Saving electricity, one consumer at a time

Lessons from Vidyut Rakshaka, a consumer-focused energy conservation and energy efficiency initiative

Ravichandran[1], Sumathy Krishnan[1], Santhosh Cibi[1], Sumedha Malaviya[2]

[1]Technology Informatics Design Endeavour, Bangalore [2]World Resources Institute India, Bangalore

k.sumathy@tide-india.org

Abstract. This paper provides long-term field evidence from Bangalore on a possible low investment pathway for demand side management by enabling household consumers to take control of their electricity consumption. Conceptualized as a citizen-led program, 'VidyutRakshaka' aims to reduce electricity consumption of residential consumers in Bangalore. The strategy adopted is to provide nudges to consumers for behavior change along with recommendations to adopt energy efficiency. VidyutRakshaka is implemented by creating awareness, conducting surveys with voluntary participants, providing customized reports with social and monetary nudges. Analysis of consumption indicates a cumulative average savings of 22% for about 48% of the participants.

Keywords: Residential electricity consumption**,** Demand Side Management (DSM), Peer Comparison, VidyutRakshaka, Nudges, Behavior change.

1 Introduction

Residential electricity consumption in India has tripled since 2000 [1]. It is further projected to rise by more than eight times under the business-as-usual scenario [2]. Urgent efforts are needed to curtail this rise and mitigate emissions from the sector. Demand Side Management (DSM) is a widely implemented and recognized concept that utilities globally have implemented to counter rising energy demand. "Demand Side Management" means the actions of a Distribution Licensee, beyond the customer's meter, with the objective of altering the end-use of electricity - whether it is to increase demand, decrease it, shift it between high and low peak periods, or manage it when there are intermittent load demands - in the overall interests of reducing Distribution Licensee costs [3].

Historically utilities in India have promoted energy efficient lights, ACs and refrigerators through replacement or buy back schemes offering the energy efficient alternative at a discount. However, while these technological interventions may

substantially bring down the electricity consumption, the role of behavior in selecting those technologies, and using them, to deliver the savings remains crucial.

Consumer behavior is complex and routinely deviates from rational economic choices. A growing volume of research on energy-consumption behavior of household's points to the deviation from expected impact [4]. Consumers demonstrate behavior driven by their biases, motivations and social norms. Understanding and changing these motivations is the key to making Energy Efficiency (EE) policies that respond to different types of customers living under different social, demographic and cultural situations.

Recognizing this need, academics and researchers in the stream of Behavioral economics across the globe have been studying consumer behavior towards electricity use and have concluded that changes in consumer behavior, attitudes and practices can contribute to electricity savings if the right nudges are provided to consumers [5].

Studies done by utilities in collaboration with behavior scientists in developed countries have experimented with nudges of different types to manage electricity use. But behavior is local and not global in character, so such programs have limited replicability across geographies.

This challenge is accentuated in a diverse country like India, requiring a disaggregated approach (based on income levels, size of houses, etc.) to influencing behavior choices. Unfortunately, data or evidences to guide such approaches are missing. Also, behavior change focused programs need long term implementation to warrant evaluation of the interventions.

VidyutRakshaka promoted by a civil society organization and a research organization is a first of its kind attempt in India to use behavior change strategies for sustained reduction in electricity consumptions among residential electricity consumers in Bangalore. Its uniqueness comes from the fact that it is an ongoing and growing field level program, uses bottoms up data for designing customized nudges and has a partnership with the utility.

2 Review of behavior change initiatives for electricity conservation

In an analysis done by European Environment Agency and other partners [6], savings from behavior change programs typically range from 5% to 15% and comprise of both antecedent (pre-program) interventions like information, goal-setting and commitment and consequent (post-program) measures like feedback and rewards [7].

A JPAL study reports a two-percentage reduction in an analysis of Home energy report on energy consumption by the company OPOWER in the United States [8]. This program has gone beyond the pilot stage and is operational in twelve utilities in the US.

A small pilot in Bangladesh reported 9% savings based on nudges like feedback given to consumers [9].

Researchers in India have captured large variations in electricity consumption even among the consumers holding similar assets and indicate the role of consumer behavior in these differences [10].

Most recently, in partnership with Oracle, Delhi-based utility, BSES Rajdhani rolled out a behavior change program for 5 lakh consumers in New Delhi in 2018.

The only other energy use-behavior study in India with a small sample of households

In Delhi, reported that nudges in the form of comparison of electricity use with neighbors resulted in 7 percent energy savings [11]. The same study reported an increase in electricity use in households given the same nudge but with additional financial rewards.

