

An AI-Assisted Qualitative Analysis of Energy Consumption Awareness and Usage Practices

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Abstract

This thesis explores user behavior concerning electricity consumption and suggests a solution to encourage energy saving. Energy demand for electricity is growing and also the efficiency is being increased due to limited natural resources, therefore, the user behavior is being important. In this thesis, the relationships between awareness of saving energy and electricity consumption in daily life in students, influenced by their living environment is explored. Questionnaire data is collected and visualized using a pie chart or bar graph. The analysis results show that students are aware of energy saving methods, however, it does not result in behavior change. The rule-based AI system is suggested to estimate the electricity consumption and predict if electricity usage is at the average or not, and offers the advice on saving energy, using a basic interface. Conclusively, behavioral research, along with a basic AI model, could improve the energy saving habits and efficiency of electricity consumption.

Keywords : Electricity Consumption, Behavioral Analysis, Energy Efficiency, Rule Based AI, Student Awareness, Dashboard System

I. INTRODUCTION

Electricity has become a crucial element for students on a daily basis especially for students in the hostel and rented rooms. This is due to the high usage of many electronic gadgets like lights, fans, mobile chargers and laptops at the same time and therefore electricity usage has escalated among the students. Most of the time, the electricity is not used to its optimum due to the negligence of the students and the lack of monitoring among the students.

The problem arises due to the fact that the major cause for the electricity usage is because of the nature of students and not because of limitations and other factors. Though the majority of students are aware of ways to save electricity by switching off unnecessary lights and decreasing its consumption, the same habits are not applied in real-life.

Therefore, this paper attempts to examine electricity usage from a behavioral aspect. A questionnaire is created to survey the habits, knowledge and patterns of electricity usage of the students and the survey data is analyzed by employing simple visualization tools such as pie charts, bar charts and word clouds to observe the general trends of electricity consumption. The primary goal of this paper is to create a simple rule based system that can measure electricity consumption depending on the users, by classifying users into categories such as wasteful efficient, suggesting them to be less wasteful with electricity and create an interactive dashboard displaying the outcomes in an easily understandable format for the students to use.

II.LITERATURE REVIEW

In the baseline study, the electricity consumption is predicted using data-driven machine learning methods. It relies on factors of various environmental and operation data in order to predict the energy demand and efficiency. It uses complex models for analysis of high-dimensional data and large data volume and illustrates that these technical methods are effective for energy management. The main area the study pays attention is on predicting accuracy and not much of user's behavior on energy consumption.

Various researches were undertaken on studying the behavior and analysis of electricity consumption. Abrahamse and Steg described the behavior, psychological and social factors as the strongest predictors of household electricity use [1]. It mentioned that awareness is not enough and should be supplemented with behavior interventions. From this, we understand the importance of incorporating user behavior into energy saving.

Machine learning was widely used for building energy consumption prediction and accurate results. Amasyali and El-Gohary showed that ANNs, SVMs and Random Forests perform best at identifying complex patterns in data. This led to more accurate predictions, however computational resources were quite expensive and required large datasets. This does not appear to be a practical approach for small scale users such as student hostels [2].

IoT provides real time monitoring and smart energy management. Sahoo et al. Propose a system where sensors and interconnected devices were used for tracking electricity use efficiently [3]. With more real time detailed feedback, better decisions could be made, but at an extra cost as well due to the required hardware.

Deep learning was used for electricity load forecasting. Kong et al. Suggested that deep neural networks were useful in modeling electricity demand on a short-term basis [4]. Their models performed well and had high prediction accuracy, however reliance on continuous data input and high computation power was quite demanding.

Wei et al. Carried out a systematic review and compared various machine learning and deep learning approaches used in buildings energy systems [5]. The article concluded that the learning models perform high prediction accuracy but these are too complex for normal users.

Chen et al. Analyzed household electricity consumption using machine learning approaches coupled with socioeconomic features [6]. They showed that human behavior was significant in determining electricity usage.

Costanza et al. Believed that user interface plays a significant role in enhancing energy awareness [7]. The study showed that through feedback, user behavior was induced into behavior change.

Salleh et al. Studied usage of electricity in household and noticed a relation between the user behavior and electricity usage [8].

Darby pointed that behavior changes alone can reduce energy use without additional technology [9]. This implies that switching of electricity at the right time or not at all will improve the efficiency by a larger margin.

Zhang et al. Investigated the link between energy saving behaviors and electricity consumption and found a positive correlation [10].

