MID Term Assessment

Real-time IoT-Based Energy Consumption Monitoring in a Bachelor Student's Household

Course Code: CSE407

Course Title: Green Computing

Section: 1

Submitted By,

Group:04

Tasfia Tahsin Annita
2021-3-60-031
Sofia Noor
2020-1-60-226
Samura Rahman
2021-3-60-064
Mohammad Tahmid Noor
2021-3-60-026
Department of Computer Science & Engineering

Submitted to,

Dr. Ahmed Wasif Reza

Professor

Department of Computer Science & Engineering

Additional Director, Quality Assurance, IQAC

Table of Contents

Introduction: 2
Brief Description of Work: 2
Detailed description of the steps: 3
Challenges & Obstacles: 4
Demonstration: 4
Tuya Energy meter: 5
Planning and researching: 5
Wattage for the chosen device: 5
AC Power Considerations: 5
Documentation of procedure and Troubleshooting: 5
Wattage of the measuring equipment: 6
Safety Issues: 6
API Issues: 6
Installation, Operation and Maintenance: 6
Future work and Limitations: 6
Cost Accounting: 7
Real Time Data or Stored Data: 7
Dataset: 8
Result: 9
Daily Cost per Computer: 10
Conclusion and Future work 11

Introduction:

As society advances, so does technological progress, leading to a rise in power consumption. In the modern era, nearly every machine relies on electricity for operation, which comes at a significant cost. Forecasts suggest that our reserves of coal and natural gas may only last until 2060. Therefore, it's imperative that we monitor our energy usage meticulously and strive for optimal electricity utilization. This underscores the necessity for a sophisticated system capable of tracking power consumption, alerting us to excessive energy usage. One innovative solution is the implementation of smart outlets, leveraging IoT technology to monitor energy consumption in residential and commercial settings.

Brief Description of Work:

Our Approach was to use a store-bought smart plug to measure power, voltage and current. With this approach, we had to order few smart plugs from an online store and we borrowed some from our seniors. We configured the plug with a mobile app. The data could be found on the Tuya platform. We used Tuya's API to fetch real time data, processed the data on our server, and then showed the data on our dashboard.

Here is a Diagram of our work flow is provided:

