ETEC 43018 – Capstone project report

INDUSTRIAL ENERGY MONITORING SYSTEM

Baddegama Ayesh Ravindu Isuranga

Prepared under the Supervision of

Mr. Thisara Pathirana

Submitted in [partial] fulfilment of the requirements for the
Bachelor of Engineering Technology Honours degree.

Department of Applied Computing
Faculty of Computing and Technology
University of Kelaniya

[2023]

Acknowledgements

I would like to express my sincere appreciation and gratitude to all those who have helped me throughout the journey of successfully accomplishing this thesis. Their supervision, encouragement and assistance have been invaluable in shaping this work.

foremost, I am genuinely thankful to my academic supervisor Mr. Thisara Pathirana and industrial supervisor Mr. Dayan Marabadda, whose expertise, persistence and inspiration aided me pass through the complications of the research process.

I extend my sincere gratitude to the faculty members of the department of engineering technology and department head Dr. Laalitha Liyanage for their invaluable teachings that inspired the foundation for my educational growth and inspired my passion for this subject.

Also, I would pressure to my thankfulness to faculty of computing and technology to give me the advice, give me the subject materials and valuable knowledge.

I would like to express my gratefulness to my family and my friends for their steady confidence in me. Their constant support and understanding delivered me with the inspiration to overcome challenges and strive for excellence in this Endeavor.

Lastly, I acknowledge the monetary support and give the space to conduct the project provided by Hemans Manufacturing, Dankotuwa premises. That permitted me to concentrate on my project without any financial liability.

Declaration

The work contained in this thesis is the result of my own work and has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: _________

Date: ______203/08/17___________________

Signatures of the Supervisors (To be filled by the academic and industrial supervisors of the project)

This thesis was submitted to us for approval on

Date of Submission:

1. Name: ,
   Faculty of Computing and Technology, University of Kelaniya, Sri Lanka

   Date: ______2023/08/18______________ Signature: __ ___________

2. Name: Imal Disnaka
   Hamas manufacturing, Dankotuwa

   Date: _______2023/08/19_____________ Signature: ______ _______

Abstract

Energy is strength that is required to sustain physical or mental activities. Energy is playing a major role in industrial operation. Energy monitoring system used to determine and monitor active energy value. The purpose of the report is to provide a pepper energy monitoring system that is suitable for existing architecture and procedures.

If the large scale of corporation has not any computerized tool, the firm could not analyse the value manually. If the factory is large, it should be more tedious, prone to occur mistakes and hard to analyse the values. This is a system that overcomes these issues and provides the best analytical techniques.

The outcomes of the project show the energy values at the point of required time and cost for the energy that consumed by the either machine or section or plant or whole system. Another objective is that the system should be suitable for existing architecture and procedures.

The working principle of the project is this system has two major parts. Hardware part and software part. The hardware part consists of analysers and gateways and communication protocols. Electric analysers measure the power and energy associated with the machine or department. Also, it transfers values to gateway through Modbus protocols. Then, gateway converts Modbus data to MQTT data and uploads it to database. In the software part, there is a web-based application. There are m users in that application (Admin user, engineering user and viewer). Those users log in to the web application and the real time energy values, graphs and analyser management as well as change their user details. This is the working principle of the system.

This report provides deeply information about the project, functions, methodology of developing and implementation of electric energy management system. Furthermore, compressive analyses about how do affect this project affects sustainability, cost effectiveness and social impact.

Table of Contents

List of Tables

List of Figures

List of Acronyms/Abbreviations

ABB	:	Alen Bradley
AI	:	artificial intelligent
API	:	Application program interface
CEB	:	central electricity bord
CT	:	Current transistor
EMS	:	energy monitoring system
IEMS	:	Industrial energy monitoring system\
HTTPS	:	Hypertext text transfer protocols secure
IT	:	Information technology
IOT	:	Internet of things.
IIOT	:	industrial internet of thigs.
KPI	:	Key performance indicator
MQTT	:	Message query telemetry transport
POP3	:	post office protocol version 3
QA	:	quality assurance
UI	:	user Interface

Chapter 1: Introduction

In current’s rapid advancing ecosphere, manufacturing organizations cooperate a decisive role in powering lucrative growth and requiring the goods and services which sustain civilizations. Nevertheless, the unprecedented extension of manufacturing actions originates at an expenditure – an immense increase in energy consumption, steering to heightened environmental concerns and escalating operational expenses. The pressing requirement to statement these encounters has triggered significant concern in implementing. sustainable reliability and energy-efficient solutions within industrial operations.

This section outlines the background (section 1.1) and context (section 1.2) of the Industrial energy management system, and its purposes (section 1.3). Section 1.4 describes the significance and scope of this research and provides definitions of terms used. Finally, section 1.5 includes an outline of the remaining chapters of the thesis.

1.1 BACKGROUND

Industrial Energy Monitoring System (EMS), a technological evolutions that influence the implication of energy management. methods within industrial settings. IEMS represents a combination of hardware, software, and data analytics constructed to facilitate real-time, comprehensive, and granular monitoring of energy consumption models through industrial processes.

This application is proposed for Hemas Manufacturing Private Ltd. Because there isn't any system to measure electric energy and pneumatic energy consumption. Thus, they allocated a person who goes around the factory every time and collects the values and notes manually. It diverges to occur errors cost ineffectiveness and time-consuming activity.

The major impartial of this report is to explore a new energy monitoring system, features and working methodology of Industrial Energy Monitoring System, its ability to boost sustainability, enhance electric energy usage, operational efficiency in enterprises. By deriving the consumption, embedded functioning, and effect of EMS (Energy Monitoring system) in a vary upon facts of industrial situations and real word interruption.

This capstone project is intended to provide insights about how manufacturing industries can establish Their energy-related objectives while mitigating their ecological footprint and cost.

.

1.2 CONTEXT

Hemas Manufacturing is one of the leading companies in the consumer good industry. But they have not any tool to measure Electric energy of the plan. Because of that, the person who visits around the firm notes the energy value in a paper. This procedure is more tedious and leads to human mistakes and errors due to the large number of points that need to be noted.

When considering the global situation, the accelerating universal proposition of energy demand, corresponding with expanding environmental consciousness and has industries to reevaluate energy usage approaches. This consciousness has been prone to a change in shifts, inducing organizations to practice new approaches to display, control and manage, and preserve energy efficiently. For change and introduce new practices, needed a proper energy monitoring approach.

In depth information is mentioned in the methodology section of the report.

1.3 PURPOSES

The proposed Industrial energy monitoring system provides more information about energy usage, cost, and graphical visuals about. This energy monitoring system's primary aim is tracking energy consumption of the firm that supposed to establish this system. The main objectives of this project are as follows:

a) build proper communication methods between devices.
b) monitor energy usage of the defined location.
c) To evaluate the impact of IEMS on energy efficiency, cost savings, and environmental sustainability within industrial settings.
d) Update the data to database
e) View data via reliable and attractive application

Via successful development of the proposed industrial energy monitoring system (IEMS) can solve the problem mentioned in above section.

.

1.4 SIGNIFICANCE, SCOPE, AND DEFINITIONS

IEMS helps firms to gather real time data about energy usage patterns, identify sections that have ineffectiveness and develop data schemes to control waste and costs. With the capacity to improve energy systems and relieve carbon (C) discharges, the successful implementation of EMS can significantly contribute to achieving sustainability targets outlined in global climate agreements.

This research paper employs a mixed-method approach, combining both qualitative and quantitative analyses. Data will be collected\ through literature reviews, case studies and statistical analysis of energy expenditure patterns in Hemas manufacturing setups.

1.5 THESIS OUTLINE

Outline The subsequent sections of this thesis are structured as follows:

- Chapter 2 provides an in-depth review of the relevant literature concerning industrial energy management, energy monitoring technologies, and the theoretical foundations of the Industrial Energy Monitoring System.
- Chapter 3 outlines the methodology employed in this research, elucidating the data collection process and analytical techniques used to evaluate the effectiveness of IEMS.
- Chapter 4 analyses the data obtained, discussing the impact of IEMS on energy efficiency, cost savings, and sustainability in industrial environments.
- Chapter 6 conclusion about the system and future steps and functions of EMS

This report provides details about literature review, protocols, functions, methodologies, and results of developed energy monitoring system.

Chapter 2: Market and Literature Survey

EMS (Energy monitoring system) plays a beneficial role among Internet of thigs (IIOT) applications when considering with cost effectiveness. Hence there are some existing systems that do same kind of activities. This literature review is to explore the existing application related to Industrial Energy monitoring system (EMS), their drawback and research gap as well as effect of energy, cost efficiency and sustainability in industrial segment. By, analyzing a reviewed publication, this review pursues in key technologies, methodologies functions, effective factors when implementing, of EMS in improving energy usage, mitigate operational budgets, in modern manufacturing accommodations. This literature review basically done on General integrative reviews, Specific books, monographs, bulletins, reports, and research articles.