Based on above, we realize that there are many researches on analyzing electricity consumption using machine learning, deep learning, and IoT systems which gives a good result. However, they lack proper attention to human behavior aspect and these were computationally expensive and demanded for a larger

dataset. Therefore, a cost-effective and behavior oriented system based on survey analysis was proposed in this paper.

II. METHODOLOGY

A. Overview of the Proposed Study

The procedure followed is simple and practical for analysis of students electricity consumption behavior and for developing energy saving system. In a general it starts from collection of data up to system development, that includes the entire process.

Following are the steps of the methodology:

- Collection of data through questionnaire
- Behavior analysis on electricity consumption behavior
- Visualization using chart and word cloud
- Rule based system development
- Interactive dashboard implementation

Initially the survey from the students are conducted regarding the appliance used by them, charging times of mobiles, how the electricity is used etc., etc., along with awareness about the energy saving measures. Then the collected data from survey is analyzed in terms of their consumption behavior. The method used for analysis is a simple behavior based analysis (not involving complicated model for analysis). Then the common patterns are identified through word cloud which are used for common appliance usage, time analysis. Then a rule based system is designed for calculation of consumption based on appliance usage and student type, and visualized on interactive dashboard using techniques like pie chart, bar graph etc.

B. Research Design

This research design follows a qualitative and explorative methodology that concerns itself with human behavior rather than machine parameters.

Salient features of research design:

- It examines the behavioral determinants of electricity consumption.
- It utilizes survey-based primary data collection.
- It tries to identify the gap between awareness and action.
- it concentrates on the practical aspect of consumption.
- It avoids the application of complex machine learning models.

C. Data Collection Method

Questionnaire is developed for student living in hostel or home to gather data.

The survey includes questions on:

- Length of time of usage of the appliances.
- Method of charging of appliance.
- Knowledge of energy conservation practices.
- Daily energy consumption habits.

The survey generates relevant results without needing big datasets.

D. Data Analysis Approach

Raw electricity data is examined to identify trends, waste, and inefficiencies in consumption.

The analysis focuses on:

- 1. Understanding the gaps between consumers' stated perceptions and their real-life consumption patterns.
- 2. Patterns in appliance usage
- 3. Electricity charging behaviors
- 4. The influence of home environment in electricity consumption

From these we are able to recognize ways electricity can be saved through behavioral influences.

E. Visualization Techniques

The visualization techniques will be used to make the analysis of the user data more understandable.

The techniques used are:

- Pie charts: this helps us determine the distribution pattern of various appliance usage.
- Bar graph: This will be useful in the analysis of comparison of usage of different appliances.
- Word Cloud: Text based analysis of behavior of the user to study his habits, patterns.

The word cloud is also a form of data visualization where it shows words in different sizes depending upon their frequency of usage. It indicates that the user might be using fan, light, charger more frequently etc.

F. Rule-Based System Algorithm

The proposed system uses a simple rule based algorithm rather than complex algorithm in order to interpret and provide suggestion about usage pattern.

The algorithm:

- Input- User data(usage+behavior)
- Processing- Rules applied
- Calculation- Electricity Consumption(kWh)= (Power*Time)/1000. Classification of the electricity usage:
 - efficient
 - moderate
 - Inefficient

Output- Suggestions for energy saving.

- Benefits of using such a simple approach:
- Simple and easy to interpret
- No requirement for huge dataset
- Less computation required
- The process of decision making is not opaque.

G. System Implementation

The system has been developed using Python with simple visualization tools.