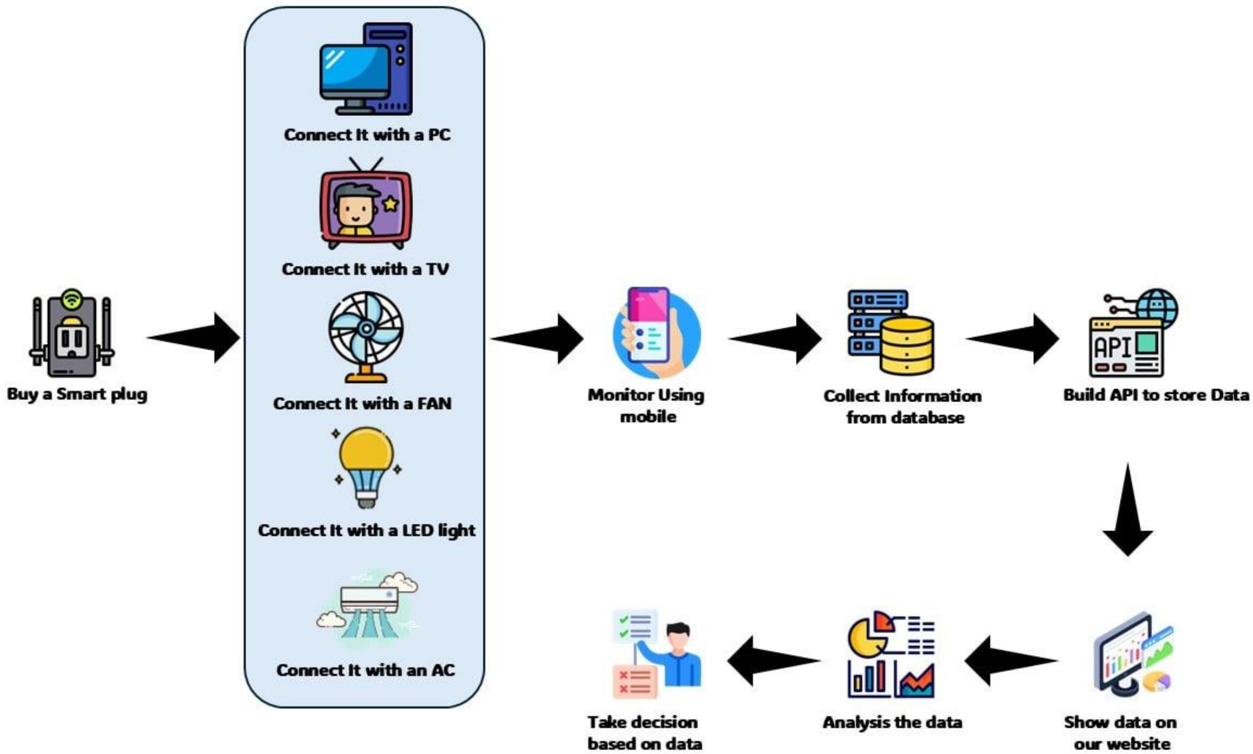


Figure 1: Flowchart of Data Collection

Detailed description of the steps:

1. **Protocol Design:** In order to carry out the experiment, we designed a particular protocol. We decided to take power usage data of a student's single room living as a bachelor. The room contained particularly five devices, an air conditioner, a television, a computer, a ceiling fan and a LED light. So, we used five tuya smart plug devices to take five readings separately from the devices.

Figure2: Architecture of a student's single room as a bachelor.

2. **Planning:** The planning phase involves identifying a feasible device that can measure the energy consumption of devices easily. We had to explore numerous measuring devices, considering the factors such as their cost, accuracy, safety and if they are easy to use or not. We also ensured that all the software or libraries which we will be using were freely available and did not require an API key.
3. **Researching:** Once we decided on our approach, we conducted research to confirm its feasibility. Store bought smart plug (Tuya): There were several smart plugs online. We bought a fairly cheap but efficient one and started with that. The brand of the smart plug we used was SMATRUL.
4. **Purchasing Store bought smart plug (Tuya):** We purchased the smart plug from Daraz online store.
5. **Configuration Store bought smart plug (Tuya):** We configured the plug to be connected with our home WiFi. We then used our server to fetch and process the data from Tuya's API.

Challenges & Obstacles:

1. We had to wait for a long period of time for the smart plug to arrive as it is shipped from overseas.
2. The Tuya API documentation is quite difficult to find and is comparatively hard to understand.
3. The Tuya API documentation does not provide clearly what unit the data is inside the API response.

Demonstration:

Link to the energy dashboard: [CSE 407 Dashboard (smart-plug-data-visualization.vercel.app/)](https://smart-plug-data-visualization.vercel.app/)