2.1 SMART ENERGY MANAGEMENT FOR INDUSTRIAL IOT [1]

This is a review about Smart Energy Management (SEM) for Industrial IoT which supposes a review of electric energy management methods in effective manner IIOT (Industrial Internet of Things) applications. this research done by Jhon smith, and it emphasizes the consequence of real-time energy monitoring and control in optimizing industrialized operations. The research gap is that this research used a low bandwidth methodology to acquire values and values will collect in the considerable time intervals that encounter problems with a bandwidth of the network. That divergence for producing blank, incomplete value or invalid information.

The project gap between Smart energy management and proposed energy management system is SEM is trend to misplaced data because of issue in communication technique and it suitable for one brand the electric analyser. But IEMS has greatly accepted any brand of electric meters. The only requirement is there should be data out pins in analysers.

2.2 ADVANCES IN INDUSTRIAL ELECTRIC ENERGY MONITORING SYSTEMSInvalid source specified.

This is a research paper that analysed different existing electric energy monitoring systems. This Advances in Industrial Electric Energy Monitoring Systems report researched technologies, advantages, disadvantages, functions, and effect on power efficiency. By referring to this paper can be able to get an idea about existing systems and their capabilities. Through this research paper, there is not any product or system that was developed.

The project gap with Advances in Industrial Electric Energy Monitoring Systems, this thesis provides a product that can easily establish anywhere that requires monitoring the energy.

2.3 ENERGYLY [2]

This is a system that can monitor energy that allows us to control and monitor the consumption. It can visualize energy usage and monitor value real-time. Also, they provide mobile app and web-based system. This system is developed for general usage and could not be able to customize.

The project gap of the software is to communicate it need special device and comfortable with only one type of analysers. But this supposes system does not require any of specific device. That means it does not depend on any equipment.

2.4 CHALLENGES IN IMPLEMENTING ELECTRIC ENERGY MONITORING SYSTEMS IN LARGE-SCALE INDUSTRIES [3]

This is research done by Mr. William Adams and Mr. Sarah Clark. This paper describes the challenges encountered throughout the implementation of electric industrial energy monitoring systems in large, scaled firms. It addresses problems related to data integration and scalability as well as cybersecurity with Industrial 4.0. In addition, the research suggested some techniques for mitigate or preventing the issue encounters when establish a system.

2.5 ENERGY MANAGEMENT STRATEGIES FOR DEMAND-SIDE MANAGEMENT IN MANUFACTURING PLANTS [4]

This report describes Energy Management Strategies in Manufacturing Plants, and this is the project that mostly closer to supposed IEMS. That investigate and observes decision based on energy management methodologies in manufacturing firm. Furthermore, the paper investigated potential parameters for load shifting, peak shaving and reducing electric cost.

2.6 INDUSTRIAL ENERGY MONITORING SYSTEM -ABB [5]

This system is developed by ABB corporation for analyse and calculate efficiencies and C(Carbon) emission. It produces reports for cost, consumption, and benchmarks. This system can monitor energy value from Alen Bradly equipment via Modbus.
The project gap is that this ABB software depends upon the brand of equipment. But the suggested system does not depend on the type of equipment.

2.7 RENEWABLE ENERGY INTEGRATION IN INDUSTRIAL FACILITIES [6]

This article researches the issues and solutions for usage renewable energy sources monitoring (Solar energy monitoring) on factory. The article considers the advantages and restrictions of renewable energy monitoring and integration. Furthermore, presents the factors and solutions for integrating renewable energy monitoring sources in factory.

2.8 IOT-BASED MONITORING AND CONTROL OF INDUSTRIAL ELECTRIC ENERGY CONSUMPTION [7]

This is a project report that explains the project on IOT based industrial energy monitoring system. This program can be able to control and monitor machinery parameters whet it reach limiting value. Specialty of this system is real-time insight generation capability and report controlling capability.

2.10 GE GRID SOLUTION [8]

This is an IEMS that can highly customizable, end to end encryption management and analyse financial status. Also, it can provide energy monitoring, reporting, and analysing facilities. The project gap is the proposed system simple design and low complexity. Also, the proposed system used reliable protocol.

2.11 ENERGY BENCHMARKING FOR INDUSTRIAL PLANTS [9]

Through study shared information on energy sampling techniques used for energy monitoring and management application. Moreover, monitors how sample values help to recognize electric energy inefficiency and other problems and mitigate the effect via continues improvements after the establishment procedure.

2.12 WIRELESS SENSOR NETWORKS FOR INDUSTRIAL ELECTRIC ENERGY MONITORING [10]

In this report discuss about the application of sensor network for industrial environment.it explore the beneficiary's wireless communication for remote monitoring. Also, explores wireless communication technique use for "wireless sensor network for industrial energy monitoring" report.

2.13 CHALLENGES AND SOLUTIONS IN DATA SECURITY FOR INDUSTRIAL ENERGY MONITORING SYSTEMS [11]

Challenges and Solutions in Data Security for Industrial Energy Monitoring Systems is a research paper that was done by Emma Roberts and Michael Lee. the report addresses the challenges and solutions related to data security in industrial energy monitoring systems. Furthermore, the paper discusses encryption methods, authentication algorithm and secure communication protocols.

2.14 POWER MONITORING AND ENERGY MONITORING SYSTEM [12]

Power monitoring and energy monitoring system is a kind of software base application that can measure power and energy and Schneider devices. This is specially designed for Schneider base systems.

2.15 SUMMARY AND IMPLICATIONS

The following table provides a summary of the literature review and other systems that did not mention in above section.

Publication Name	**Description**	**Features**	**Limitations**	**Project gap**
Smart Energy Management for Industrial IoT	Overview of intelligent energy management for IIoT applications	Real-time energy monitoring and control	Limited to IIoT applications	IEMS has greatly accepted any brand of electric meters. The only requirement is there should be data out pins in analyzers.
Advances in Industrial Electric Energy Monitoring	Comparative study of different electric energy monitoring systems	Analysis of pros and cons of monitoring technologies	Limited to monitoring systems in industrial settings	can easily establish anywhere that requires monitoring the energy.
Data Analytics for Energy Optimization in Industrial	Focus on data analytics approaches for energy optimization in industrial facilities	Use of machine learning algorithms for energy optimization	Limited scope to data analytics in energy management	This is only analysis. But proposed IEMS provide analysis as well as the total system (Hardware and software)
Challenges in Implementing Electric Energy Monitoring	Examination of challenges faced during implementation of electric energy monitoring	systems in large-scale industries	Addressing issues of data integration and scalability	Dedicated challenges for the system not a complete application

Publication Name	**Description**	**Features**	**Limitations**	**Project gap**
Real-Time Monitoring of Power Quality in Industrial...	Importance of real-time power quality monitoring in industrial networks	Continuous monitoring for smooth operations	Limited to power quality monitoring in industrial	can easily establish anywhere that requires monitoring the energy. Does not required any specific devices.
Energy Management Strategies for Demand-Side Management	Study on energy management strategies for demand-side management in manufacturing plants	Implementation of load shifting and peak shaving strategies	demand-side management in manufacturing plants	Dedicated strategies for the system not a complete application
Renewable Energy Integration in Industrial Facilities	Investigation of challenges and solutions for integrating renewable energy sources into industrial facilities	Benefits and limitations of renewable energy integration	Limited to renewable energy integration in industrial settings	Can be used only for renewable source. But the proposed system can apply for all energy sources.
IoT-Based Monitoring and Control of Industrial Electric	Exploration of IoT for monitoring and controlling electric energy consumption in industrial settings	Potential for real-time insights and remote control	Limited to IoT-based monitoring and control	Undependability with brand of equipment.
Energy Benchmarking for Industrial Plants	Presentation of energy benchmarking methodologies for industrial plants	Application of benchmarking to identify energy inefficiencies.	Limited to energy benchmarking in industrial plants	can easily establish anywhere that requires monitoring the energy.

Publication Name	Description	Features	Limitations	Project gap
Sustainable Energy Management in Data Canters	Focus on sustainable energy management in data canters.	Proposal for dynamic power allocation strategy	Limited to energy management in data canters	Can be used only for renewable source. But the proposed system can apply for all energy sources.
Wireless Sensor Networks for Industrial Electric Energy	Discussion on wireless sensor networks for electric energy monitoring in industrial environments	wireless communication for remote monitoring	Limited to wireless sensor networks in industrial environments	Does not require any extra sensor. Suitable for industrial operation
energy	Can be determine energy, power and cost for manufacturing cell or machine	Wired energy measurement	same type or brand can be connected to the system	Undependability with device type and brand
Allen Bradley system	Use to measure power between ABB devices	Measure running time, power, and energy	Can be used only for ABB devices.	Undependability with device type and brand.
Siemens system	Use to measure power between ABB devices	Measure running time, power and energy. Can show insight using visuals, graphs.	Can be used only for ABB devices.	Undependability with device type and brand.

