Predictive, Corrective actions of Energy management and benefits through Data Analytics with Intelligent Reporting

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Abstract- This paper presents the software model of energy management adapting standard ISO 50001 and the upgraded version of its model with several improvisations to the same. The application of the sustainable energy management system helps to increase the efficiency in energy management aims at reducing production of energy costs and improving efficiency of acquiring energy parameters from the Energy meters. The paper also analyzes the efficient implementation of energy management with dynamic reporting facility for the required Energy parameters like the Energy consumption ,current ,voltage and many more comparisons involving cost calculation , relative energy utilization and trend prediction. The Energy parameter values are efficiently stored in the Database with priority scheduling of highest polled quantum value .The paper also discusses the advantage and disadvantage of implementing ISO 50001. Survey results and use cases show the suitability that the model can be deployed immediately and also propose a roadmap of implementing the same with cloud server storage.

Keywords- ISO50001, Modbus, Energy Management, sense and store, dynamic reporting.

Energy conservation refers to reducing energy consumption through using less of an energy service. Energy Management and conservation plays a prime role in the modern world of Globalization. Optimization and Management of energy consumption is critical considering economic and ecological implications. Detailed analytics involving trend prediction are applied and a visualization engine renders graphs and alerts through the visualization feature of the software. By quantitatively and qualitatively assimilating energy consumption behavior, not only are device-level optimization techniques proposed, but rather an intuitive way to consciously and judiciously consume energy is implied. Some of the ISO 500001 standards are also applied.

Energy Engineering – The Need of the Hour

It is predicted that Global energy needs are set to increase 40% by 2030. This would bring in immense pressure on utilization of existing resources and thus prices. Energy management systems are becoming very critical in today's context due to increased consumption and decreased resource availability. The IOT Cloud (BIC) service provides a tailor made and effortless platform for seamless integration of physical node data into the internet. For instance, a day to day display of per capita energy usage could go a long way in creating awareness that a single watt saved multiplied by a lot of people can end up saving a lot of kilowatts of energy. **Sustainable architecture** minimizes the negative environmental impact of buildings by efficiency and moderation in the use of materials, energy, and development space[1]. Energy Management Systems (EMnS) are integrated, computerized systems for monitoring and controlling energy-related building services. Small buildings may have independent controls for energy systems, but for larger or more complex buildings, sites with a number of buildings, or organizations with buildings on a number of sites, the integration of systems operation through a single Building Energy Management System offers greater control and can achieve significant savings [8]. Increasingly, simple EMnS is being developed that are suitable for even the smallest buildings.

II. EASE OF USE

The purpose of this paper is to establish a standard method for monitoring and reporting on the Energy performance of commercial buildings. It determines the energy consumption, electrical Energy demand, and on-site energy production in existing commercial buildings of all types. It mainly provides a software perspective for improving efficiency of Energy management in commercial buildings. To provide this ISO 50001 standards are followed. Also, a comparative study on Energy parameters with and without following the standard has been done.

III. GOALS OF ANALYSIS.

1. To design and implement an embedded system for energy consumption monitoring and control at commercial buildings.

2. The solution has currently been deployed to monitor the complete campus, providing valuable information with visualization and analysis to the facilities team.

3. Energy Management mainly includes the following stages,

- Data Acquisition
- Data Processing
- Data Analytics
- Data Visualization
- Control/feedback/Optimization

4. The project aims to design and implement an embedded system for energy consumption monitoring and control at any commercial building.

5. The solution has currently been deployed to monitor the complete campus, providing valuable information with visualization and analysis to the facilities team.

A comparative study on Energy metrics with and without ISO standards is done and few of the Energy parameters are compared and analyzed. Also, big data analytics and web services might be used to improve the efficiency of data storage that is Energy data can be stored on priority basis (highest polled meter or the main meter) on the cloud storage space.

IV. LITERATURE REVIEW

The Energy Management Solution (EMnS) helps answer these vital questions in both qualitative and quantitative manner providing vital data points for the end user and enabling him take decisions that make energy management more efficient EMnS aims to build a technological platform for energy management in buildings, offices and commercial spaces.

The ongoing revolution of everyday objects wirelessly connected to the network, called the Internet of Things (IoT), is creating interesting and unexpected opportunities in reducing energy consumption and improving environmental comfort in buildings.

