suppliers and consumers. However, it is not easy for consumers to comprehend and evaluate data on their consumption from the bill in its typical current format (Joshi & Sen, 2021; Salamon, 2017). Consumers often fail to understand how they are being charged, become confused by technical jargon, and have trouble comprehending numbers in tiny font sizes. A well-constructed billing format, on the contrary, would inform and educate consumers even as it charges them (Brühl et al., 2019). A redesigned bill can also serve as a vehicle for energy-saving tips delivered in an uncluttered, simplified visual format that would impose a lower cognitive load on users, while allowing them to comprehend helpful, actionable information. Our study aims to reduce overall energy consumption in urban Indian households by designing behaviourally-informed electricity bills.

Literature Review

In order to address the issue of high electricity consumption in Indian households and promote more energy-efficient habits, we have conducted an in-depth literature review. This review explores different energy-saving behaviours and interventions used to reduce household energy use. Empirical studies on household energy conservation have been an area of interest globally for several decades. Research in social and environmental psychology focuses on testing the effectiveness of interventions that aim to change energy-related behaviours. In this regard, interventions have been categorised as focussing on either the antecedents (making a commitment, goal-setting, and access to information) or the consequences of the target behaviour (feedback, rewards). These interventions have been studied extensively and their effectiveness tested in various contexts. Our study draws on findings from previous research to design an effective repertoire of strategies for reducing household energy consumption in India.

A commitment is an oral or written pledge or promise to change behaviour (e.g., to conserve energy). Studies have also measured the effectiveness of the foot-in-the-door tactic for reducing electricity consumption. This method works as follows: a successful initial, modest request often results in compliance with a subsequent, bigger request (Katzev & Johnson, 1983). For instance, Katzev and Johnson (1983) found that households receiving either of two requests, or both, saved more energy than the control group. In another study, the authors (Pallak & Cummings, 1976) used commitments to promote gas and electricity conservation among households. Those who had signed a public commitment (i.e. publishing their commitment in a leaflet) showed a lower rate of increase in consumption of both gas and electricity than did those in either the private commitment group or the control group.

The foot-in-the-door tactic is based on the behavioural principle of consistency, which suggests that individuals are more likely to take an action that is consistent with their values, beliefs, and prior actions. When an individual yields to a small, easy request (e.g. switching off their appliances when not in use), they develop an (often implicit) self-image as being eco-conscious. Later, when they face a request to perform a slightly more effortful action (e.g. segregating their waste), they become more likely to yield to this request, too, so as to remain consistent with their new self-image.

Goal-setting entails giving households a reference point, for instance, to save 5% or 15% of energy as compared to baseline consumption. In one study (Becker, 1978), households were given either a relatively difficult goal (20%) or a relatively easy goal

(2%) of electricity use reduction. Some participants received feedback on their progress towards the goal (three times a week); ; others did not. Households that received a difficult goal along with feedback conserved the most (15.1%) and were the only group to significantly differ from the control group in consumption levels post-intervention.

Information provision is a commonly used strategy to promote energy conservation. This may be general information about energy-related problems or specific information about possible solutions, such as information about various energy-saving measures households can adopt. Another study (Winett et al., 1982) showed that households who had received an energy audit (providing tailored recommendations for saving energy on heating and air-conditioning) used 21% less electricity as compared to a control group.

Studies have shown that providing general information on power-saving tips can also significantly reduce household electricity consumption. A study conducted in the United States found that providing households with energy-saving tips reduced electricity consumption by 4 to 12% (Ehrhardt-Martinez, 2011). Similarly, a study conducted in the United Kingdom found that households that received tailored information on energy-saving tips reduced their electricity consumption by 5% compared to the control group (Abrahamse et al., 2007). McMakin et al. (2002) tailored information to promote energy conservation among households in two US military installations. This tailoring was based on focus group interviews and targeted heating-related energy use in the Washington group and cooling-related energy use in the Arizona group. Results were mixed, with households in Washington saving 10% on gas and electricity, while households in Arizona used 2% *more* electricity compared to baseline.

Feedback gives households information about their energy consumption or savings. In a study that gave households continuous feedback over 11 months by highlighting the monetary costs of electricity use, using a monitor displaying electricity use in cents per hour, households with a monitor installed in their homes used 12% less electricity than the control group (McClelland & Cook, 1979). Other researchers (Bittle et al., 1979) assigned households to either a daily feedback group or a control group. The feedback group reduced their electricity use by an average of 4% compared to baseline and also saved more money than the control group.

