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Campus Energy Monitoring System

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Abstract - *Supply and demand of energy undergo major dynamism on a day-to-day and seasonal changes basis. In such situations, energy management and control systems depend on the energy consumption analysis of residential buildings. This paper focuses on how electricity consumption can be predicted by utilizing the data from smart meters. The abundant amount of data enables in-depth statistical analysis of electricity consumption to study the behavior of distinct customers. Initially, electricity usage patterns present in the data are discovered and summarized using data mining techniques. Second, the K-means algorithm is applied to the clustering analysis, and the level of electricity usage is divided by the cluster centers. Daily notification of the energy consumed is also aimed. Electricity consumption data of our entire college is analyzed. As the next step, modern methods of electricity consumption forecasts would be applied to predict college electricity consumption. This prediction would assist the power sector in grasping the dynamic behavior of college electricity for supply and demand management strategies and provide a decision-making reference for the optimal allocation of the power supply. This will be advantageous in improving the power grid quality from overall perspective [1].*

***Key Words*: Statistical analysis, data mining, K-means, clustering analysis, forecast**

1.INTRODUCTION

Campus Energy Monitoring System is a web application that will help in monitoring the overall energy consumption in the campus across all the buildings [2]. With the help of smart meters, energy values are retrieved and are used for data analysis. Machine Learning is implemented to predict future energy consumption. Machine learning algorithms like regression analysis which predict the output values based on input features from the data fed in the system have been used to predict future energy consumption. 9 months of data had been used for machine learning. Light GBM has been used as a distributed gradient boosting framework for machine learning. The Light Gradient Boosting Machine is based on decision tree algorithms and used for machine learning tasks such as ranking, classification, and many others. The data collected is analyzed and pre-processed before it is used for model training and testing. The performance of each of the methods is compared based on RMSE metrics.

2. EXISTING SYSTEM

2.1. Existing Approaches / System

Microgrids are the energy systems which enable us to work both in connected or, islanded modes to/from the main power grid. An example of a Microgrid is a smart campus: a university campus that implements different types of Distributed Energy Resources (DER). As there is no guarantee for continuity of the power supplied by DERs; the new Microgrid needs a scheduling management software, called Energy Management System (EMS), which will manage the DERs for the smart campus to use energy efficiently Smart meters were set up at GNITS in collaboration with IIT-Hyderabad that can be monitored using a web application which updates dynamically the data every 5 minutes [3]. It is used to receive daily updates and to display the energy consumption of various blocks while monitoring the total energy consumed in the different blocks of the campus. As a part of IoT applications, smart energy meters have been installed and data is being monitored and displayed through the website continuously. A total of 11 smart meters are installed on the campus. Raspberry pi was used for the functioning of the smart meters. A file in the server location currently has the data being written into it.

A few of the chronicles related to such work that already exist are the following:

- Extraction of Data from an RS-485 enabled Multi-Function Meter for Building Monitoring Systems. This model mainly focuses on the first step of data extraction. It does not throw light on analyzing data and drawing conclusions from it. According to this model, data will be stored in a file location making it hard for the data analysts to access.

- Smart Campus Energy Management System paper explains about various existing architectures of an EMS, along with a way to improve it's efficiency by incorporating cloud computing into the microgrids.

2.2. Drawbacks in the Existing System

- The smart meters only dynamically update the energy values. The data collected has not been used for any analysis.

- The user interface was not developed to access the data that is being collected by the smart meters.
- In the existing system, the energy values were collected only for a single device.
- The energy values taken from the smart meters were not stored in the database.

3. PROPOSED SYSTEM

3.1. Motivation for Proposed System

- The conventional system does not facilitate data analysis and visualization.
- The proposed system employs various kinds of data mining techniques, heat maps to generate reports which are useful for the administration department to know about the energy consumption of various blocks in the campus and detect anomalies if they exist.[4]
- Analyzing the data organizes, interprets, structures, and presents the data into useful information that provides context for the data and is useful to optimize energy consumption.
- Machine learning algorithms were developed to predict future energy consumption. Decisions pertaining to energy purchase or generation can be taken easily with help of an accurate prediction of energy demands. Furthermore, an accurate prediction will have a significant impact on preventing overloading and allowing efficient energy storage.
- In the proposed system, the energy consumption of the entire campus is recorded by the smart meters.
- Send daily, weekly, monthly reports via email to the administrator.
- The data is written directly into the database. The data thus can be made available to the engineers through a common web portal. This web portal can have the data segregated according to period.

3.2. Implementation

Smart meters were set up at GNITS in collaboration with IIT-H which are connected to a Raspberry Pi and used to send data that can be stored. The raspberry pi is programmed in such a way that the data is read and synced into dropbox every minute. In dropbox, a new file is created every day at 12:00 with the name as the date. Every minute the data is read from corresponding meters and stored in the file line by line in comma-separated values. The data includes information about time, meter id, power, voltage, and current values. A task is created in the Task scheduler such that it runs a file every 5 minutes. This file contains the code which reads the newly updated data and adds it to the database. This file takes the help of another file, which notes down the last read line. The website is created to view and analyze real-time and historic data using the database which is updated every 5 minutes. A Machine learning algorithm is used to predict energy consumption in the future using the stored data [5].