VidyutRakshaka is recognized as DSM initiative by the public electricity utility BESCOM in Bengaluru [12].

3 VidyutRakshaka

VidyutRakshaka was conceptualized and is being implemented as an action-oriented program. It has evolved from a pilot of about 500 consumers in two residential neighborhoods of Bangalore in 2014-15. Based on the experience and pilot's results, a larger city-wide enrollment drive was initiated in 2016 and has resulted in about 3800 voluntary signups for the program as of January 2019. The basic tenets of the program are:

- Conservation forms the foundation for any energy efficiency efforts. Impacts of energy efficiency without promoting energy conservation is not sustainable and is known to have rebound effect [13].
- Energy conservation is primarily driven by behavior change; and positive nudges can encourage conservation.
- Continuous reinforcement of conservation measures combined with knowledge on efficient appliances and renewable energy can lead to long-term changes towards sustainable consumption.

The program's unique strengths are building capacity in local communities through one-on-one customized engagement and leveraging social / community influences. The program invites engagement from various stakeholders (consumers, consumer groups, utility) and has helped create a data driven platform for deeper research to drive policies. Most importantly, it enables consumers to take control of their electricity consumptive actions.

3.1 The rationale:

VidyutRakshaka combines both antecedent (information and goal-setting) and consequent interventions(feedback) as highlighted in the schematic Fig. 1 describing the process flow. Feedback is primarily the report with recommendations and nudges which were carefully worded to avoid paternalism or bias to a particular solution.

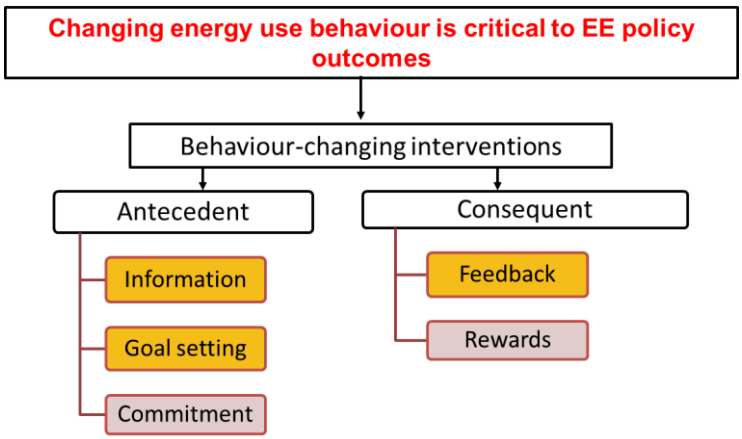

Fig. 1. Energy conservation through behavior change

4 Methodology

The methodology adopted in VidyutRakshaka (See Fig. 2). arises from the goal of having a continually running program where multiple stakeholders are contributors as well as the receivers of benefits accrued, and the need to make it cost and resource efficient in the long run.

4.1 Sign Up

VidyutRakshaka consciously adopted a process of nurturing champions by reaching out to various forums, Resident welfare associations, corporate and educational institutions. Some of them were trained as stewards, those who would do consumer outreach and sign up consumers for the program. The data input, processing and report generation have been standardized through an android app [16].

4.2 Data Processing

There were two streams of data: (1) profile and asset related from the consumer and (2) the electricity consumption data for the same consumer from the utility. The latter ensured data accuracy and continuous availability of data removing the dependency on consumers to provide this. The two streams are cleaned up and merged for further analysis.