Monetary rewards may serve as an extrinsic motivator to conserve energy. Rewards can either be fixed-amount, or contingent on the amount of energy saved (e.g. a certain percentage of reduction from baseline). In a study that tested the effect of rewards, feedback, and information on electricity use, the interventions were implemented sequentially in a multiple baseline design, resulting in all participating households reducing their electricity consumption (Hayes & Cone, 1977). In a

different study on the effect of high versus low monetary rewards in combination with feedback and information, households in high- and low-reward groups saved more energy than the other groups (Winett et al., 1978). During the second part of the intervention period, households that initially had only received information were now also given a high reward, resulting in savings of 7.6%. For eight weeks, households that had received a high reward, feedback, and information reduced electricity use by about 12%. In addition, intervention strategies have also included providing customised home reports to households along with their electricity bills. These reports include a combination of tailored information, social comparison feedback, and environmental feedback (Hernandez et al., 2022).

Although various interventions have been implemented globally to reduce household energy consumption, there is limited research on their effectiveness in the Indian context. Given India's unique and diverse cultural, social, and economic contexts, it is crucial to test these strategies and tailor them to fit the Indian population's needs and preferences. Only a few behaviourally-informed interventions have been tried in India, namely home reports (Hernandez et al., 2022) and rewards (Sudarshan, 2017).

Hernandez et al. (2022) provided feedback to households on their energy consumption and suggested energy-saving actions through personalised home reports. In contrast, Sudarshan (2017) gave households feedback on their electricity consumption and monetary incentives. While both studies found positive effects on households' energy conservation behaviour, they had limited scope, sample diversity, and long-term effects. Furthermore, both studies tested only a limited number of interventions.

As a result, there is limited data to understand which behavioural ideas work best in the Indian context to reduce energy consumption. Our study aims to fill this gap by testing the long-term impact of a range of behavioural interventions on the Indian population and identifying the most effective nudges that can be incorporated into electricity bills to help households reduce their energy consumption. By designing behaviourally-informed electricity bills, this study aims to reduce the overall energy bills of urban Indian households and promote energy-saving behaviour.

Idea Detail

The Specific Behaviour That Needs to be Triggered

The study intends to trigger the behaviour of individual household members to reduce their daily electricity consumption. To this effect, we plan to incorporate different behavioural nudges into electricity bills to encourage households to reduce electricity consumption.

Our proposed nudges include: 1) signing commitments to conserve energy; 2) setting goals to reduce electricity consumption; 3) information provision; 4) providing different types of feedback; and 5) rewards.

Target Population

The study will focus on individual household members aged 25-45 belonging to middle- and high-income households in Indian cities who are the primary decision-makers and key influencers in their household regarding energy usage and related behaviour. The rationale behind focussing on middle- and upper-income groups is as follows: these households have higher purchasing power and are more likely to use energy-intensive appliances like air conditioners, washing machines and refrigerators, and to be less financially concerned about their electricity bills. They thus contribute significantly to the overall electricity demand in the country. Given high class discrepancies in electricity use in India, it is important for us to focus on users with the highest per-capita demand, as previously discussed.

The study will be conducted in two major Indian cities, Delhi and Mumbai, during the first phase of the pilot. These cities are two of the most populous urban centres in India; sampling in these cities will provide us with a broad range of perspectives on and insights into electricity consumption and related behaviour among urban Indians in general.

Proposed Interventions and Behavioural Principles that Inform these Interventions:

We will test five different nudges:

1. Informational nudges can include a) general power-saving tips, b) information on the environmental consequences of electricity consumption, c) providing appliance-specific energy-saving tips and/or information about peak period electricity usage (in India, generally in the evenings), and d) energy-saving tips tailored to each household. Informational nudges can help to address behavioural barriers created by limited scope of attention and cognitive overload. Specifically, such nudges provide individuals with relevant and

useful information in a way that is easy to understand and remember, thus reducing the cognitive burden associated with decision-making.

2. Feedback can include a) general suggestions on how to conserve electricity, b) tailored tips to conserve electricity, which is specific to the household, based on their past consumption, c) comparisons with neighbouring households, d) framing feedback in terms of cost savings from lowered electricity usage, and e) feedback on how household electricity consumption is creating environmental costs. Feedback helps individuals become more aware of their actions and the outcomes they produce, motivating them to change their behaviour in the desired direction. Feedback addresses several behavioural barriers, including lack of awareness, and lack of motivation. Tailored feedback equips individuals with relevant and meaningful information, which can increase their motivation to adopt energy-saving behaviours. Social comparison-based feedback provides individuals with information about how their electricity consumption compares to their peers, and can trigger powerful social motives of competition and cooperation. By highlighting social norms and promoting energy-saving behaviours among a group or community, feedback can increase the perceived personal, financial, and social benefits of energy-saving behaviours.