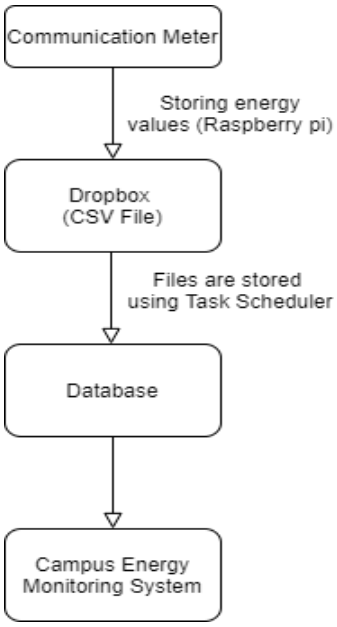


Chart -1: Flow of backend process

Chart -2: Architecture of the proposed system

4. RESULT

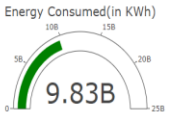
Machine learning algorithms like regression analysis and Light GBM, short for Light Gradient Boosting Machine which

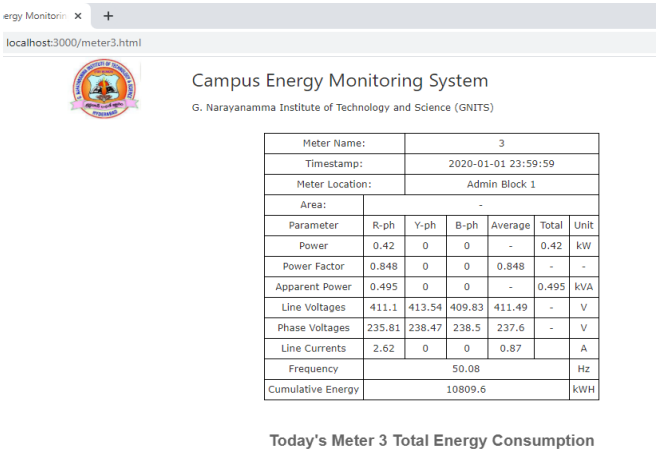
is a distributed gradient boosting framework and is a decision-tree-based algorithm are used to predict future energy consumption [6]. 9 months of data had been used for this process for which accuracy of 82% was achieved. Given more data, the accuracy increases as patterns for a particular month will be similar, but this can be found only when the quantity of data is of at least 2 years.

5. RESULT ANALYSIS

The cumulative amount of energy consumption by all meters in a month is organized in tabular and pictorial form. The tables and line graphs are also used for every individual web page for each meter [7]. This data is updated every five minutes. The tooltips and labels help in following the information easily.

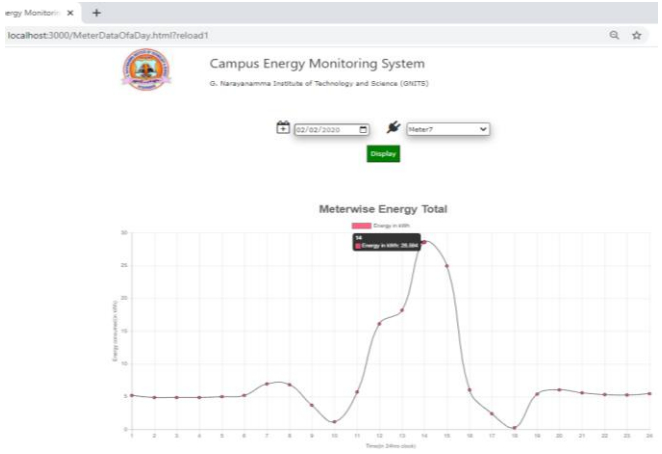
Meter ID	Meter Name	Energy Consumption(Kwh)
2	GPR memorial	38737
3	Admin 1	574315476
4	Admin 2	487371716
5	IT part 1	209851220
6	EEE, ECE Hostel, CSE	5662042889
7	Generator bypass	592708546
8	IT F block	624136613
9	Auditorium H block	1185144545
10	Canteen motors	153903591
11	Capacitor Bank	340112285

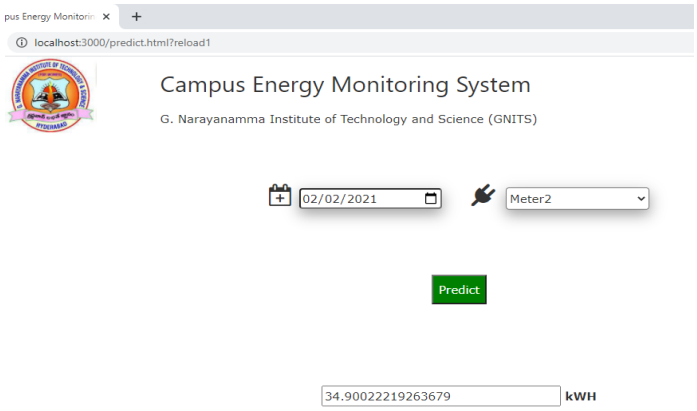




Meter Name:	3					
Timestamp:	2020-01-01 23:59:59					
Meter Location:	Admin Block 1					
Area:	-					
Parameter	R-ph	Y-ph	B-ph	Average	Total	Unit
Power	0.42	0	0	-	0.42	kW
Power Factor	0.848	0	0	0.848	-	-
Apparent Power	0.495	0	0	-	0.495	kVA
Line Voltages	411.1	413.54	409.83	411.49	-	V
Phase Voltages	235.81	238.47	238.5	237.6	-	V
Line Currents	2.62	0	0	0.87		A
Frequency	50.08					Hz
Cumulative Energy	10809.6					kWH

Today's Meter 3 Total Energy Consumption





The prediction is provided as a special individual feature in a new page with filters provided to select the date and meter particularly to predict. The energy consumed on that day is filled in the blank text box present at the bottom after clicking the green color predict button. The values predicted are with an accuracy of 82%.

5. CONCLUSION

This project focuses on analyzing the data collected from the smart meters and visualizing the data in the form of real time graphs. It helps in detecting when the consumption exceeds what was expected. This project also includes machine learning algorithms to predict future energy consumption. This project can be further extended in the following ways:

- Set up alarms when the consumption deviates from the standard consumption.
- To generate heat maps based on the energy consumption.

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