Publication Name	Description	Features	Limitations	Project gap
Schinder IEMS	Use to measure power between ABB devices	Measure running time, power, energy	Can be used only for ABB devices.	Undependability with device type and brand. Show data with visual insights and analyse data

Table 1 : project gap

2.16 PROJECT NOVELTY

EMS (Energy monitoring system) plays a beneficial role among Internet of thigs (IIOT) applications when considering with cost effectiveness. Hence there are some existing systems that do same kind of activities. This literature review is to explore the existing application related to Industrial Energy monitoring system (EMS), their drawback and research gap as well as effect of energy, cost efficiency and sustainability in industrial segment. By, analysing a reviewed publication, this review pursues in key technologies, methodologies functions, effective factors when implementing, of EMS in improving energy usage, mitigate operational budgets, in modern manufacturing accommodations.
All above systems have unique features and drawbacks. There are several unique features in proposed electric energy monitoring system. Thise are,

- Undependability upon device types and brands
- Can be substitute for existing architecture.
- IOT platform
- More attractive simple and user-friendly user interface etc.

Above description mention about difference between existing system and proposed system in terms of technology, cost, and function. Based on the analysis, can figure out the supposed application provides more innovative solution in sufficient, necessary, and effective methodology.

Chapter 3: Methodology

Energy is the most valuable tool in the words. energy may be electric, pneumatic, or hydroid. Energy catastrophe and the universal movement to achieve green objectives. Through this methodology part, show how objective of the research achieve structured methodology is adopted for the development and evaluation of IEMS. The below steps followed to complete the project in a more sufficient and effective manner.

1. Analize and verify the problem.
2. Research
3. Draw related diagrams.
4. Finalized list the required equipment.
5. Create database and UI (User interface).
6. Connect one analyzer.
7. Write a program for it.
8. Expand the technique for one panel.
9. Test
10. Implement

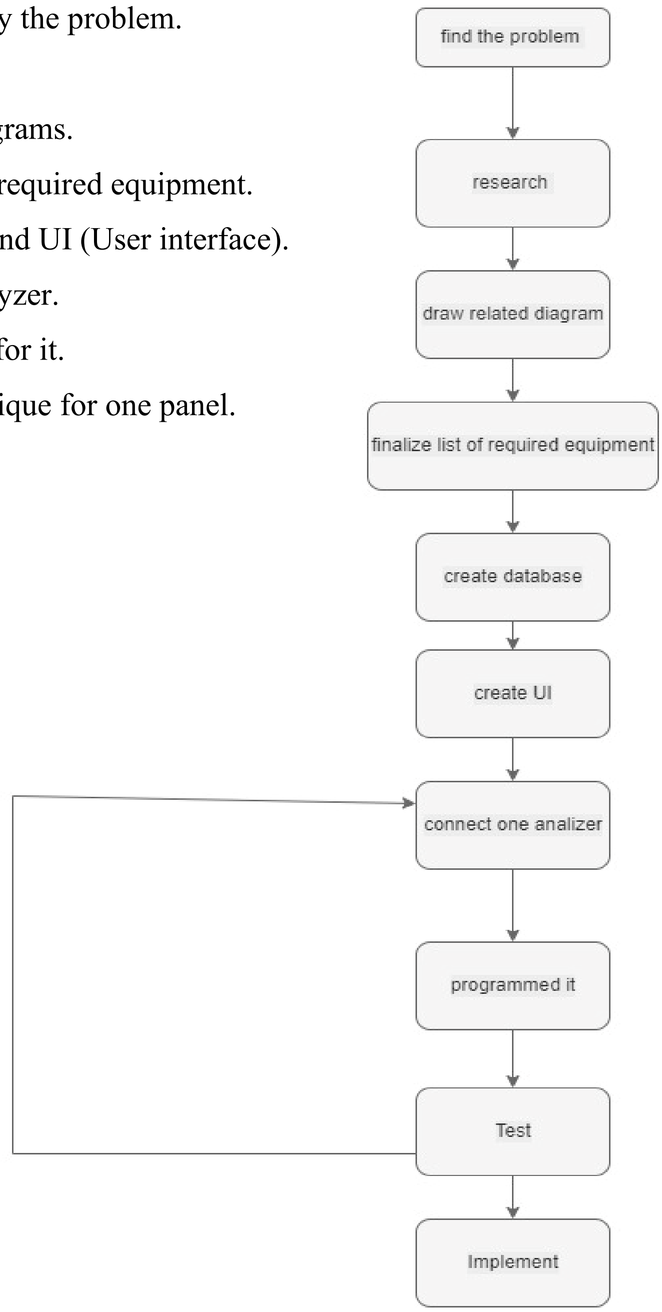


Figure 1 development flow diagram

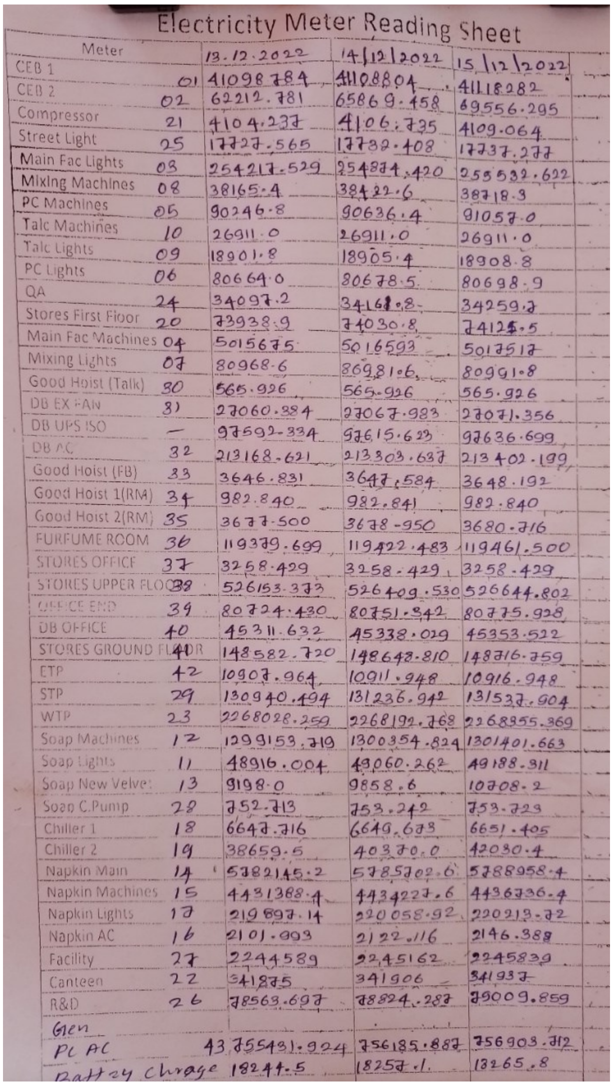
This chapter describes the design adopted by this research to achieve the aims and objectives stated in section 1.3 of Chapter 1 [if you wish, you can restate those objectives]. Section 3.1 discusses the methodology [to be] used in the study, the stages by which the methodology was [will be] implemented, and the research design; section 0 details the participants in the study; section 3.2 lists all the instruments [to be] used in the study and justifies their use; section 3.3 outlines the procedure [to be] used and the timeline for completion of each stage of the study; section 3.4 discusses how the data was [will be] analysed; finally, section 3.5 discusses the ethical considerations of the research and its [potential] problems and limitations.

3.1 METHODOLOGY AND RESEARCH DESIGN

3.1.1 Methodology

In this section, analysed the problem that the system are solving, verified the problems actually happened in real world scenarios, find the root cause for the issue and can it solve in more innovative, sufficient, reliable and successful through the proposed system.

This IEMS system was implemented to Hemas manufacturing private ltd. At Hemas premises, there is not any tool to measure energy. Hence, there are some people how go everywhere and note energy consumption manually. Manual system is shown in figure 2. Then it enters the google sheet.