3. Goals can be a) modest or b) ambitious (e.g. reducing electricity consumption by 2% vs 20%). A goal that is too easy can fail to activate the necessary cognitive, affective, and behavioural mechanisms, including planning, excitement, and anticipatory pride. . On the other hand, a goal that is unrealistically ambitious can create fear of failure and inertia. Therefore, it is advisable to test different difficulty levels to see which level of goal works best. Realistic goals can help individuals build their self-efficacy or belief in their ability to adopt energy-saving behaviours. By highlighting their past successes and progress towards their goals, individuals can gain confidence in their ability to continue to make positive changes in their behaviour. By setting specific, measurable, achievable, relevant, and time-bound (SMART) goals, individuals can use feedback to monitor their progress towards goals and adjust their behaviour accordingly.

4. Commitment devices or pledges can be effective in changing behaviour too. The degree to which commitments successfully change behaviour depends on the nature of the commitment device and the mode of commitment. Signing a commitment to reduce baseline energy consumption by x% could either be done a) privately/anonymously or b) publicly.

   Signing a commitment in public, with other members of one's social reference groups as witnesses, creates social pressure, which might have a

greater impact than signing a commitment anonymously or privately. Commitments work based on the shame or contempt that a person anticipates feeling if he/she reneges on a publicly stated promise. Even though we generally greatly overestimate how much attention other people are paying to our actions, our belief that we will be negatively judged often powerfully affects our behaviour.

5. Rewards can be of a high or low quantum, and in the form of direct monetary incentives or rebates. Rewards for reducing electricity consumption use the behavioural principle of positive reinforcement to encourage energy-saving behaviours. Positive reinforcement is based on the observation that individuals are more likely to repeat behaviours if they are followed by desirable consequences. Incentives can motivate individuals to adopt energy-saving behaviours and maintain them over time; in many cases, rewards can be phased out over time, as meaningful behaviours become self-sustaining. Rewards can be incorporated into energy-saving programmes through gamification, including point systems, leader boards, and badges. Gamification can make energy-saving behaviours fun and engaging, and break up seemingly challenging behaviours into achievable steps, thus increasing the adoption of sustainable behaviours.

An online experiment will be conducted to test the impact of seven to eight nudges based on the five intervention buckets mentioned above. Please refer to Stage 1 in the Testing Plan (next section) to understand the online lab experiment in detail. The experiment will help derive insights to understand which interventions work best in the Indian context. The top two or three successful nudges will be chosen; on their basis, we will present redesigned and reframed electricity bills to households. We intend to do this by partnering with power utility companies in the selected cities:

- In Delhi, BSES Rajdhani Power Limited, BSES Yamuna Power Limited, and Tata Power Delhi Distribution Limited, which supply electricity to high-income households in various parts of the city.
- Reliance Infrastructure Limited, Tata Power Mumbai Distribution Limited, and Brihanmumbai Electric Supply and Transport Undertaking (BEST), which serve primarily high-income households in Mumbai.

Partnering with these power utility companies can help us gain insights into their consumers' energy usage habits, allowing us to tailor research questions and interventions and obtain comprehensive data on factors influencing electricity consumption. Through this partnership, we can collaborate on initiatives aimed at promoting energy efficiency and sustainability among consumers, identifying common interests and developing strategies to reduce consumption and emissions.

Hence, the project will span five stages: 1) designing eight different nudges under the five broad intervention areas to reduce electricity consumption, 2) running an

online experiment to understand which of these nudges are most effective for our target population and which underlying behaviours are easy to change – usage habits, maintenance of appliances, or purchase of energy-efficient appliances, 3) selecting the most promising nudges and running an on-the-ground pilots in selected cities with the power utility companies, 4) refining interventions based on the learnings from the pilot, and 5) creating a scale-up plan for a wider rollout.

Testing Plan

The intervention will be deemed impactful if households reduce their electricity consumption, which can be straightforwardly observed through their electricity bills. Baseline data on current electricity consumption, and on consumers' current level of understanding of the bill, will be collected before the initiation of the intervention, which will provide a benchmark against which the change will be measured. After our treatment, we will add behavioural games or survey questions to check if the treatment was effective. To examine if the intervention translated to a change in the consumption of electricity, we will collect the endline electricity bill.

Stage One: Online Experiment

We will run an online experiment with members of urban households in Delhi and Mumbai who are aware of their electricity bill amounts, to measure their willingness to change their electricity consumption patterns. This online experiment aims to narrow down the interventions we will run in Stage 2, i.e. the field pilot. We will employ a between-group design, since playing the game twice would have a learning effect but would also result in fatigue. We will aim to receive electricity bills over two periods and see the difference in intention (and online action) in response to the behavioural intervention they receive.

Variables that will be tested: We will employ behavioural games to assess the change in intention to reduce electricity consumption in response to the treatment. In order to isolate the effectiveness of the nudges, we will control for different characteristics (e.g., education, values, pro-environmental attitude) which may impact behaviour.

Sample size: We will select eight interventions from the existing literature based on impact and feasibility. Each treatment i.e. intervention will be deployed to a sample size of 200-250 leading to a total sample of 1600-2200, given 7-8 treatments. This includes a control group. i.e. a set of households that will not receive any treatment, and against which the households receiving the treatment will be compared.