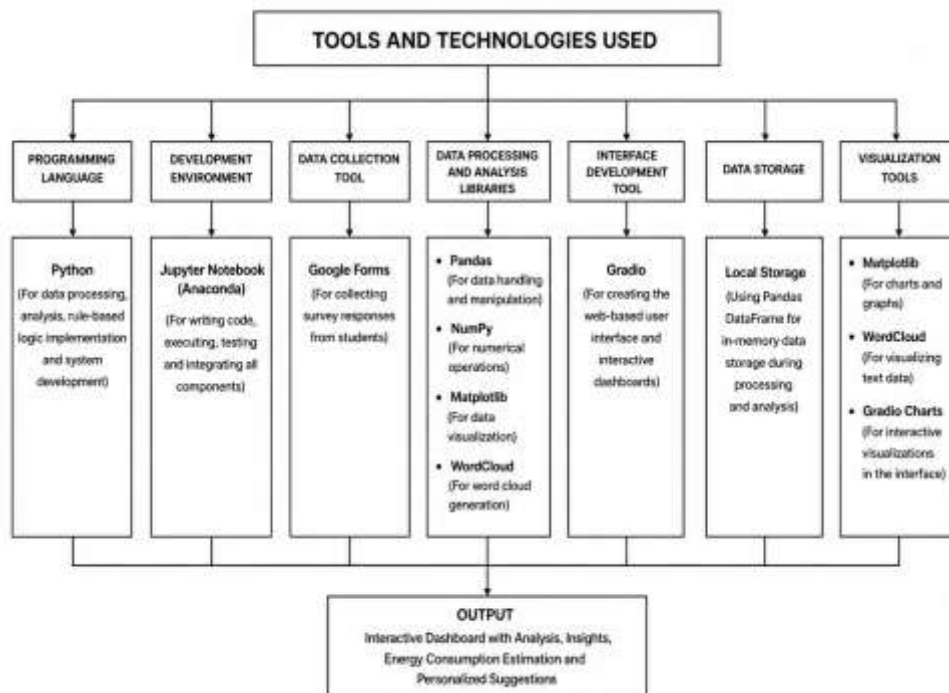
Tools that are used are:-

- Python
- Pandas, NumPy (for data manipulation)
- Matplotlib, Seaborn (for visualization)

- Gradio (for the dashboard)

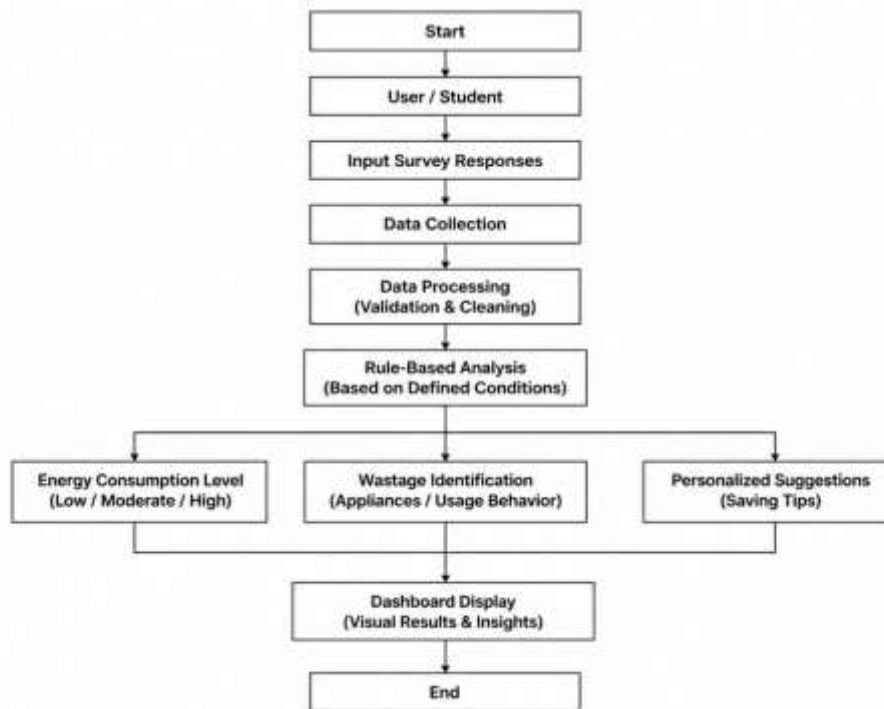
The system s flow is:-

User Input ---> Processing ---> Analysis ---> Output



H. Workflow of the System

- Input - data entered by the user
- Data pre-processing
- Rule based analysis
- Calculating consumption
- Classification
- Suggesting appropriate items
- Visualization



I. Evaluation and Validation

System is measured against accuracy and ease of use:

- Metrics used for evaluation are:
- Logical correctness of the output
- Compliance with actual real world models
- Student usability
- Efficiency of suggestions

The system results in accurate analysis of behavior and increases energy-saving practices.

IV.RESULTS

This research is built upon a questionnaire survey and system analysis for student's electricity consumption.

- It found out that students who reside in hostel consumes higher amount of electricity than at home due to lower accountability and higher independence.
- Most students have high to medium energy saving awareness, yet actual consumption behavior cannot reflect such awareness. It demonstrated there is a gap of awareness and behavior.
- Inefficient behaviors of the majority are: charge electronics over a long period; appliance left on without reason; overlong usage of fans and light.
- Compared to all appliances, the fans and light consumption are high while chargers and laptops consumption are at a medium level due to their usage hours.
- The data showed that higher the electricity consumption, higher the cost. Little behavioral change can decrease the energy consumption significantly.
- The designed system effectively estimates the electricity consumption, classified students into three levels: efficient, average and inefficient, and provides related advice for them. The dashboard outputs such as charts and graphs also assisted to show clearly the pattern of the electricity usage and enhance the users understanding.