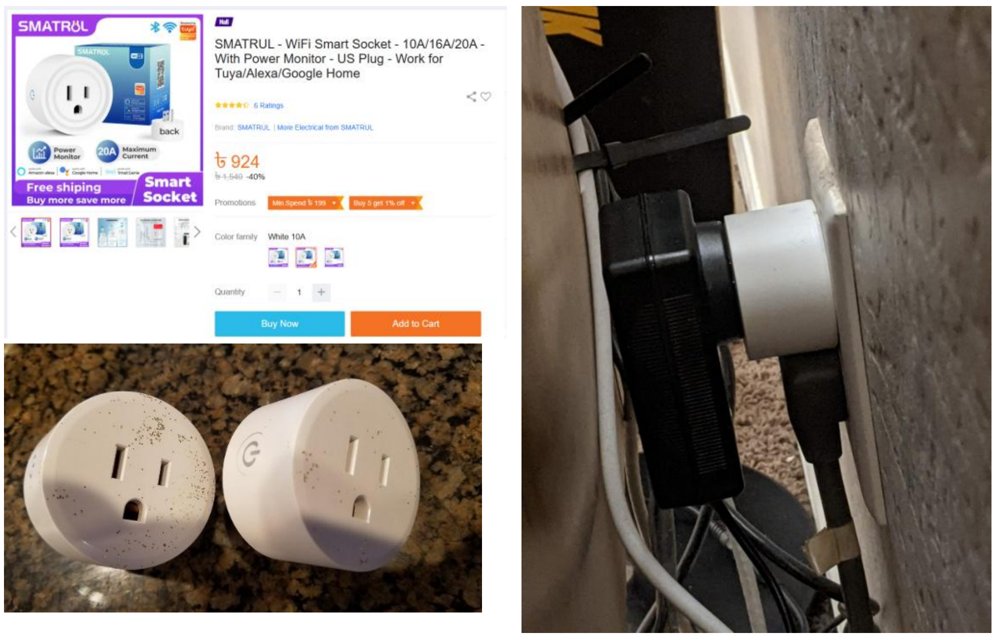


Figure 3: SMARTRUL smart Plug

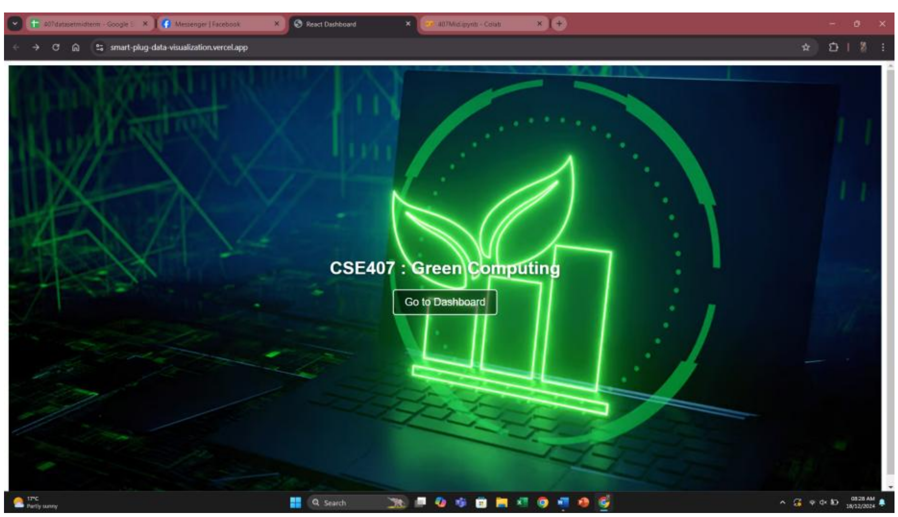


Figure 4: Dashboard

Tuya Energy meter:

Planning and researching:

We choose to monitor the power consumption of a bachelor student's room which contains devices like: computer, air conditioner, fan, led light, and television using Tuya smart plug for our project. We picked this device for numerous reasons. For example:

1. Tuya smart plug is compatible and has a wide range of devices, making it a flexible solution for energy monitoring.
2. It has smart features like: remote controlling, scheduling and energy monitoring. These features make it a multifunctional tool for managing and monitoring energy consumption.
3. This smart Plug is a very user-friendly device as it can be easily configured and installed. It does not require any complex wiring processes making it a convenient choice for users.

SL. No.	Appliance	Brand/Model	Maximum Power Consumption	Eco Energy Efficiency
1.	Computer	Dell (i5 gen 11)	500Watt	No
2.	Air Conditioner	Walton Inverna	3635Watt	Yes
3.	Television	Walton Smart TV	400Watt	Yes
4.	Fan	Vision	65Watt	No
5.	LED Light	SLED	30Watt	Yes

Table1: Details of Appliances that have been monitored

Wattage for the chosen device:

The Smart Socket uses 100 - 250V which is the wattage power of this device. In conclusion, the electrical rating is 100-250V AC50 Hz, which is very suitable for many devices.

AC Power Considerations:

This device uses AC power because the devices we selected to monitor (air conditioner, fan, led light, and television) are generally powered by AC power.

Documentation of procedure and Troubleshooting:

The entire process of how the setup should be done and how the Tuya Smart plug should be used is documented in a user-friendly manual. The manual is small but all the processes are explained in a detailed way.

Wattage of the measuring equipment:

The electrical rating is 100-250V AC50 Hz, which is very suitable for many devices. Users should ensure connected devices do not exceed this rated capacity. However, calculating Rth, Vth and Pth is not possible as it requires more information and additional devices such as a multimeter.

Safety Issues:

Safety was the most important concern throughout the project. Appropriate measures were taken to prevent any kind of accidents. The energy meter was properly insulated and electrically isolated to prevent accidents from occurring. We made sure to handle the equipment with dry hands and disconnect the power supply every time making any adjustments to the device setup. Thus, we maintained an accident-free environment throughout the project's execution.