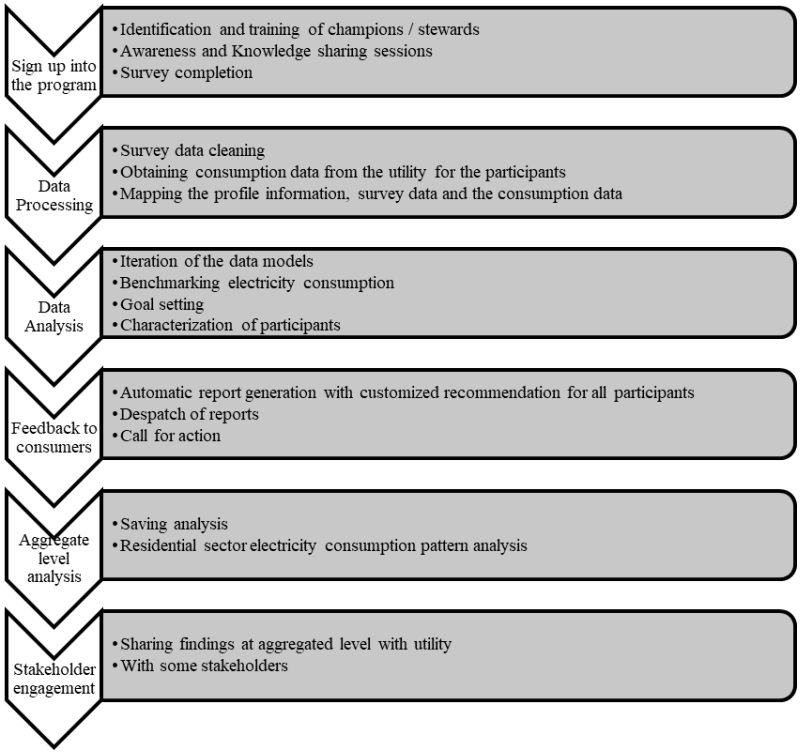

Fig. 2 Stepwise implementation of VidyutRakshaka

4.3 Data Analysis

The consumer data is first profiled on BHK (bedroom, hall, kitchen was used a surrogate instead of household for practical reasons.) categories: 1, 2, 3 and 4+. The

consumption of the consumers is then analyzed on a per month basis (averaging over a year) and on a per capita basis (based on the occupancy details shared by the participants). The annual averages are used to avoid any biases due to variations across months. Consumption was not normalized for seasons as data did not show direct correlation between seasons and consumption for Bangalore. However, for individual participants, information is provided on their seasonal consumption variations.

VidyutRakshaka then applies three unique self-iterative models to benchmark each participant as shown in Table 1

1. Neighborhood model
2. Historical consumption model
3. Optimal use model

Table 1. Data Models for VidyutRakshaka

Neighborhood Model	**Historical Model**	**Optimal – use model**
*BHK as classifier in all models		
Compares use with the average consumption in the neighborhood	Captures use trend from previous years (eliminates seasonality)	Compares split of different end-uses against an "Optimal-use" model
Participants categorized into: • Energy Saver- using less than average • Champion- using just at the average • Future champion- above average	Participants categorized into: • Consistent saver • Spender to saver • Consistent Spender • Saver to Saver • Random behaviour	Participants given comparison of their use and optimal use as per enduses below and recommendations against each: • Lighting • Cooling • Heating • Appliances • Entertainment • Miscellaneous

Neighborhood Model.

Among the myriad factors that influence the household electricity consumption, normative social influence is found to be playing a definite role [17]. In VidutRakshaka, this aspect is built in through the neighborhood benchmarking.

Every household is benchmarked in his BHK category in his immediate neighborhood and are categorized, both on monthly consumption and per capita consumption as:

- Energy Saver – Those consuming below the neighborhood average
- Champion – Those consuming at the neighborhood average
- Future Champion – Those consuming above the neighborhood average

Historical consumption model.

Historical consumption model is constructed for each consumer, unlike the neighborhood and optimal model. It captures the electricity consumption trend for the last 3 years, prior to joining the program.

Table 2. Categorization based on the historical trend

Category	Description
Consistent Savers	Historically was showing decreasing trend which is continuing after joining the program
Saver to Spender	Historically was showing decreasing trend but started increasing after joining the program
Spender to Saver	Historically was showing increasing trend but started decreasing after joining the program
Consistent Spender	Historically was showing increasing trend which is continuing after joining the program
Inconsistent	Fluctuating or random behavior

Optimal use model.
The average ownership and usage of different types of electrical assets (classified into lighting, heating, cooling, appliances and entertainment) is modeled for each BHK category. Each consumer is then benchmarked in its BHK category based on this optimal model. This optimal model is iterated periodically based on current data / usage pattern.

4.4 Feedback to consumers

To optimize report generation for VidyutRakshaka participants, an MS Excel based automation has been introduced which helps in generating customized reports for each consumer by using specific criteria. A report template fed with meta data is used to generate customized reports.

The final report is divided into the following sections:

- Profile data including program ID, date of joining, contact details
- Benchmarking (against the three models described above)
- Best practices already followed by the participant
- Recommendations customized for each participant
- Goal setting
- Other details including contact, resource section, disclaimers

4.5 Report Duration.

The program is attempting to settle into a quarterly report cycle with dependence of the utility for the data.