In general, the students electricity consumption is affected by their behaviors rather than the techniques.

Fig. 1: Awareness Level Analysis of Students

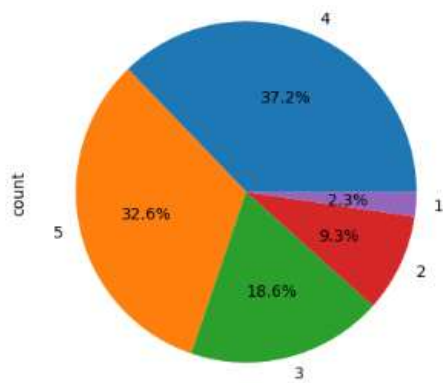


Fig. 2: Comparison of Electricity Consumption (Hostel vs Home)

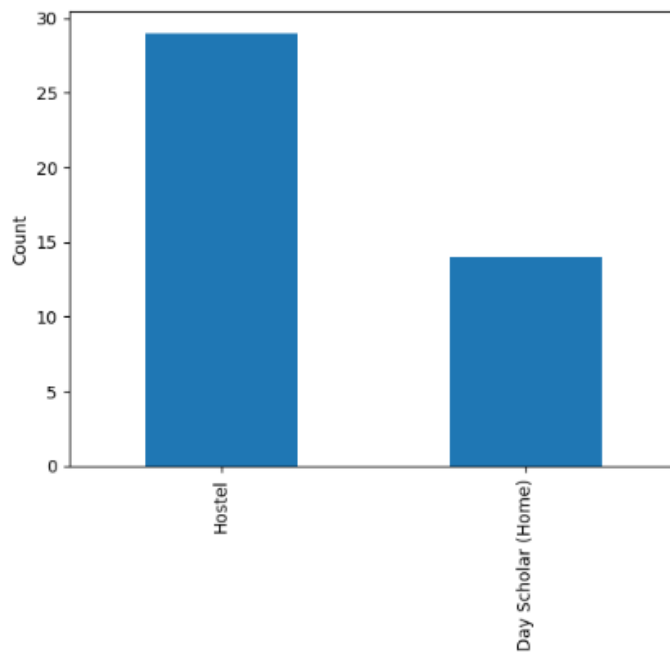


Fig. 3: Energy Consumption Pattern Analysis

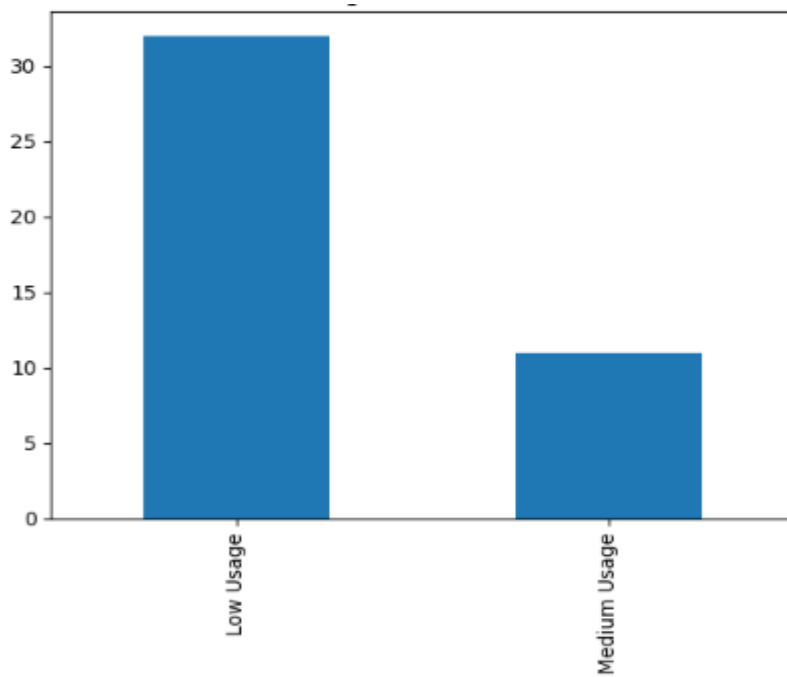
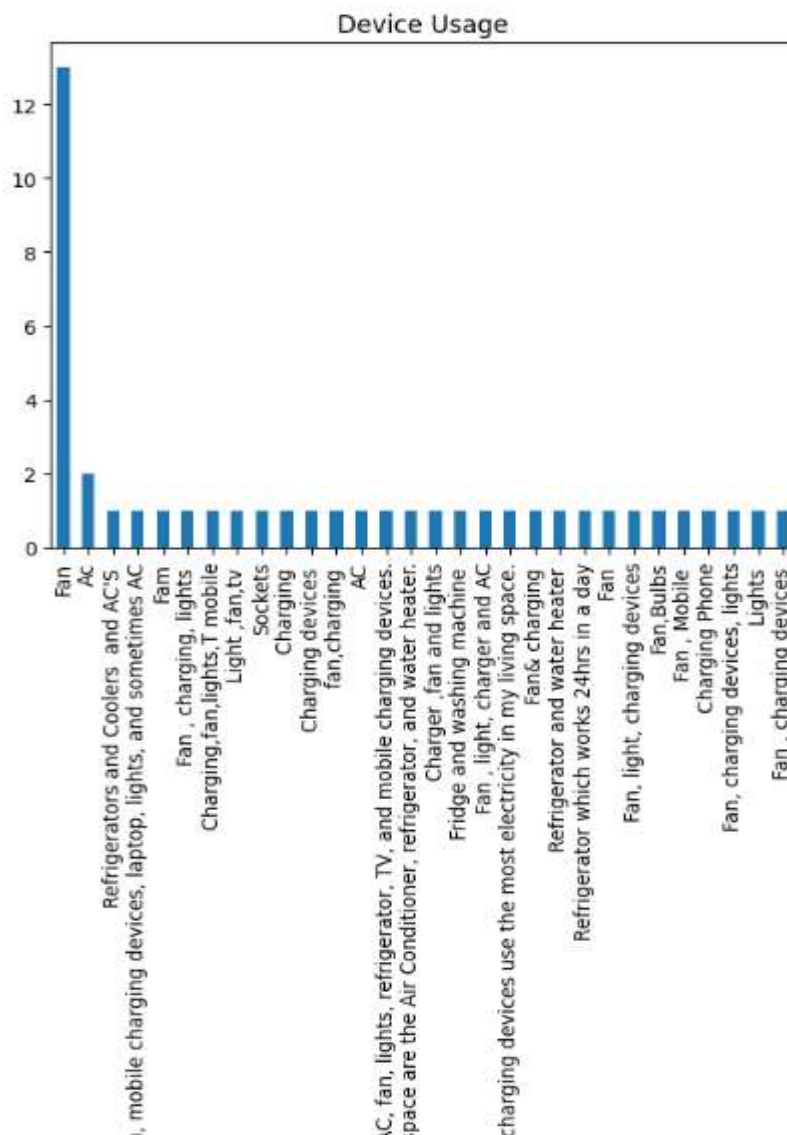


Fig. 4: Appliance Usage Distribution



V. DISCUSSION

This study shows that human behavior rather than technical constraints play the role in controlling student electricity usage. Large awareness behavior gap was detected between the students. While aware of energy saving measures students were unable to adapt them to their daily routine. Host students consumed higher energy than home students due to lack of responsibility and close observation. Inappropriate consumption behaviors such as switching appliances on and off unnecessarily and improper use such as charging gadgets for longer periods contribute towards high electricity consumption.

It can be deduced from the study that improving efficiency needs a behavior intervention approach apart from technical ones. A rule-based system and a dashboard, such as proposed in this study effectively overcome the gap of awareness-behavior. Study further implies that simple and low cost system can impact users to conserve energy. Increasing students' awareness of cost of electricity and the implementation of either monitoring or incentive mechanisms can make them more energy conscious.

VI. CONCLUSION

Our experiment shows that the primary reason for students electricity usage is the actual behavior and not necessarily the technology. There is a clear awareness-behavior gap the students know what the behaviors are but fail to adjust their behavior. Our rule based system was able to predict electricity usage and classify the users, providing a range of actionable recommendations that were feasible and affordable for the students to implement without any complex devices or models. The use of dashboards with visualizations helped to develop better understanding of electricity usage and encouraged awareness and saving behaviors among students.

Limitations: The data was collected from a survey which is not a purely objective measure; data collected might be biased or contain errors based on students' judgment. Our rule based system provides estimation to the value and the relationship between the parameters are not fully represented. We did not get the opportunity to collect actual usage data with sensors or smart meters. This study was done within a specific group of students therefore not entirely applicable in general or different context.

Take-aways: Behavior play significant role in saving electricity. Basic AI based systems can be developed and use to enhance students' consciousness and effectiveness about their electricity consumption. The combination of behavioral study and technology is key to achieving an efficient and sustainable usage of electricity.

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