A. What is ISO50001?

ISO50001 is a standard designed to manage energy across the entire international commercial sector, affecting energy use, which can be monitored and influenced by an organization. The purpose of ISO50001 Energy Management System (EMnS) standard is to enable organizations to establish the systems and processes necessary to improve energy performance, including energy efficiency, use and consumption[2]. The implementation model also applies Plan-Do- Check-Act (PDCA) cycle which consists of five clauses i.e. Energy Policy, Planning, Implementation, Monitoring and Corrective Action and Management Review [9].

B. Why ISO50001?

An ISO50001 energy management system (EMnS) is applicable to all the activities under the organizational control. This would enable organization to achieve its policy commitments, take action as needed to improve its energy performance and demonstrate the conformity of the system to the requirements of the International Standard [2]. It is also an instrument to quantify the energy use and consumption, and to plan energy efficient practices by fine tuning the operational controls and organizational behavior. Optimal energy performance should be achieved using existing resources, with minimum or low cost investment, through the housekeeping efforts prior to suggesting improvement that require financial investments [3].

C. Challenges in ISO50001 implementation

Despite valuable benefits, achieving and sustaining the EMnS and energy efficiency are challenging for organizations. Survey mainly records three major challenges i.e. lack of management commitment [2], lack of communication and understanding at all levels [10], and design error due to not prioritizing energy efficiency during the design stage [8]. In addition to these, particularly in Asia, lack of financial support and lack of policies by the government are also barriers that need to be tackled [1]. Therefore, for the organizations to enjoy the benefits of EMnS implementation, it is essential to overcome these challenges.

D. Challenges faced in EMS implementation

The Energy meters are generally functional. Sometimes, the values can become null or zero as they might become non-functional or reached threshold values .So, measures have to be taken to handle these exceptions both in database storage and software development. Despite many available connecting techniques, serial communication is used and therefore there is deferred calculation of Energy parameters even though it is addressed as current data .This depends on the logging interval.

V. METHODOLOGY

Metric Definitions.

Functional Area: is measured as the Gross Interior Floor Area of all spaces that have energy use included in the Building Energy Use metric. This may include the whole building, or it may be divided into separate areas with different functions such as office, mercantile, lodging, and parking [5].

- Building Electrical Demand (kW or kVA): Peak electrical demand of the electrical building Energy Use during the month.
- Building Electrical Demand Intensity (kW/ft2, kW/m2, kVA/ft2, or kVA/m2)= Building Electrical Demand ÷ Functional Area
- Building Energy Use Intensity (BEUI)(kWh/ft2 kWh/m2, Btu/ft2, or Joules/m2)= Building Energy Use ÷ Functional Area
- Building Lighting Energy Use(kWh, Btu, or Joules)= Installed Lighting Energy Use + Plug-in Lighting Energy Use + Facade Lighting Energy Use Reported as: Monthly totals (tabular), monthly daily averages (graphical), annual total, graph of peak day in each billing period .
- Building Purchased Energy Cost Intensity(CurrencyYear/ft2 or CurrencyYear/m2) = Building Purchased Energy Cost ÷ Functional Area Reported as: annual value

For cost, calculations the energy utilization is multiplied with the unit rates separately for Peak hour, Industrial hour and Night hour with the respective unit rates depending on the requirement ,that is , hourly, per day, per week ,per month and annually.

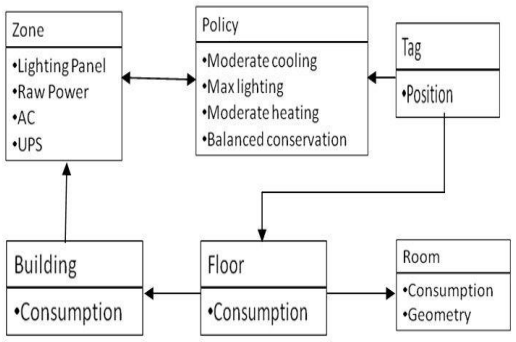

Fig1.Building model in UML

VI. SYSTEM ARCHITECTURE .

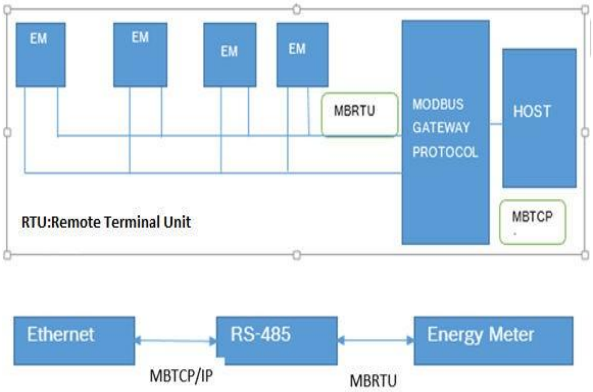

Fig 2. System architecture

This study uses the data collected from Energy meters as input to the software. Energy meters are connected using MOBBUS RTU to the Modbus gateway protocol. This gateway is connected to host by MBTCP[10]. It is connected in round robin fashion with a given time quantum to fetch Energy data from each Energy meter. The highest value read along with all other values of Energy parameters is recorded and for the second round, the highest valued meter is polled with priority. So, small modification is made to round robin with priority scheduling of Energy meter polling pattern.

