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MONITORING OF ELECTRICITY CONSUMPTION OF HOUSEHOLD DEVICES

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Abstract: Electricity capacity growth is not as fast as electricity demand. Energy conservation scenarios need to be prioritized and promoted. Consumers need to be educated about optimal consumption and at the same time made aware of wasteful consumption. This study proposes a configuration of real-time electricity monitoring and providing insights into monthly consumption of households. Apart from the conservation aspect of this study it also aims to gain knowledge about each individual device's consumption and its contribution in the total monthly consumption. Based on the monthly analysis of collected data it will also attempt to detect faults in connected systems.

I. INTRODUCTION

With the advancement of humans into modern world the demand for energy and its consumption has peaked. But energy requirements are not followed by the growth of existing inventory. Also, wasteful consumption is on the rise which leads to further deadlocks in the collective plan to conserve and optimize the use of energy. The electricity users remain inefficient when using energy, such as when the user leaves the room, the electrical equipment is still on. In addition, it is also important to figure out how energy is used in buildings to find wasted energy consumption. In this paper, we propose an analysis method to figure out how energy is used in a typical household to find how they consume energy on a daily basis and how providing monthly consumption data changes their approach towards energy consumption.

India's announcement that it aims to reach net zero emissions by 2070 and to meet fifty percent of its electricity requirements from renewable energy sources by 2030 is hugely significant moment for global vision of energy consumption. India is pioneering a new model of economic-development that could avoid the carbon-intensive approaches that many countries have pursued in the past- and provide a blueprint for other developing economies The energy policy of India is to increase the locally produces energy in India and reduce energy poverty, with more focus on developing alternative sources of energy, particularly nuclear, solar and wind energy.

II. Methodology

This study is designed to monitor the consumption of electrical energy in a regular household, assumed users have a smartphone and connect to a network.

A. Identifying Characteristics of the System

Identifying the characteristics of the system can begin with a description of the actual system.

Identification starts from analyzing the behavior of building's user in using electricity, includes the type of equipment used wastefully, the duration of waste, how often it happens, what drives people's behavior to become more energy efficient. After wasted behaviors identified, then a conceptual design to manage energy consumption behavior in public buildings is discussed and formulated by some experts. The system can provide feedback to the users about the status of the equipment used, the amount of energy that has been wasted (in energy unit or in energy price), a notifying system, and last, a reporting system that shows statistics and the impact of the proposed system in changing behaviors of the users towards energy use.

B. Designing the System Model

The design of the system model is made to show what kind of system we want to develop or build. The system can monitor the use of electrical energy in a household based on the amount of electricity used by electronic equipment using a current sensor mounted on the devices. The data read by the sensor will be sent to the web server through the internet and will be saved in the database. Wi-fi in the room together with user's smartphone will form a system that can monitor the movement of user entering or leaving the room and the power status On/Off of the equipment. If the system identifies that the user leaves the room without powering off the devices in the room, a notification will be sent to the user's smartphone and encourage them to come back to the room and take action to save energy. Some scenarios on how the system would work in various situations are also developed and evaluated.

C. Selection of Sensor Devices and Notifications System

1) **Sensor Devices** - The components used for the sensor device consists of a current sensor. It only needs to pair it for electrical equipment cables. The model also uses a voltage sensor and a relay module.

D. Draft Testing Tool and Notifications

Testing the design tools and the notification is done by simulating the system in an experimental room. The size of the test room is 3 m x 2.5 m. The room has air conditioning, TV, lights, and computers. The room is also equipped with WIFI which is used to detect any smartphone (equivalent person) entering or leaving the room.

1. Flow Sensor Testing

Results from current readings by sensors on one equipment will be derived. Based on the picture, the current of electricity is readable even though the current flow is small meaning that the sensor's readings are valid to be used for data analysis. We can show a comparison between current read by sensor compared to the digital tool clamp multimeter. At this time the equipment tested is the air-conditioning apparatus. From the test results, it can be concluded that the measurement results using the tools and sensors produce the same results.

2. Notification System and Database

The database is used for data storage. The data stored in the database is in the form of user data, admin, sensor data, room data. The data stream is transmitted by the sensor. The notification system can be run only if the user has logged into the system. If a user never uses the room previously, then the system will guide the user to register in advance.
Once a user has registered, he/she can log in by entering their email and password that has been set. If the password or email used/entered is not correct, the user cannot use Wi-fi and cannot get into the system. If the user has successfully logged in to the system, the display statement will be displayed on the smartphone's screen.

III. Implementation

1. Data Collection and Device Monitoring Setup

To execute the estimation of appliance electricity consumption, a comprehensive data collection and device monitoring system was implemented. Smart meters and sensors were strategically installed on selected appliances within the target environment. These devices were chosen based on their representation of typical energy-consuming equipment in the given setting.