Electricity Meter Reading Sheet

Meter		13.12.2022	14/12/2022	15/12/2022
CEB 1	01	41098784	41108804	41118282
CEB 2	02	62212.781	65869.458	69556.295
Compressor	21	4104.237	4106.735	4109.064
Street Light	25	17727.565	17732.408	17737.277
Main Fac Lights	03	254217.529	254874.420	255532.622
Mixing Machines	08	38165.4	38422.6	38718.3
PC Machines	05	90246.8	90636.4	91057.0
Talc Machines	10	26911.0	26911.0	26911.0
Talc Lights	09	18901.8	18905.4	18908.8
PC Lights	06	80664.0	80678.5	80698.9
QA	24	34097.2	34168.8	34259.7
Stores First Floor	20	73938.9	74030.8	74125.5
Main Fac Machines	04	5015675	5016593	5017517
Mixing Lights	07	80968.6	80981.6	80991.8
Good Hoist (Talk)	30	565.926	565.926	565.926
DB EX FAN	31	27060.384	27067.983	27071.356
DB UPS ISO	—	97592.334	97615.623	97636.699
DB AC	32	213168.621	213303.637	213402.199
Good Hoist (FB)	33	3646.831	3647.584	3648.192
Good Hoist 1(RM)	34	982.840	982.841	982.840
Good Hoist 2(RM)	35	3677.500	3678.950	3680.716
FURFUME ROOM	36	119379.699	119422.483	119461.500
STORES OFFICE	37	3258.429	3258.429	3258.429
STORES UPPER FLOOR	38	526153.373	526409.530	526644.802
OFFICE END	39	80724.430	80751.342	80775.928
DB OFFICE	40	45311.632	45338.029	45353.522
STORES GROUND FLOOR	41	148582.720	148648.810	148716.759
ETP	42	10907.964	10911.948	10916.948
STP	29	130940.494	131236.942	131537.904
WTP	23	2268028.259	2268192.768	2268355.369
Soap Machines	12	1299153.719	1300354.824	1301401.663
Soap Lights	11	48916.004	49060.262	49188.311
Soap New Velve:	13	9198.0	9858.6	10708.2
Soap C.Pump	28	752.713	753.242	753.729
Chiller 1	18	6647.716	6649.673	6651.405
Chiller 2	19	38659.5	40370.0	42030.4
Napkin Main	14	5782145.2	5785702.6	5788958.4
Napkin Machines	15	4431388.4	4434227.6	4436736.4
Napkin Lights	17	219897.14	220058.92	220213.72
Napkin AC	16	2101.993	2122.116	2146.388
Facility	27	2244589	2245162	2245839
Canteen	22	341875	341906	341937
R&D	26	78563.697	78824.287	79009.859
Gen				
PC AC	43	755431.924	756185.887	756903.712
Battry Chrage		18244.5	18257.1.	18265.8

Figure 2 : manual system

That methodology diverges to make errors, time wasting as well as more tedious activity. The difference between calculated value and CEB (Central electricity bord) value was 15621 units. Hence, I suggest this IEMS (Industrial energy monitoring system).

Based on those problem mansions above, there are some problems encountered indirectly because of the inefficient parking system. There are,

- Environment impact

Because unpropped and unmanaged procedures could not make a sense in energy saving manners. Hence, they cannot manage the consumption of the firm. The considerable proportion of Energy is generally generated from the procedure of burning process. During the generation procedure of energy in an apparatus, it also produces carbon dioxide, carbon monoxide and other green gases. As a result of that, the proper system produced a negative impact on the environment.

- Performance

  Errors of the measurement system reduce the performance as well as efficiency in industrial operation.

Above analysis proof that there are problems to solve. The root cause is that there is not any proper methodology to measure power and energy. By establishing a proper system, the problem can be solved easily. Hence, suggested to develop an energy monitoring system that having a capability of using it in industry.

3.1.2 Research Design

Firstly, identify existing systems and those mentioned in Chapter 2. In here, consist of information about internal research in the factory premises. There are 37 access points at Hems Manufacturing Dankotuwa premises. Those are shown in the following table.

access point number	Name of access point
1	CEB 1
2	CEB2
3	DB AC
4	main fact light
5	main fc machine
6	office end
7	PC Light
8	PC Machine
9	Stores first floor
10	UPS
11	good Hoist (FC)
12	good Hoist 1 (RM)
13	good Hoist 2 (RM)
14	chiller 2
15	AC
16	ETP
17	STP

18	soap new velvet
19	Facility
20	Soap machine
21	soap pump
22	WTP
23	chiller 1
24	Compressor
25	R&D
26	napkin AC
27	napkin Light
28	napkin machine
29	Mixing machine
30	DB office
31	perfume room
32	QA
33	Stores ground floor
34	Stores office
35	stores upper floor
36	talc light
37	Talc machine

Table 2 : list of access point

After identifying the access point, a table that consists of device information and is it suitable for digital energy monitoring system. nineteen analysers should be replaced for conducting this system. Because of those analysers did not have any communication protocol.

Name	code	gateway requirements	analyser requirement
CEB 1	**CVMC10**	1	0
CEB2	**CVMC10**	1	0
DB AC	**EM 1260**	0	0
main fact light	**EM 1260**	0	0
main fc machine	**EM 1260**	0	0
office end	**EM 1260**	0	0
PC Light	**EM 1260**	0	1

PC Machine	**EM 1260**	0	1
Stores first floor	**EM 1260**	0	0
UPS	**EM 1260**	1	0
good Hoist (FC)	**EM 1260**	0	0
good Hoist 1 (RM)	**EM 1260**	0	0
good Hoist 2 (RM)	**EM 1260**	0	0
chiller 2	**EM 306A**	1	1
AC	**EM1200**	1	0
ETP	**EM1200**	1	0
STP	**EM2100**	1	1
soap new velvet	**EM360A**	0	0
Facility	**MANUAL**	1	1
Soap machine	**PM 2100**	0	1
soap pump	**PM 2100**	0	0
WTP	**PM 2100**	0	0
chiller 1	**PM 2101**	0	0
Compressor	**PM2100**	1	0
R&D	**PM2100**	1	1
napkin AC	**PM710**	1	1
napkin Light	**PM710**	1	1
napkin machine	**PM710**	1	1
Mixing machine	**VIPS 84E**	1	1
DB office	**VIPS84E**	1	1
perfume room	**VIPS84E**	0	1
QA	**VIPS84E**	0	1
Stores ground floor	**VIPS84E**	0	1
Stores office	**VIPS84E**	0	1
stores upper floor	**VIPS84E**	0	1
talc light	**VIPS84E**	0	1
Talc machine	**VIPS84E**	0	1

Number of items	**38**	15	19

Table 3 analyser replacement

The EMS should use several protocols, topologies, and techniques. The following section expresses those technologies.

3.1.2.1 COMMUNICATION PROTOCOLS

The figures out what communication protocols which support by the analysers. Usually, analysers communicate in MODBUS. Hence the following protocols are used for this system.

- MODBUS
- MQTT
- POP3
- HTTPS

MODBUS

Modbus is a technique that is widely used for industrial automation and control systems. It develops in 1970 by Modion cooperation. This protocol operates on Master slave architecture. Master devices enable communication with salve devices.

There are two Modbus protocols available,

- Modbus RTU (remote terminal units)

  Modbus RTU uses serial communication topologies such as RS-232 and RS-485

- Modbus TCP (Transmission Control Protocol)

  Modbus TCP transfers data over the ethernet network via an IP address

This protocol is simple, flexible, and robust and makes it greater for various range of applications. Modbus has a function code. read and write data from or register addresses in the devices.

Function codes for Modbus include:

Read Holding Registers (Function Code 3)

Read Input Registers (Function Code 4)

Write Single Register (Function Code 6)

Write Multiple Registers (Function Code 16)

It's important to note that Modbus does not provide built-in security features, so it is crucial to implement additional security measures when using it in critical systems.

MQTT

MQTT (Message Queuing telemetry transport) is the protocol that is a very lightweight messaging protocol that designs for efficient and resalable communication between IOT (Internet Of Things) and other remote devices Or systems. It was developed in 1990 By IBM company. It is populated with the growth of IOT applications.
This protocol operates on a publish-subscribe architecture. the client device can publish a message to the broker and another client device can subscribe to a specific topic to receive the message. This model allows decoupling communication and making scalability.
There are three primary components in MQTT. Such as,

- Broker

  The broker is a central server that facilitates message distribution between clients. It received messages published by the client and forwards them to subscribe clients based on topic filters.
- Publisher

  The publisher is a client device that sends messages to brokers.
- Subscriber

  This is a client device that registers with a specific topic and receives the message sent by the publisher.

Generally, MQTT is a lightweight protocol that is achieved via small packet size and binary message format and makes for low bandwidth and High-legacy networks. Thus, MQTT supports Quality of service level (QoS), providing levels of message delivery guarantees.

- QoS 0: The message is delivered once or not at all (At Most Once)
- QoS 1: the message is delivered at least 1, generally leading to duplicate messages,
- QoS 2: the message is delivered extract once, ensure no duplicate messages.

POP3

Pop (post office protocol version 3) is a protocol deal with email retrieval protocol used to download messages from the mail server to the user's device. It works in a client-server architecture. The client is connected to the server, authenticates with credentials, and accesses the mailbox. Generally, email messages are downloaded and removed from the mailbox(server). That makes it unsuitable for multi-device synchronization.

HTTPS

HTTPS (Hypertext transfer protocol secure) is advance and secure version of the HTTP (Hypertext Transfer protocol) used to communicate over the internet. It offers secure as well as encrypted connection between web browser and web server. HTTPS protocol confirms the concealment and integrity of data exchanged during a browsing session. There are several features in HTTPS. Such as,

- Encryption

  HTTPS uses SSL/TLS (secure socket layer and transfer layer security) encryption to secure the information between web browser and server. This feature prevents unauthorized parties from intercepting and reading sensitive information.

- Authentication

  HTTPS offer digital proof to verify the identity of the sever. This process ensure that the user is connecting to unsafe web server.

- Data integrity

  HTTPS guarantee for data by encryption algorithms that identify any of modification during data transmitting.

- Green padlock

  This is visually show whether user in secure on unsecure web site.