Dynamic reporting feature is also developed where costs, energy utilization details with respect to each meter and zones is available .The reports are created on selecting the required date and can be viewed either in the Report Viewer or as PDF. It also includes the implementation of ISO50001 EMnS as described in the –Introduction‖ section. Deviation from standard value is calculated for ISO implementation .To evident the implementation activities, the communications, analysis and results were recorded in EMnS tool. The EMnS Tool is an Excel workbook sending and storing data to database via TCP/IP port and also on cloud with SAAS service and storage service provided by AWS or an IoT private cloud provided by the company or customer.

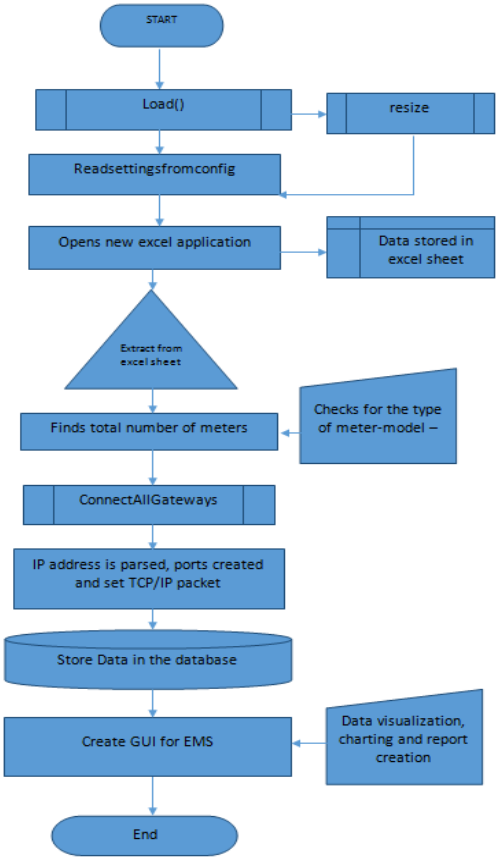

Fig 3. Flow of work

The data acquisition process begins with reading settings from the configuration file which has the list of IP addresses of Energy meters that are treated as hosts. Also Device ID‘s are assigned to each Host .Once all meters are read with the meter model , all gateways are connected , here the MODBUS gateway protocol is used .IP address are parsed and data is parsed and formatted accordingly . TCP/IP packets are used for sending and receiving through the TCP/IP layer of Network .The data is formatted with respect to the type of Networking Model followed and stored in the database. This data is used for visualization and analysis. Also, reporting with ISO 50001 standards is adapted to increase efficiency of energy utilization. Modbus TCP/IP and Modbus RTU are used for communication between Energy Meters and Modbus Gateway Protocol and the same and Host systems respectively. Results of the EMnS implementation are shown in the next section.

VIII. RESULTS

Results mainly include the visualization and reporting of Energy parameters.

WORK FLOW

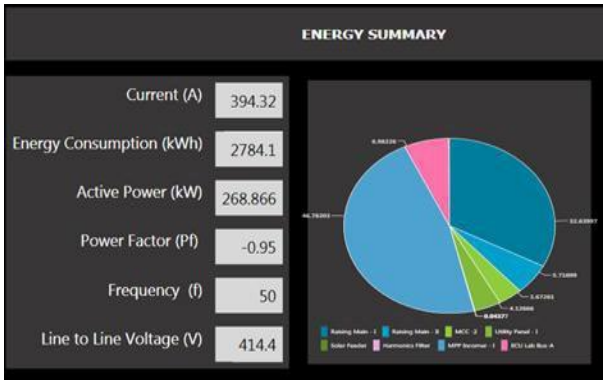

Fig 4. part of Dashboard representing energy params

The above graph represents the Lighting Panel Zonal division. It displays the meters included in the Lighting Panel zone and few of the Energy parameters like Current, Energy Consumption, Active power, Power factor, Frequency, Line to Line voltage around 10 am from 12.01 a.m.