2. Data Acquisition

A dedicated data acquisition system was established to collect real-time information from the monitored devices. This system was configured to capture relevant metrics, such as power consumption and usage patterns. The data acquisition process was designed to ensure minimal interference with the normal functioning of the appliances.

3. Integration of IoT Technology

Internet of Things (IoT) technology played a pivotal role in the implementation phase. The monitored devices were equipped with IoT-enabled sensors, allowing seamless communication between appliances and the centralized data storage system. This integration facilitated remote monitoring and real-time data retrieval, enabling a more dynamic and responsive approach to energy consumption analysis.

4. Visualization and User Interface

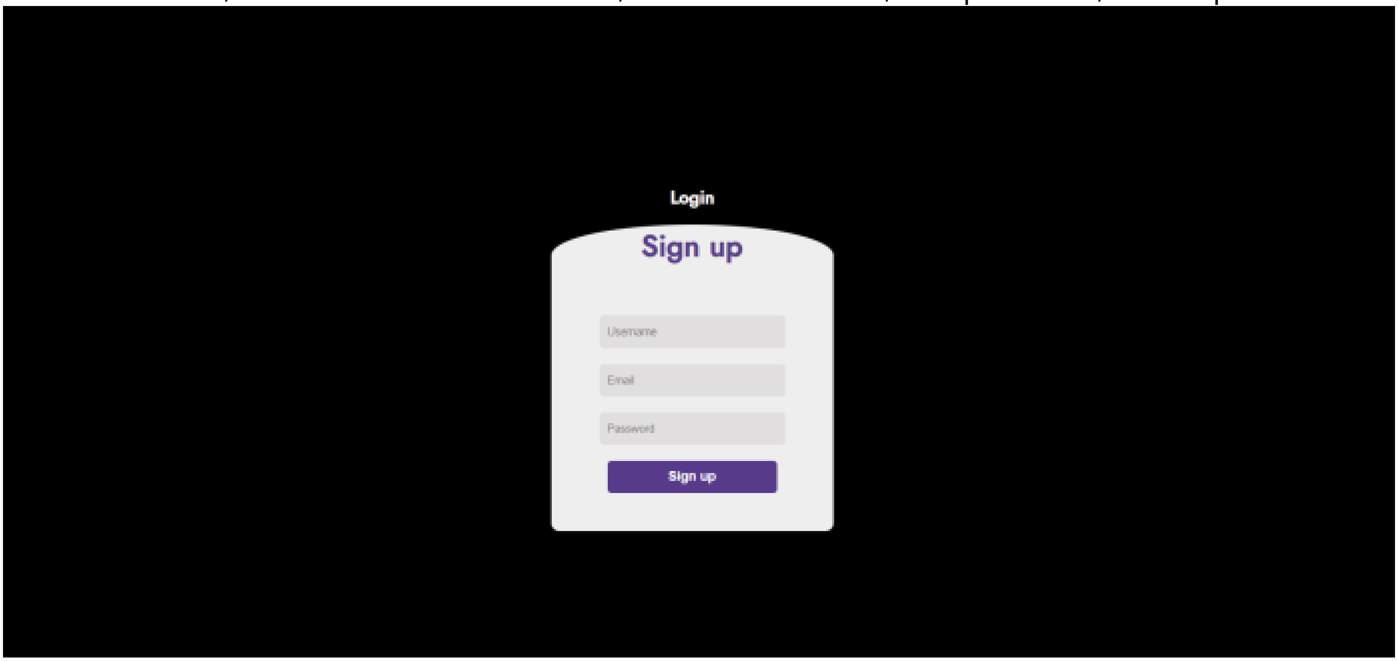
To enhance accessibility and usability, the research team developed a user-friendly interface for visualizing the analyzed data. This interface provided stakeholders, including both consumers and businesses, with intuitive dashboards and reports that conveyed key insights into their electricity usage patterns.

5. Continuous Monitoring and Feedback Loop

The implementation phase emphasized the establishment of a continuous monitoring system. Regular updates and feedback mechanisms were integrated to ensure the ongoing accuracy and relevance of the collected data. This iterative process allowed for adjustments in the estimation models and recommendations for energy-efficient practices.