- SEO benefits

3.2.1.2 WORKING PRINCIPLE OF ANALYSER

Electric analyser, also known as electric meter, is device that is used to measure electrical parameters in industries. That supports engineers, technicians and electricians and top management for understand behaviours and performance of the entire system. The working principle depend upon according to the type of measurement and measuring methodology. For this application used Schinder easy logic analyser. The importance of this IEMS, undependability of analyser type and brand. This system can apply all kind of analysers that having a capability of Modbus communications.

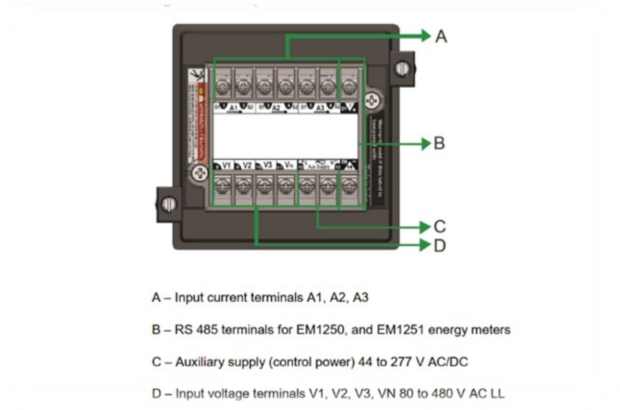


Figure 3 analyser rear [13]

KVA measurement of the analyser

The EM1200 series energy analysers have two different kVA dimensions, specifically **3D** and **Arithmetic.**

- 3D measurement: This is factory default version of general analyses. this is Advanced approach which delivers the more precise and expected measurement under uneven as well as distorted wave shapes.

$$KWA_{3d} = \left(\sum W^2 + \sum VAR^2 + \sum D^2\right)^{0.5}$$

Equation 1 : 3d Measurement calculation

- Arithmetic measurement: applied when the energy meter requires to match the readings of the older or simpler meters. [13]

$$kvA_{ayith} = KVA_1 + KV_2^A + KvA_3$$

CT connection

A CT (current transformer) is a kind of transformer that is used to decrease an alternating current (AC). CT produces a current in its secondary winding which is directly proportional to the current in its primary winding. Establish the current transformers (CTs) as close as possible to the analyser for best accuracy and precision. The following table show the maximum suggested distances for numerous CT scopes, assuming the connection is through 2.5 mm2/14 AWG cable. [14]

5 A CT size	Maximum Distance in meters (in feet) (CT to EM12XX Series Energy meter)
2.5 VA	3.05 m (10 ft/ 120 in.)
5.0 VA	4.6 m (15 ft/ 181 in.)
7.5 VA	9.15 m (30 ft/ 360 in.)
10.0 VA	12.2 m (40 ft/ 480 in.)
15.0 VA	18.3 m (60 ft/ 720 in.)
30.0 VA	36.6 m (120 ft/ 1441 in.)

Table 4 CT values

3.2.1.3 PROGRAM LANGUAGES AND TECHNIQUE

This is a web base system so the project done by using following languages.

1. HTML/CSS
2. JavaScript
3. PHP
4. Python
5. C
6. MySQL (database)

- Farmwork: Django
- MQTT server: emqtt
- Used software for the development of system.
    1. SOLIDWORD electrical for draw wiring diagrams
    2. Sublime Text as IDE (Integrated development environment)
    3. Wamp for local server

3.2 INSTRUMENTS

This proposed Industrial energy monitoring system, acquired data as MODBUS and it should convert TO MQTT data. So, the gateways are needed to do that task. There are several gateways available in market. But IEMS used following gateways,

- Haiwal cloud box (CBOX)-
- USR-N510
- USR-N520
- USR-N540
- USR-G771

These gateways select depend upon number of analysers in given location. There were some electric monitors that have not communication feature. Hence some of analysers replaced with Shinder easy logic 1000 series analysers.

After draw the diagram and identifies required equipment that satisfy the requirement of the project in most effective necessary and sufficient manner. Following table shows list of the apparatus.

REQUIRED ITEMS	QUANTITY
USR-N540 one port	13
USR-N540 two port	6
USR-N540 for port	1
USR-G771	3
analysers	19
CBOX	1
ethernet cable box	2
RJ45 adaptors	200

Table 5 : list of equipment

3.3 PROCEDURE AND TIMELINE

3.3.1 ANALYSE THE PROBLEM.

First, the problem was identified and found the root course of the problem encountered in measuring energy related values. In this section analysed the problem encountered in industry about Energy measurement. This IEMS system was implemented to Hemas manufacturing private ltd. At Hemas premises, there is not any tool to measure energy. Hence, there are some people how go everywhere and note energy consumption manually. Then it enters the google sheet.

That methodology diverges to make errors, time wasting as well as more tedious activity. The difference between calculated value and CEB (Central electricity bord) value was 15621 units. Hence, I suggest this IEMS (Industrial energy monitoring system). The chapter 3.1.2 has expressed the problem in deeply.

3.3.2 TIMELINE

This proposed IEMS is 12-week project as shown in following figure.in first week of time research about the problem. In second week, research about existing system with do same kind of operation and find suitability for each application. After that start actual development if the system that goes from mid of third week 10nth week. Finally testing part stated and all the project activities end on 12 weeks.

Usually, this project needs at least 28 weeks. Because of change of the project title from Machine monitoring system to this industrial energy monitoring system, time was significantly limited. So, the project completed with fully potential in constrained period by paying more effect to the IEMS.

The additional justification regarding development and beneficiaries and technologies that used for the industrial energy monitoring application state in the project report.

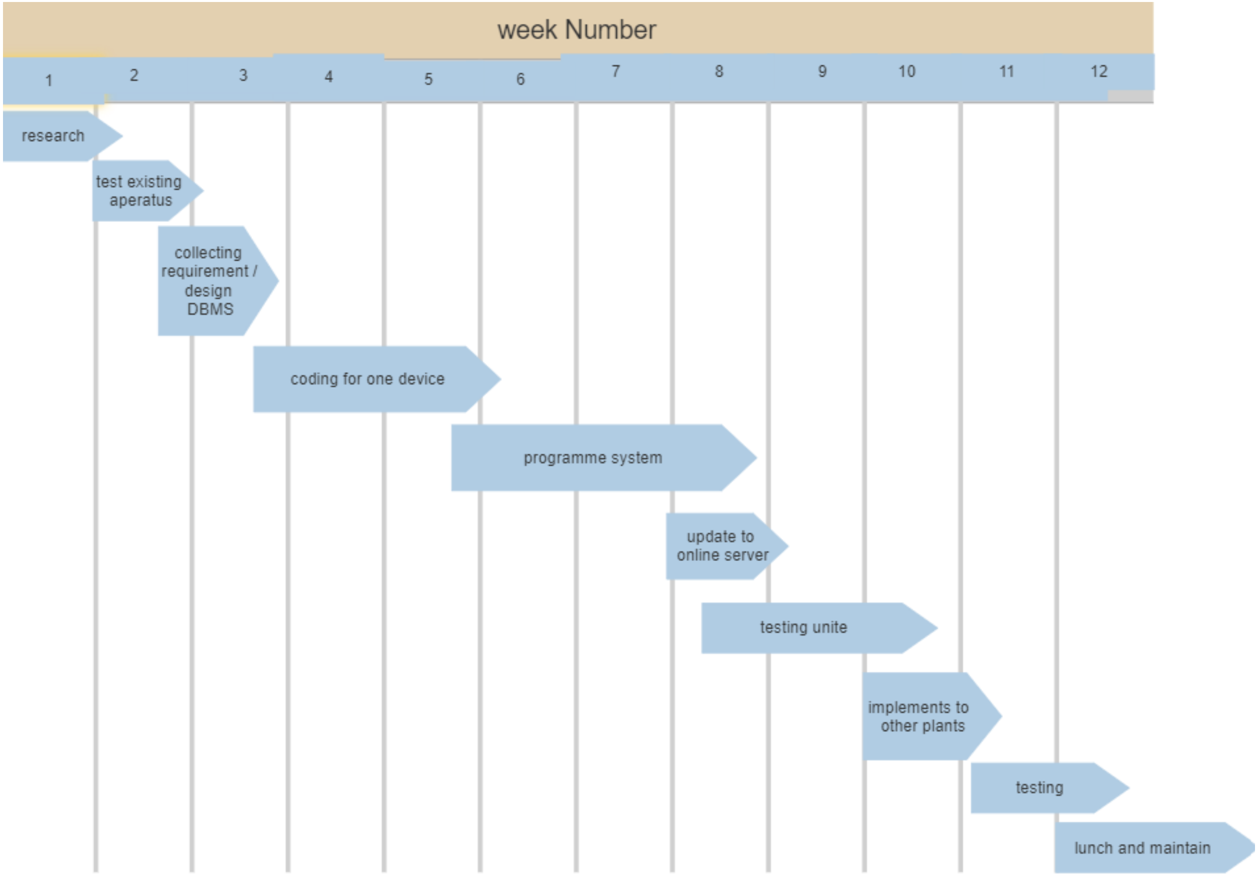


Figure 4 : timeline

3.3.3 RESACH

After identified the problem, did research about the technologies that can used and equipment which need to develop this proposed industrial energy monitoring system. The figured out what communication protocols which support by the analysers. Usually, analysers communicate in MODBUS. Hence the following protocols are used for this system.