API Issues:

Although the Tuya Smart Plug is a versatile tool it has a few disadvantages too. For instance, it was difficult to find the API endpoints of the plug. Furthermore, establishing a connection between API and the device was quite challenging particularly because the free tier does not provide all the information at once.

Installation, Operation and Maintenance:

The Tuya Smart Plug is relatively easy to install and operate. The installation only involves plugging the device onto the power outlet and connecting it to the app. The energy consumption can be monitored and controlled by the smart app even from a longer distance. If any user needs to change their Wifi, then they need to connect the smart plug to their new router. The whole process needs to be done exactly in the same way again. This device does not need any other additional maintenance but the app can be updated periodically when the update notification appears to ensure smooth and quick operation.

Future work and Limitations:

Although this energy meter is a versatile tool and works magnificently well, it has some limitations which need to be addressed too. They are:

1. The API endpoints are hard to find.
2. Documentations can be more readable and can be printed on a larger manual.

For future work, this decision totally depends on the company's shareholders or board of directors. They can try to change the UI/UX to make it more appealing.

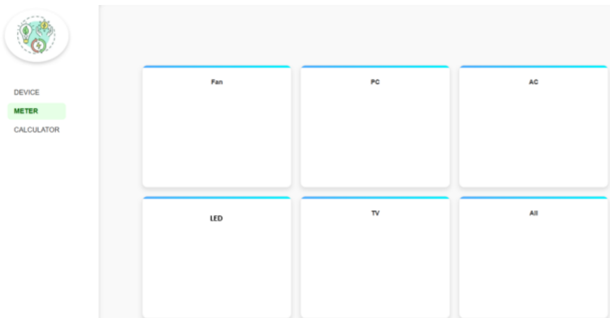
Cost Accounting:

Throughout the project, we kept a record of expenses to maintain a comprehensive financial ledger.

SN	Product	Quantity	Expense (BDT)	Remarks
1	Smart Plug	3	924*3 = 2772	Daraz BD
2	Borrowed Smart Plug	2	0*2 = 0	Senior Students
2	Internet Cost	-	60	ISP
3	Shipping Cost	-	80	Daraz BD
	Total Cost		2,912	

Table2: Cost we bared to take the readings

Real Time Data or Stored Data:



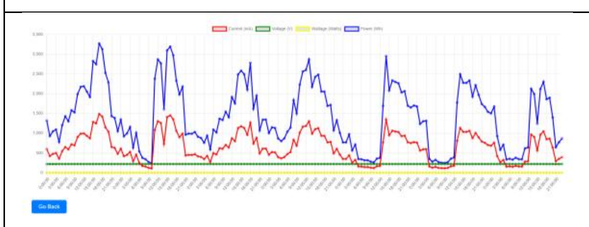
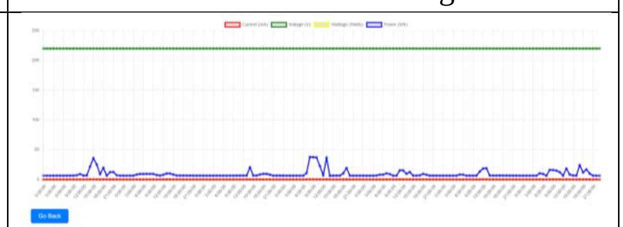
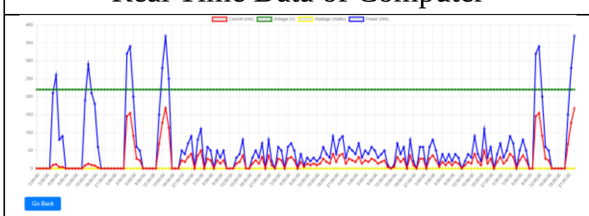
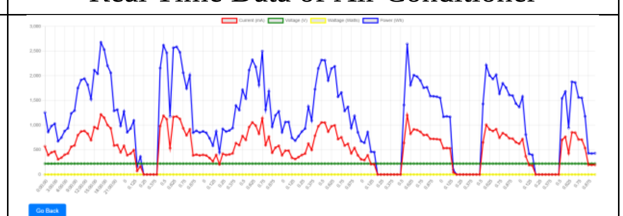
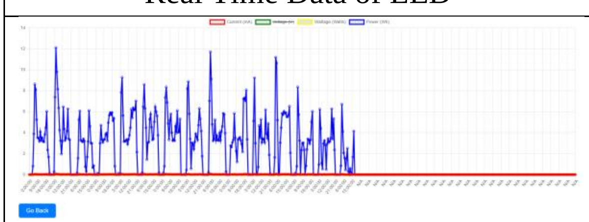
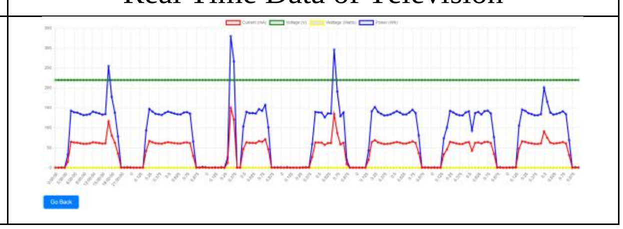
Real Time Data of the Room	Real Time Data of Ceiling Fan
	