Methodology for testing: We will conduct an online gamified experiment in which users will interact with the digital prototypes of electricity bills, each designed with a different nudge, e.g., a bill with information on environmental impact, or one with feedback on comparison with neighbours. After exposure to the bill and the chosen nudge, we will measure the intent to reduce electricity consumption and various channels which can lead to this intention. We will include behavioural games to tease out factors, such as altruism, price sensitivity, care for the environment, etc. that drive the willingness to reduce electricity consumption.

Pre-defined limitation: There is a possibility of an intent-action gap in our experiment, as in most other behavioural studies. To see if the intention reported by the participant translates into action, we will ask them to upload their electricity bill so that their next cycle's electricity bill can be used to test if this gap exists in our sample.

- Individual behaviour has also been observed to vary in experiments or online settings, vis-a-vis their behaviour in real life. This is a common concern in using experimental designs. We will observe the gap in online and offline behaviour when we compare the actual electricity bill with their usage in the online setting.
- There might be a difference in participant behaviour in the online experiment and real life. This might be due to household-level constraints, like habits or behaviours of other members of the family, lack of control of household-level decision-making, etc. We will not be able to control for this, however we wish to measure the degree of impact it has on individual behaviour.
- In a few cases, we might attempt to use interventions which are combinations of two predefined interventions. Due to the small sample size, we will not be able to ascertain which nudge is responsible for what fraction of the impact.

Stage Two: In-field Pilot

Based on the learnings from the online experiment, we will shortlist the nudges (ideally 2) which show the highest potential to test them on the field. An on-the-ground field pilot will be conducted by partnering with the government/private utility company in both cities. Here we will measure the actual electricity consumption of the households after exposing them to the nudges selected from the experiment. We will incorporate the results and insights from the experiment and the field pilot to create a scale-up plan which can be used for a wider rollout across the country.

Variables to be tested:

- Outcome variable: Change in electricity bill month on month, for two cycles to check the short and long-term impact of the interventions.
- Mediator variables: To ascertain the underlying pathway through which the change in outcome variable (i.e. electricity consumption) arises, we would like to test differences in these independent or mediator variables between the treatment and control households post-treatment. Below is the list of pathways we want to measure:
    - Environmental awareness;
    - Perceived need to act on environmental concerns;
    - Intrinsic motivation to reduce electricity consumption;
    - Price sensitivity;

- Hedonic personality (if individual tries to minimise effort); and
- Social norms

Sample size: We will aim for ~1000 participants per intervention.

Methodology for testing: This is an on-ground pilot where we will assess the change in electricity consumption in response to our nudges. It will be done in partnership with a government/private utility company. We will work with the company to execute the interventions on the ground.

We will provide different nudges (e.g., feedback, commitment, information) to the treatment groups along with their electricity bill (physically or over a smartphone) and measure the change in consumption over one month. We will randomise at a ward level to reduce the possibility of potential spillovers. We will also do a follow-up study three months later to assess the sustainability of change.

Pre-defined limitation: Given that we will be implementing various interventions and will not be able to prevent participants from interacting with one another, we must be aware of potential treatment diffusion or spillover effects that could impact the accuracy of our results.
Since our treatments will be given through electricity bills, we can only implicitly assume that people read and are impacted by the bills. However, if respondents do not engage with the bills, our treatment would be ineffective.

Conclusion

Despite a proliferation of lower-carbon technologies and increased scientific understanding of low-carbon pathways, societal action and uptake of these technologies and pathways remains low. We believe that climate action has been wrongly framed as a 'technical' problem that requires technical solutions. It is clear that progress on climate change needs to be seen as a societal challenge that also requires drastic societal, behavioural, and normative change. The ultimate objective of this study is to support reflexivity among high-income households in India, whose consumption patterns are increasingly unsustainable and whose carbon footprint is likely to be at par with per capita emissions in developed nations. High-income households are already contributing contribute omore than their fair share of the national carbon budget. As the number of such households in India grows, their adopting low-carbon lifestyles is not just critical for India but also the world.

In attempting to reduce overall electricity consumption, members of households can trigger a range of behaviours relating to curtailment of overall consumption, reducing wastage of electricity, maintenance of appliances, and investment in energy-efficient products and devices. In the long run, higher levels of altruism and social responsibility in relation to pro-environmental behaviour and climate change would progressively lead to individuals reshaping their own norms, tastes, and desires so as to align with broader societal goals. While behavioural nudges can help users identify unnoticed actions and choices and adopt more environmentally-conscious habits, ultimately, norms and values will need to change.

This study also seeks to contribute to developing evidence-based policies and interventions rooted in social science research that can help India achieve its energy efficiency and climate goals.

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