- MODBUS
- MQTT
- HTTPS

the researched about how electric analysers are work and how they behave in a system to measure the consumption.

3.3.4 DRAW RELATED DIAGRAMS.

According to the research, develop concept that can unravel the problem in more resalable and effective way.This is project consisting of hardware part as well as software part. Figure 4 shows general diagram for IEMS project.

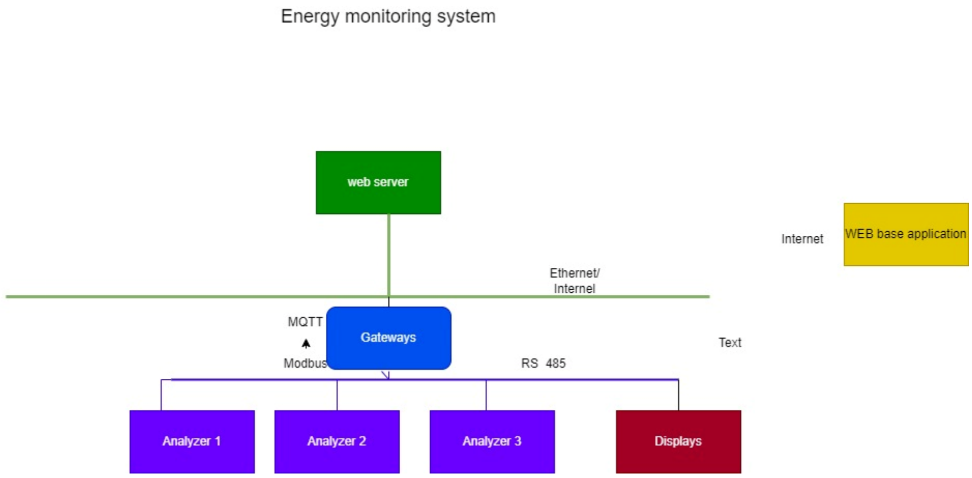


Figure 5: general diagram

All analysers connected according to daisy topology. The analyser network connects to gateway that converts Modbus data in form off MQTT. and upload it into a database. This procedure is done every time that it changed. If the user request data, find it from Database and send to user's device. This is the general procedure of the system.

analysers connected to main 3 phase line through CT. machine is connected through analyser as figure 05.

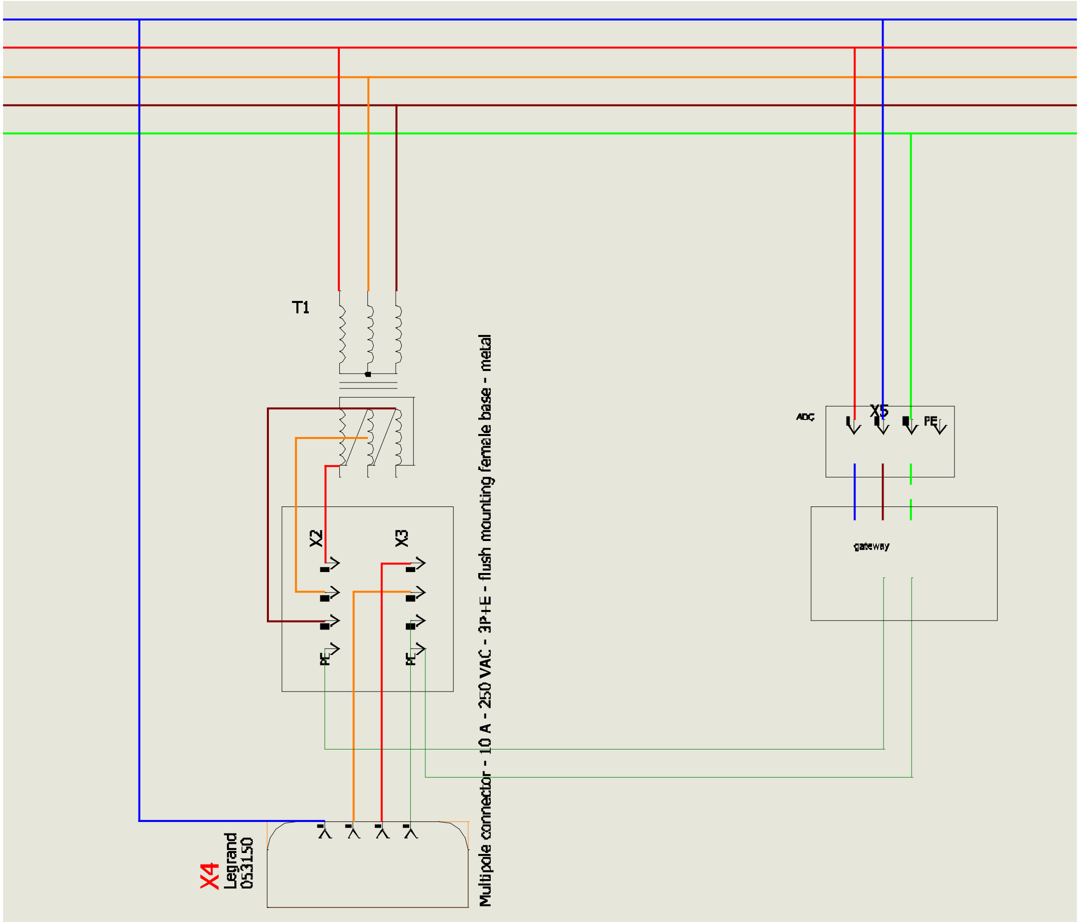


Figure 6 wiring diagram.

The CEB (Central electric Bord) is published tariff methodology to collect their bills from industries. The following table 5 shows the details about tariff and time cost relevant tariff as well as cost for the significant timespan.

Table 6 : Tariff list

Tariff name	Time span	Cost per one unit (Rs)
Peak	18-30 PM -10:30PM	37.00
Off-peak	10.30 PM – 5.30 AM	39.00
Day	5.30 AM- 18.30 PM	34.00

According to the above table, prepared flow chart for the gateway. Thats shows in figure 06. The process flow of Gateway is shown in following figure.

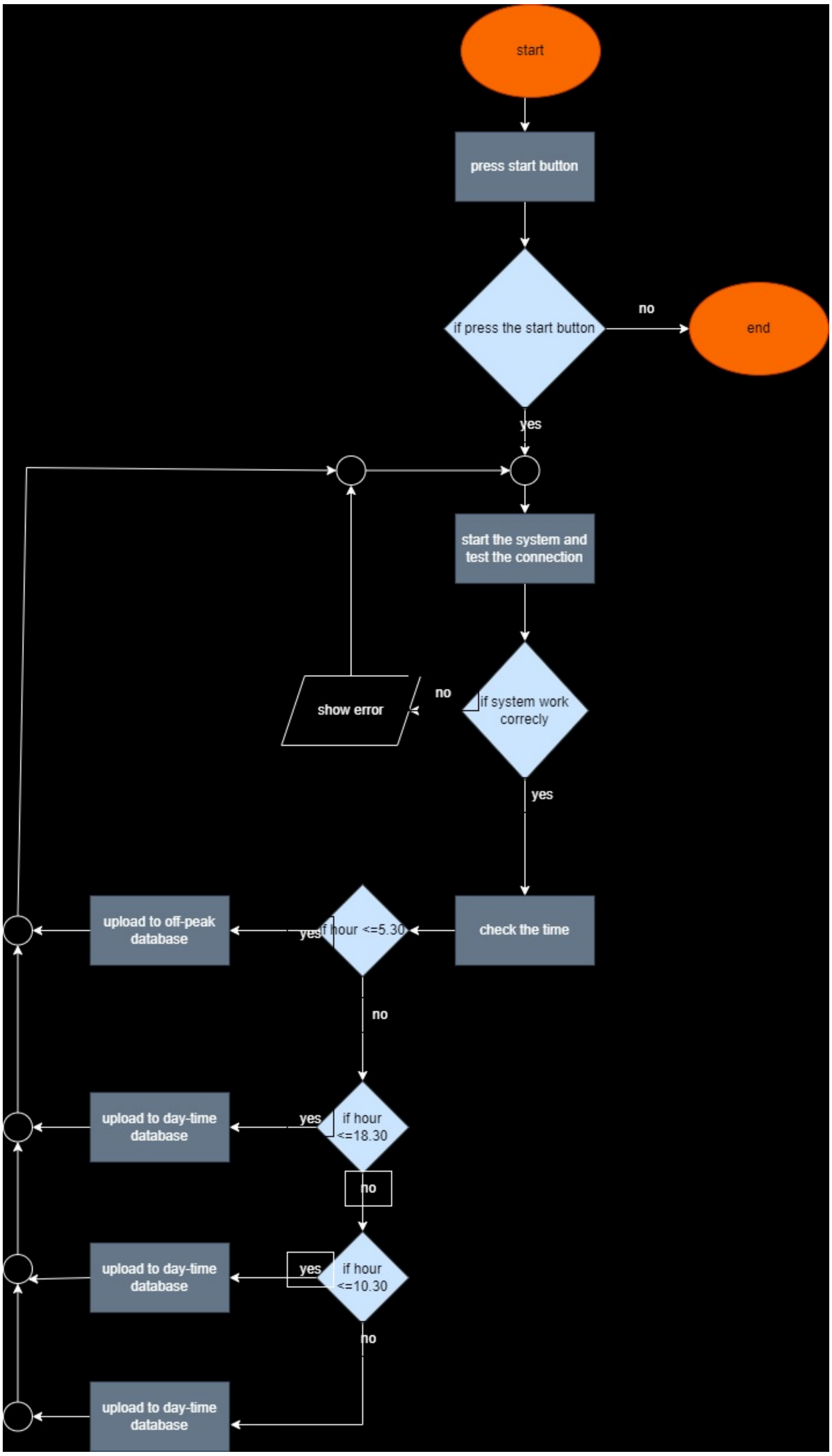


Figure 7 : flow diagram for gateway

Based on the tariff time, relevant database updated automatically without any human interaction by using MQTT protocol until the stop button is press.