Real Time Data of Computer	Real Time Data of Air Conditioner
	
Real Time Data of LED	Real Time Data of Television
	

Figure 5: Real Time Data Monitoring of Smart Plug on dashboard

Dataset:

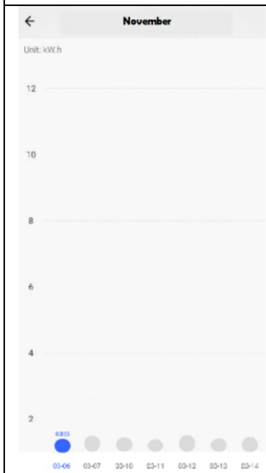
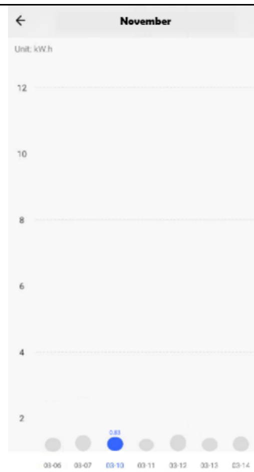
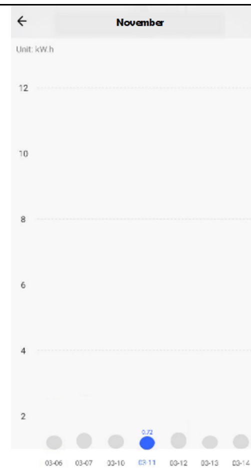
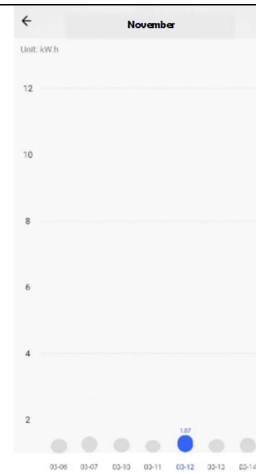
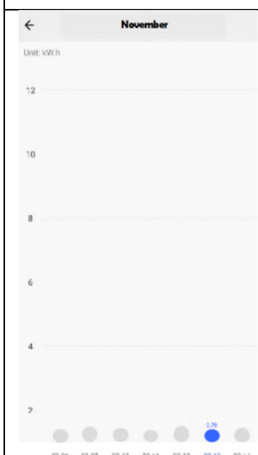
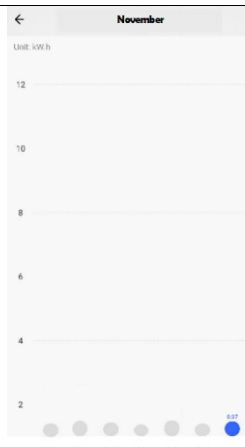
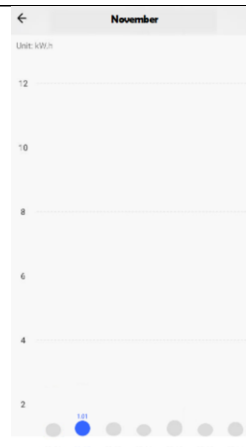
We have created a dataset using Real time power usage data of a bachelor student's room from 1st November, 2024 to 7th November, 2024.