TABLE 1. COST TABLE

	Energy Meters	Cost
Cost Previous Day	Vital Loads	73334
	Main Incomer Load	159461
Cost Previous Week	Vital Loads	928731
	Main Incomer Load	1279468
Cost per month till date	Vital Loads	1126768
	Main Incomer Load	2199151

The table shows the cost comparisons of the vital loads and the main incomer load with data analyzed per day, per week and month. Also, the required date can be selected from the calendar option and the particular day‘s Energy consumption and other parameters can be retrieved.

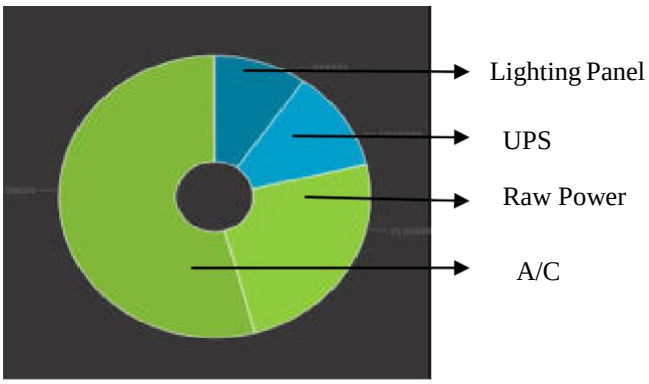

Fig 5. Zonal distribution

Pie chart shows the zonal energy distribution between
1) Lighting Panel.2)UPS3).Raw Power 4).A/C

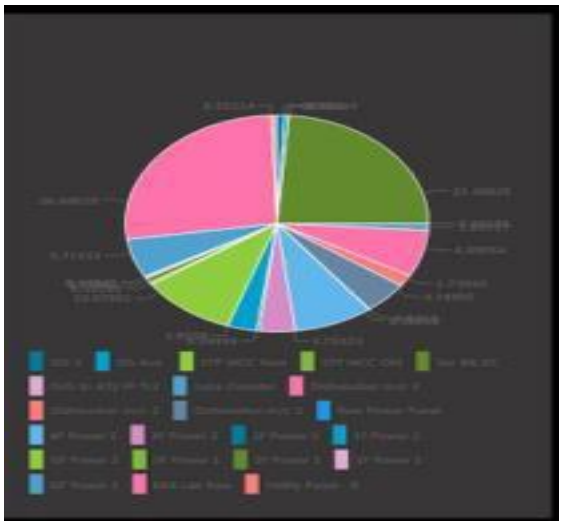

Fig 6. Chart depicting various meters in Zones

The pie chart shows the Energy Meters per zone and also the Energy consumption value .Here Energy meters grouped under Raw Power is shown which includes many meters like MCC mains, 2F Power and many more.

Fig 7.Emoticon

Emoticons are to be added to measure relative energy consumption- the energy consumption value is compared to the previous day‘s value at the given time .If the current days‘ consumptions is less than the previous one , then it is indicated by green color else red .
Green smiley indicating efficient utilization of Energy.

A. Advantages of the proposed approach

- EMS is intended to provide organizations with a recognized framework for integrating energy performance into their management practices.
- Multinational organizations will have access to a single, harmonized standard for implementation across the organization with a consistent methodology for identifying and implementing improvements.
- Cost estimation
- Outlier frequency analysis.
- Design of Algorithms for Data Analytics and Optimization
- Data can be better analyzed and trend predictions and further improvements can be performed.
- Dynamic reporting is added for analyzing making the Energy data readable.
- A Dashboard is to be generated with the display of Energy parameters. The dashboard should also

include the Graphical Representation of Energy parameters described.

The real-time visualization and notification system has empowered the facilities team to monitor and optimize energy at the campus. The little savings gained are first steps towards a greater milestone for the planet.

CONCLUSION

In this paper, an optimized method for classification of building energy-consumption data has been proposed. First, the features of the daily energy-consumption profiles are extracted by using MODBUS protocol connected serially. Data analysis and data visualization techniques have been used to extract information in a customer adaptable manner. Trend analysis is done based on historical data. As a result, abnormal energy consumption can be identified in real time, enabling building managers to investigate and correct problems as they occur. Also, dynamic reporting feature is made available where current data can be represented and analyzed for further improvisation of data acquisition techniques.ISO 50001 standards have been followed and also a comparative study with and without In this system, the procedure followed are computationally efficient and robust, therefore, can feasibly be integrated into existing building energy management systems. Further work will aim to build on this classification technique to provide additional tools for automated analysis of metered building and optimizing the storage capacity.

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