Website Details:

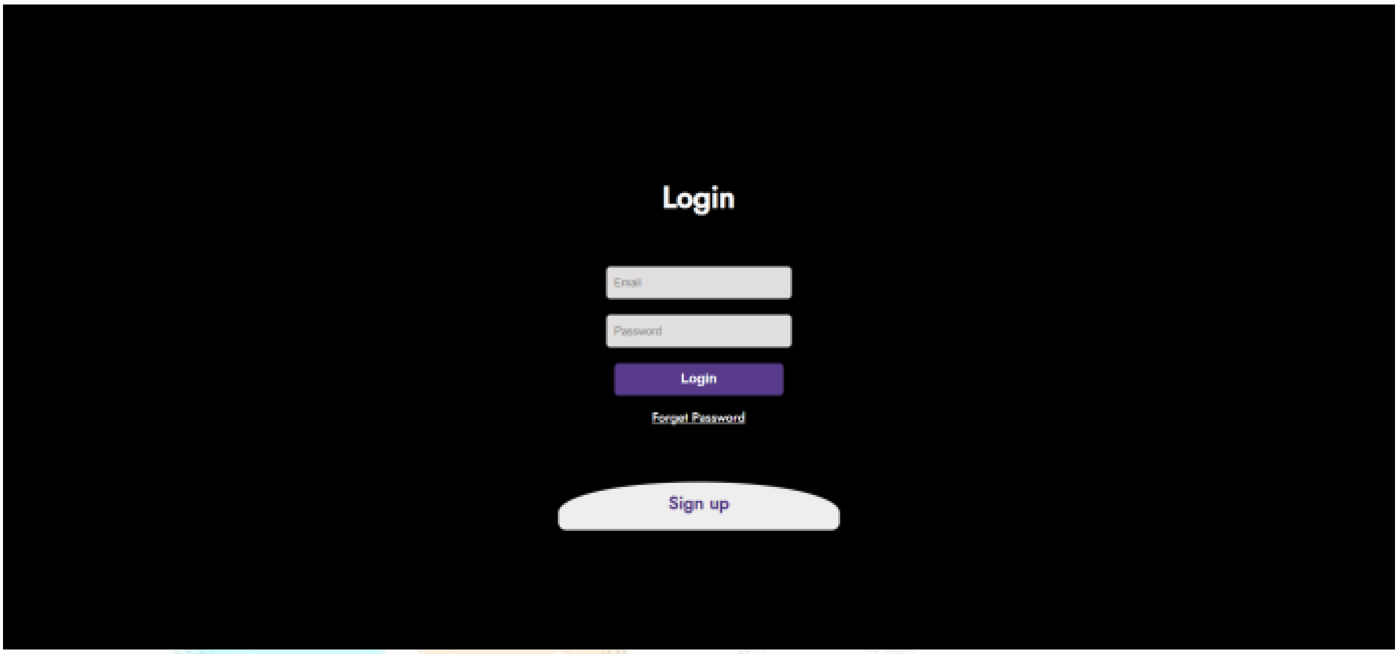
The signup page is designed to onboard new users onto the platform, enabling them to create accounts and access the system's functionalities. New users are required to provide essential information, such as their email address, desired username, and password, to complete the



registration process.

Sign up Page

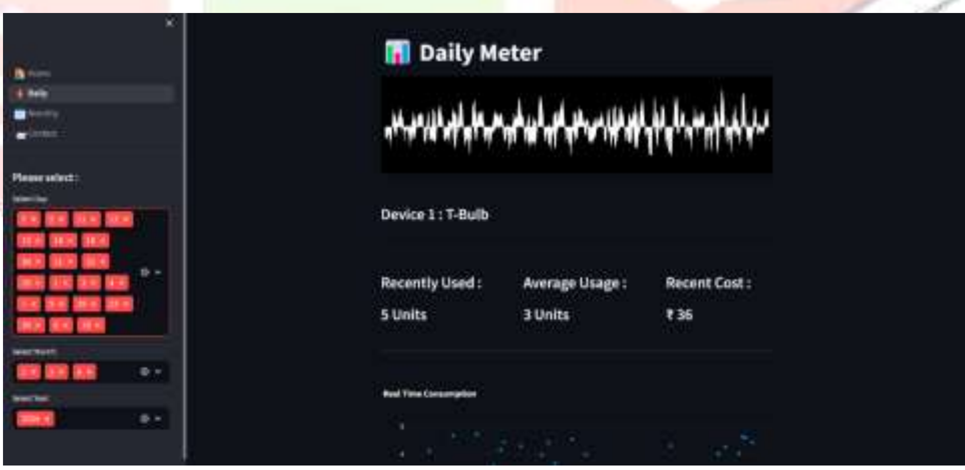
The login page serves as the entry point for registered users, allowing them to securely access their accounts. Users are prompted to input their credentials, typically consisting of a username and password, to authenticate their identity. Upon successful login, users gain access to their personalized dashboard, where they can explore detailed insights into their household electricity consumption.



Login Page

The daily cost chart depicts the monetary expenditure associated with electricity consumption on a day-to-day basis.

By identifying peak consumption periods and associated costs, users can implement strategies to minimize expenditures and enhance overall energy efficiency.