Use case diagram.

A use case diagram is the methodology that describe the interaction actress and system. This diagram provides a greater level of overview of the functional requirements in various systems. In the system, there are four members. Amin, Engineering and viewer. The each of person behaviour of the web base system is shown in figure 07.

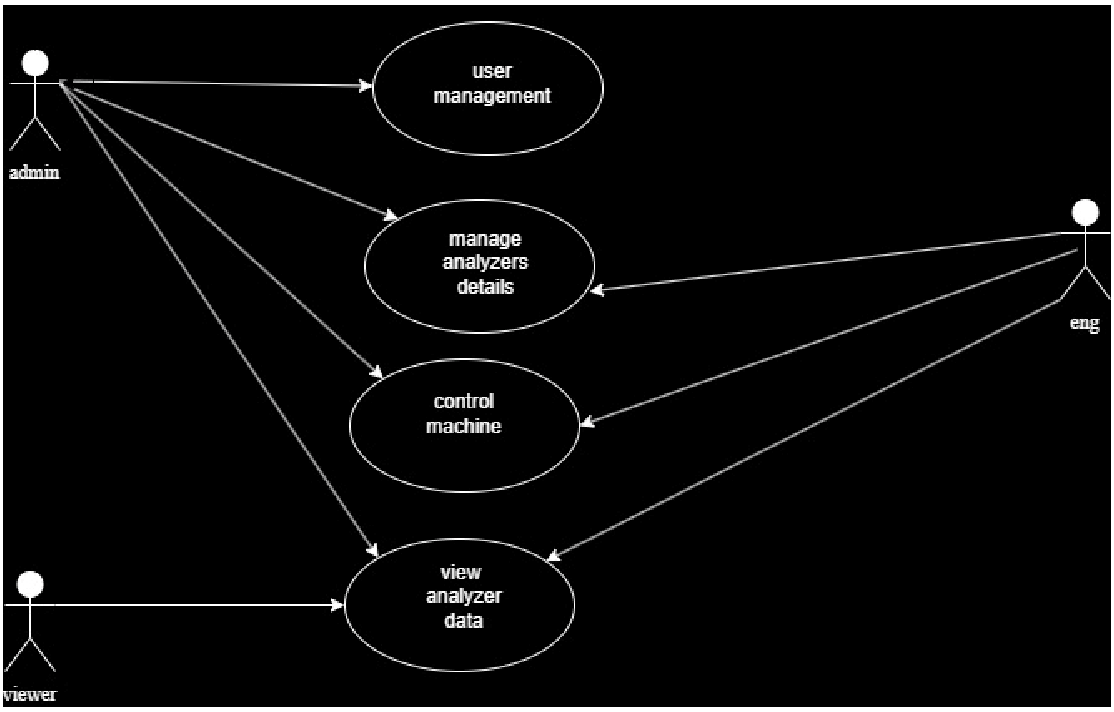


Figure 8 use case diagram.

Admin has every access for all functions including user management, manage analyse information, control machine operation and view analyser data and power consumption as well as show analytical reports. As similar engineering user can also participate those operation existing of user management. But Viewer can only view the power of each machine or group of machine or plant and insight about power usage.

ER diagram (Entity relationship diagram)

Entity relationship diagram is representation the relationship between entities in a system and attributes related to the entities. This diagram provides a clear and structural model of the database. There are two components in ER diagram, Entities (tables) and Attributes (fields).

ER diagram is used to decamine relationship between tables in the database.

So, draw ER diagram (Entity relationship diagram) for the system. There are several tables in relation database. Those are,

- Admin
- Engineering
- Viewer
- Plants
- Analysers
- Peak value
- Day time value
- Off peak value
- Cost
- Month data
- Cost for month

The relationship of the table is shown in following diagram.

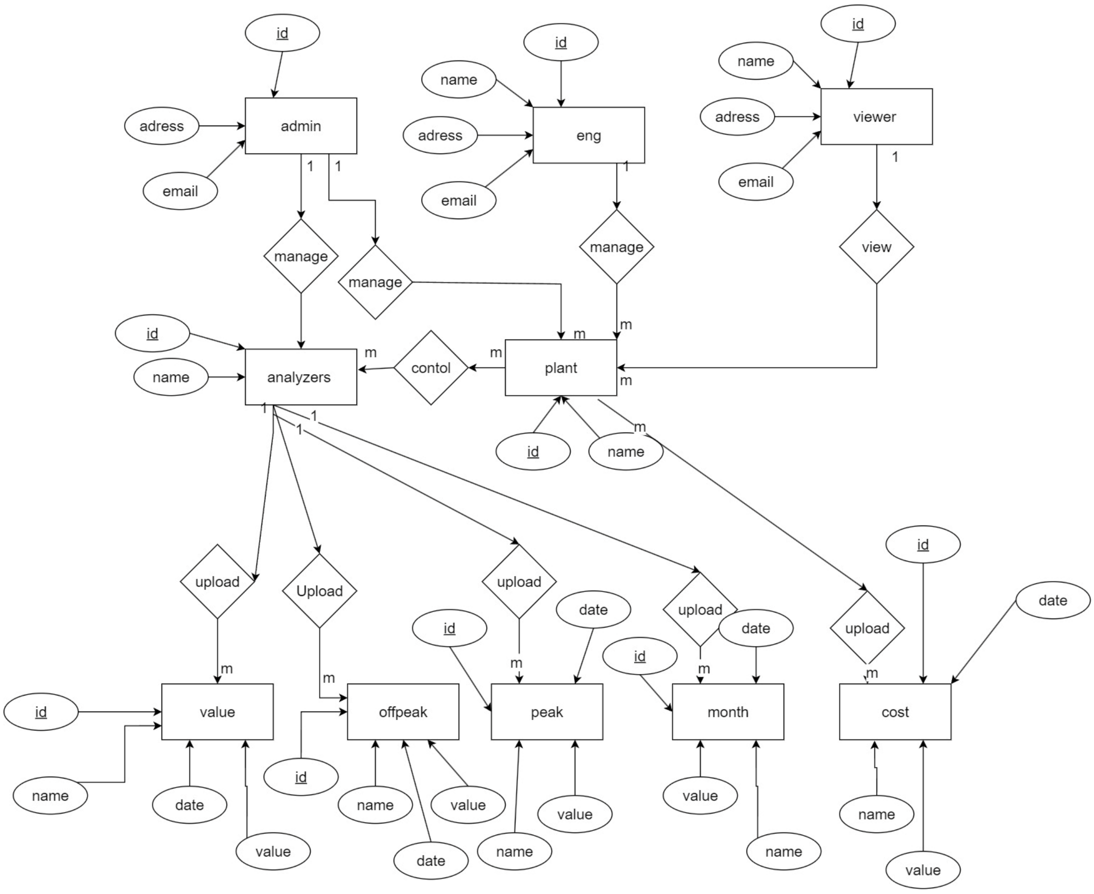


Figure 9 ER diagram

3.3.5 CREATE DATABASE AND USER INTERFACES.

The second section of IEMS system is software design part. UI (User interface) is the one of the major parts of the application. It decides how much get the attraction of users stay with the system.

The UI designed by using technique of HTML (Hyper Text markup language) and CSS (Cascading style sheet). When design the UI consider following factors.

- User attraction
- How do stay user with application
- The easiest way of doing activities.
- Easy access of futures that user every time.
- Simplicity of the system

By considering all facts, designed interfaces as shown in below. The following figures represent UI Elements of the system.