4.6 Aggregate level analysis

While individual consumer reports are the main focus of the program, the data available at the aggregated level is emerging to be of great value and use to understand the trend at the residential sector level and to assess the impact of the nudges provided.

4.7 Utility engagement

VidyutRakshaka is aligned with the utility's DSM goals. While providing the muchvalued consumer outreach, and promoting DSM, VidyutRakshaka has balanced the interest of the consumer and the utility. While the consumer receives reports to save energy, the aggregated data helps utility understand the residential consumption patterns in Bangalore city. The data can inform both DSM program and Energy Efficiency policies.

Savings has been calculated for participants who have been in the program for more than 1 year. 1553 households thus qualified for assessing the savings. In order to ensure that factors like billing errors, non-occupation etc. do not affect the savings calculation, some data had to be removed resulting a final set of 1255 households for this calculation as of January 2019. A summary of indicative results as on date is provided below

1. Benchmarking results: Out of the 1255 consumer data available, 444 are categorized as Energy Savers, 94 as Champions and 717 as Future Champions

Table 3. Split of Consumption Trend across BHKs in numbers

Consumption Trend	1 BHK	2 BHK	3 BHK	4 BHK
Energy Saver	245	126	60	13
Champion	49	26	18	1
Future Champion	428	183	73	23

2. Per capita electricity consumption across BHKs is calculated by the total electricity consumption and the number of people within the household.

Table 4. Per capita annual electricity consumption across BHKs in kWh

	1 BHK	2 BHK	3 BHK	4 BHK
Number of Households	722	347	151	37
Per capita consumption (annual)	320	578	814	809

3. In figure 3, the annual per capita consumption across different BHK categories is plotted against the number of occupants in the house. This shows the large variation in per capita electricity consumption across BHKs and based on occupancy. In the case of the 4+ BHK houses, the per capita electricity consumption without data set is as high as 2001 units per year and this is almost double the India's per capita electricity consumption value of 1149 units per year [18].

At an aggregate level, our analysis of 1255 households we find 599 households have reduced consumption by an average of 31 units monthly, approximately, 22% of their cumulative monthly consumption.

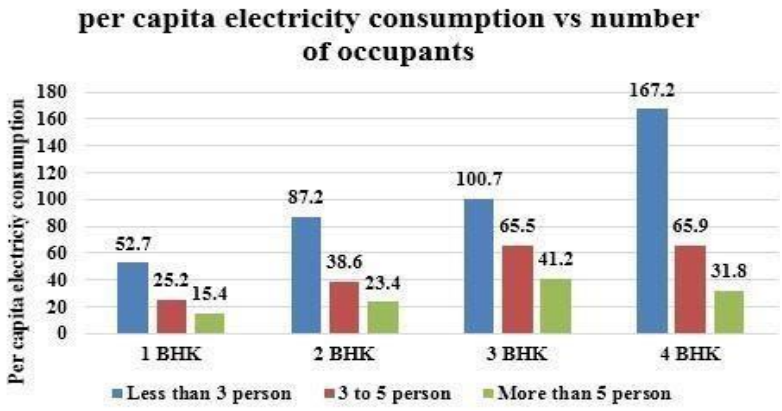

Fig. 3. Occupancy vs per capita electricity consumption

5 Conclusion

Our program 'VidyutRakshaka' shows an electricity savings potential of about 26% (or 19 MU per annum) if adopted at Bangalore city level by all residential consumers. The success of this program showcases the potential of such low investment behavior change programs for DSM. This is a good case study for Utilities, State electricity regulatory commissions and Forum of Regulators (FoR). In addition, programs like this provide data-based evidence to address many hitherto unanswered research questions in the area of residential electricity consumption.

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- Study of the patterns of electricity consumption based on the trends in the ownership of different appliances and equipment and their variation across household sizes. This can give inputs to the Standard and Labeling program by Bureau of Energy Efficiency, India.
- Study the demographic impact on the residential electricity consumption and socio-economic inequalities in consumption within a city. This can help in the design of energy efficiency policies and programs catered to the varying needs of different communities.
- For Bangalore, seasonal index calculation did not point to clear seasonal consumption changes. However, better understanding of variations in the seasonal consumption helps in better power purchase planning opportunity for the utility based on the reliable ground level data.
- Government through various schemes has promoted various efficient appliances programs. This kind of consumer driven behavior change programs address the opportunity to neutralize the rebound effect of energy efficient appliances.

To conclude, developing countries like India with diverse demographics needs disaggregated field level data to plan energy policies and programs like VidyutRakshaka fills this gap.

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