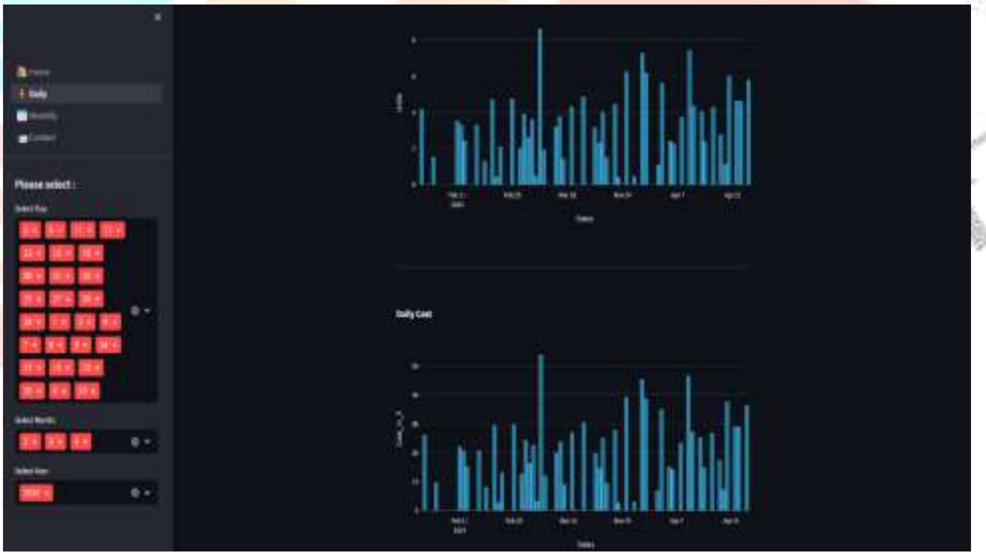


Daily Consumption Chart

Consumers also can choose to look at monthly consumption data of any month and at same time get an idea about the cost associated with it

Monthly Meter Charts

The electricity consumption chart presents a graphical representation of the amount of energy consumed by household devices over time. By visualizing consumption trends, users can gain valuable insights into their usage patterns and identify potential areas for improvement. Whether it's identifying energy-intensive appliances or monitoring the impact of behavioral changes, this visualization empowers users to take proactive measures to reduce their carbon footprint and contribute to sustainable living practices



Daily Cost and Unit Consumption Charts

IV. Software Requirements for Developers

1. **Integrated Development Environment (IDE)** - Software like IntelliJ IDEA, Eclipse, or Visual Studio Code for coding and development.
2. **Version Control System** - Git for tracking code changes and collaboration.
3. **Database Management System** - MySQL or a similar DBMS for local development and testing.
4. **Web Server** - Apache Tomcat or another web server for deploying and testing the application locally.
5. **Build Automation Tool** - Maven or Gradle for building and managing dependencies.

V. Hardware Requirements for Developers

1. **Computer** – A workstation which can be laptop or desktop.
2. **Communication Devices** - Includes communication devices (e.g., Wi-Fi or Ethernet modules) to facilitate the transfer of data from the monitored devices to a centralized storage.
3. **Centralized Data Storage** – Servers or cloud-based storage solutions to centralize and securely store the collected data. Ensure that the storage system has sufficient capacity.
4. **Computing Hardware** – Computing Hardware required for data processing and analysis.
5. **Smart Meters** – Smart Meters capable of measuring electricity consumption with high precision.

Conclusion:

In conclusion, the development and implementation of our web-based household electricity consumption monitoring system represent a significant step towards promoting energy awareness and conservation among users. Through the utilization of innovative technologies and data-driven analytics, our platform offers users a comprehensive suite of tools to monitor, analyze, and optimize their energy usage habits.

The insights gleaned from the system's charts and visualizations enable users to make informed decisions regarding their electricity consumption, ultimately leading to more efficient resource utilization and reduced environmental impact. By empowering users with real-time data on their consumption patterns and associated costs, our platform fosters a culture of accountability and sustainability, encouraging users to adopt more eco-conscious behaviors.

Looking ahead, there is immense potential for further enhancements and integrations to expand the functionality and reach of our monitoring system. Future iterations could incorporate machine learning algorithms to provide personalized energy-saving recommendations or integrate smart metering technology for seamless data collection and analysis. Additionally, partnerships with utility providers or government agencies could facilitate broader adoption and incentivize energy-saving initiatives on a larger scale.

Overall, our project underscores the importance of leveraging technology to address contemporary challenges in energy management and environmental sustainability. By empowering individuals with the tools and knowledge to monitor and control their electricity consumption, we can collectively work towards building a more resilient and sustainable future for generations to come.

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