TimeStamp	Fan	PC	AC	LED	TV	Total
11/01/2024 0:00	0.00644	0	1.2564	0	0.0004	1.26324
11/01/2024 1:00	0.0064	0	0.8624	0	0.0004	0.8692
11/01/2024 2:00	0.0064	0	0.9836	0	0.0008	0.9908
11/01/2024 3:00	0.0064	0	1.0292	0	0.0004	1.036
11/01/2024 4:00	0.0064	0	0.6736	0.0008	0.0328	0.7136
11/01/2024 5:00	0.0064	0.21	0.7476	0.00388	0.1432	1.11108
11/01/2024 6:00	0.0064	0.26	0.88	0.00864	0.1392	1.29424
11/01/2024 7:00	0.0064	0.08	0.9372	0.00812	0.1384	1.17012
11/01/2024 8:00	0.00648	0.09	1.2388	0.00524	0.1348	1.47532
11/01/2024 9:00	0.00652	0	1.2948	0.00352	0.132	1.43684
11/01/2024 10:00	0.00712	0	1.7524	0.00348	0.1328	1.8958
11/01/2024 11:00	0.00912	0	1.9176	0.0032	0.1344	2.06432
11/01/2024 12:00	0.0066	0	1.9428	0.00408	0.1408	2.09428
11/01/2024 13:00	0.0066	0	1.8184	0.00328	0.1384	1.96668
11/01/2024 14:00	0.02156	0	1.5288	0.00352	0.1364	1.69028
11/01/2024 15:00	0.03568	0.19	2.1156	0.00316	0.1332	2.47764
11/01/2024 16:00	0.02504	0.29	2.0412	0.00312	0.1344	2.49376
11/01/2024 17:00	0.00888	0.21	2.6776	0.00384	0.2556	3.15592
11/01/2024 18:00	0.0196	0.18	2.5316	0.00448	0.1776	2.91328
11/01/2024 19:00	0.00656	0.06	2.2048	0.00604	0.1384	2.4158

Figure 6: Sample image of the Dataset

Result:

Include visual representations of the experimental results, such as graphs depicting energy consumption patterns over time. Visuals enhance understanding and make results more accessible.

1st November	2nd November	3rd November	4th November
			
5th November	6th November	7th November	
			

Here is a comparison Diagram of the peak hour and off-Peak hour Power Usage:

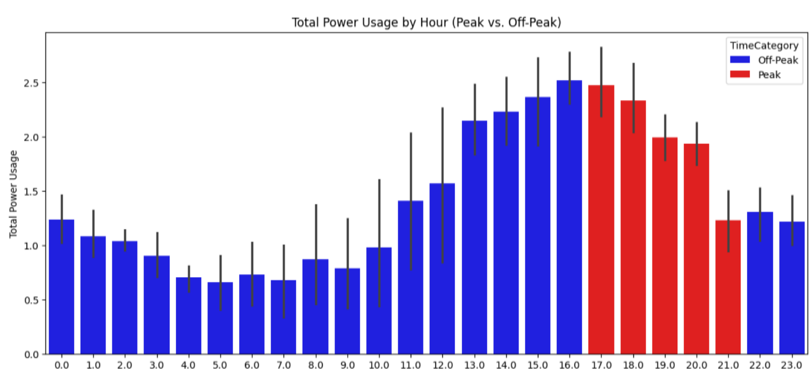


Figure 7: Total Power usage of a student's room

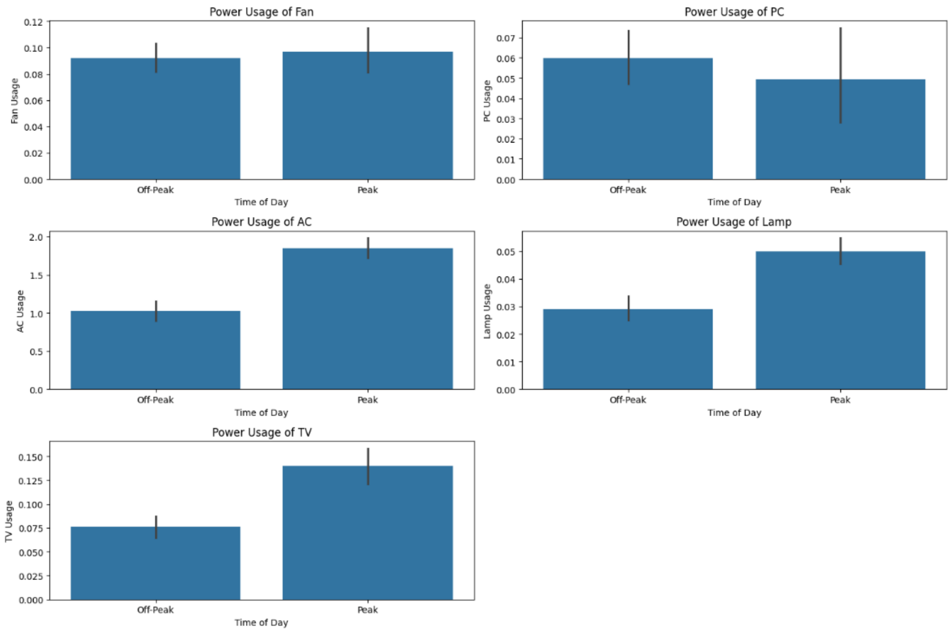


Figure 8: Individual devices' over all usage at peak and off peak hours

Daily Cost per Computer:

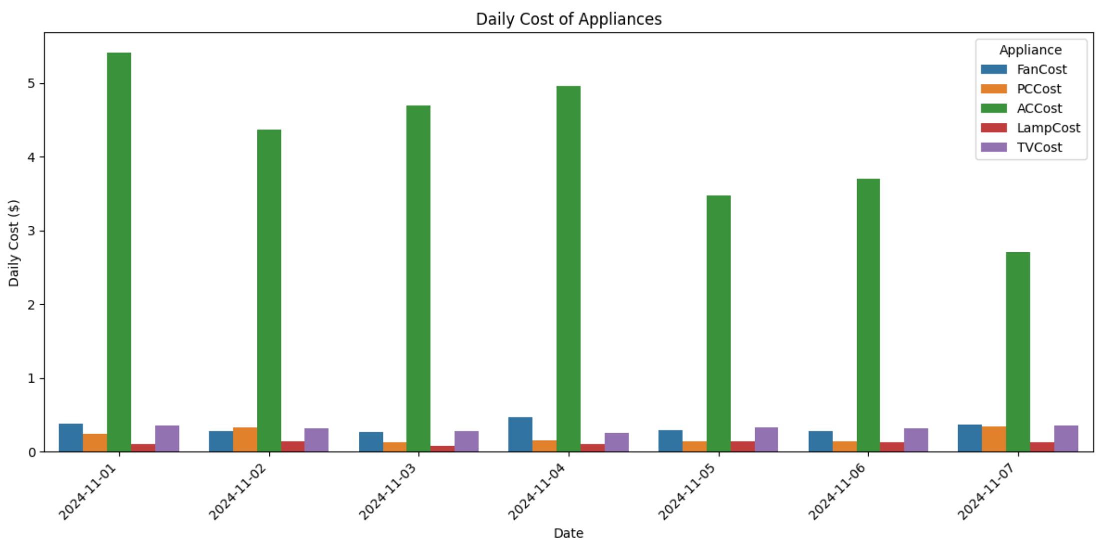


Figure: Daily cost of all the five devices in a single student's room

Date	1st November	2nd November	3rd November	4th November	5th November	6th November	7th November
Unit KW/h	1.68	1.40	1.42	1.50	1.11	1.17	0.96

Table 3: Average total power usage per day

Conclusion and Future work

The research endeavor introduces a dashboard powered by a web server, aimed at promoting energy conservation and fostering sustainable energy habits, aligning with principles of green computing. Through real-time data, users can make informed choices regarding their energy usage. The system's architecture incorporates a web server for IoT cloud integration and non-intrusive sensors for data gathering. Notably, the inclusion of dataset from a single student’s household contributes significantly to understanding energy consumption patterns, thereby advancing green computing practices in household environments. Overall, the project serves as a valuable tool for advocating energy-saving behaviors and cultivating a culture of responsible power consumption.

In future we can do this kind of work:

● Improve the user-friendliness and informational value of the dashboard controlled by the web server.

● Explore methods for integrating machine learning models to analyze energy usage trends.

● Guarantee the security and privacy of collected energy consumption data through robust measures for data transmission and storage.

● Broaden the system's capabilities to encompass smart appliance management and interaction driven by energy consumption data.