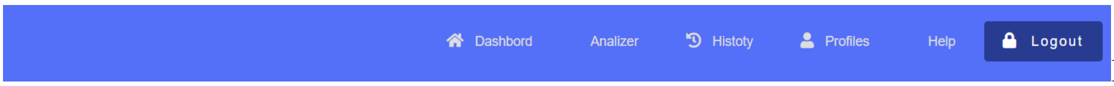


Figure 10

Header

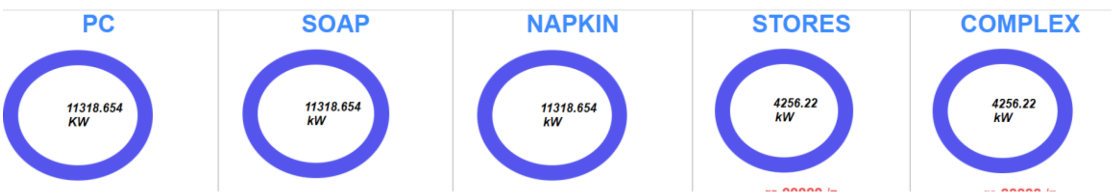


Figure 11: UI for daily usage

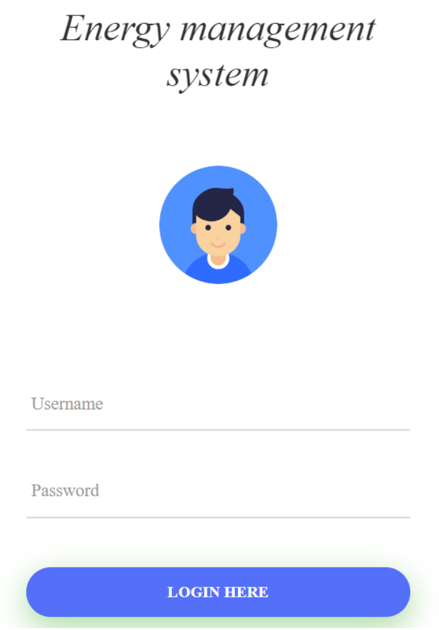


Figure 12 : UI for login

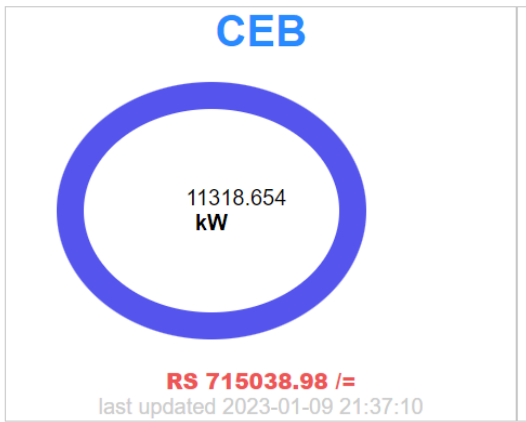
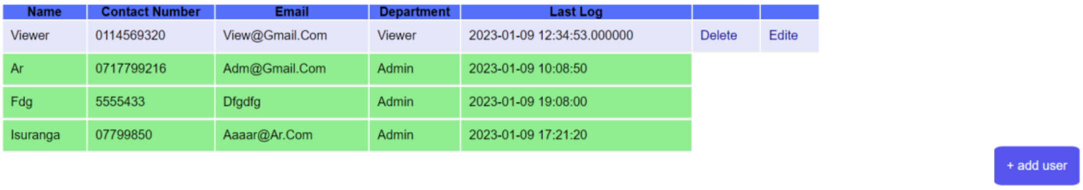


Figure 13 : UI Element for Total usage

id	name	value	plant
1	FURFUME ROOM	267288	complex
2	OFFICE END	531008	complex
3	DB OFFICE	116935	complex
4	DB AC	49286.6	complex
5	DB UPS	2360.61	complex
6	FAN	106961	complex
8	STORES GROUND	921.201	stores
9	STORES GROUND	3152.52	stores
10	STORES UPPER FLOOR	163439	stores
11	STORES OFFICE	966.748	stores
12	GOOD HOIST	21055.4	stores

Figure 14 : UI for table of analysers



Name	Contact Number	Email	Department	Last Log		
Viewer	0114569320	View@Gmail.Com	Viewer	2023-01-09 12:34:53.000000	Delete	Edite
Ar	0717799216	Adm@Gmail.Com	Admin	2023-01-09 10:08:50		
Fdg	5555433	Dfgdfg	Admin	2023-01-09 19:08:00		
Isuranga	07799850	Aaaar@Ar.Com	Admin	2023-01-09 17:21:20		

Figure 15 : list of users

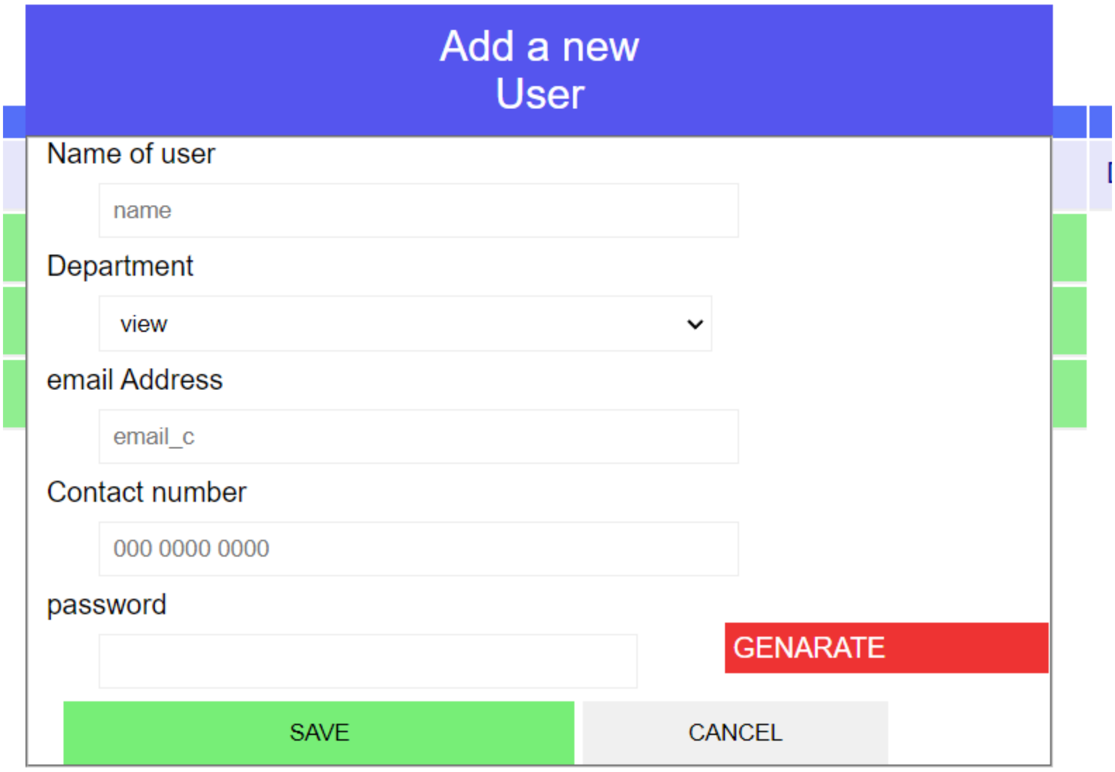


Figure 16 : user management

There are more interfaces of this application. In above, mentioned selected interfaces because, there are large number of unique interfaces.

3.3.6 CONNECT ONE ANALYSER & WRITE A PROGRAM FOR IT.

Then connect an analyser for acquire the relevant Power, Energy as well as other measurement witch necessarily need to monitor.

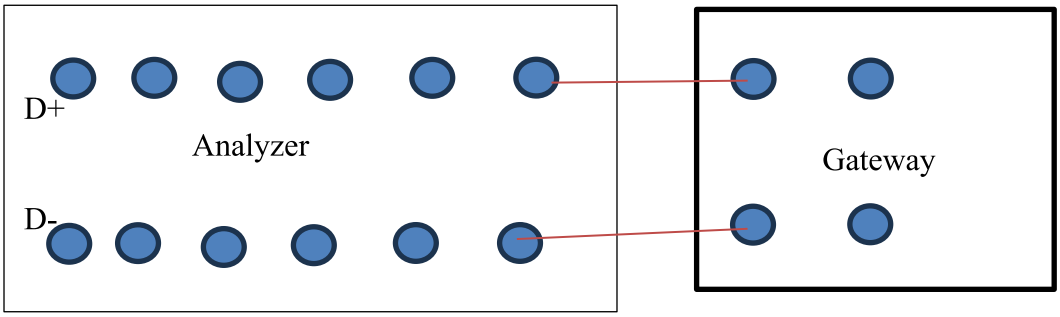


Figure 17wiring diagram of one analyser.

Connected according to above image and programmed its parameters. such as,

- Slave Id as uniquely identifiable number
- Communication status to True
- Bound rate as 19600
- Password of the analyser

Then program a code by using Collaboration of C and JS (Java script). Pseudocode for that is explore below.

```
Begin modbusDataAquire
Variable:
        Value1: Float
        Value2: float
        Value:float
main
        Read register value1.
        Read register value2.
        Convert register value1 to binary data type.
        Convert value2 register to binary form.
        Set value by Add together.
        Convert to decimal format.
        Display
End modbusDataAquire
```

Figure 18 pseudo code

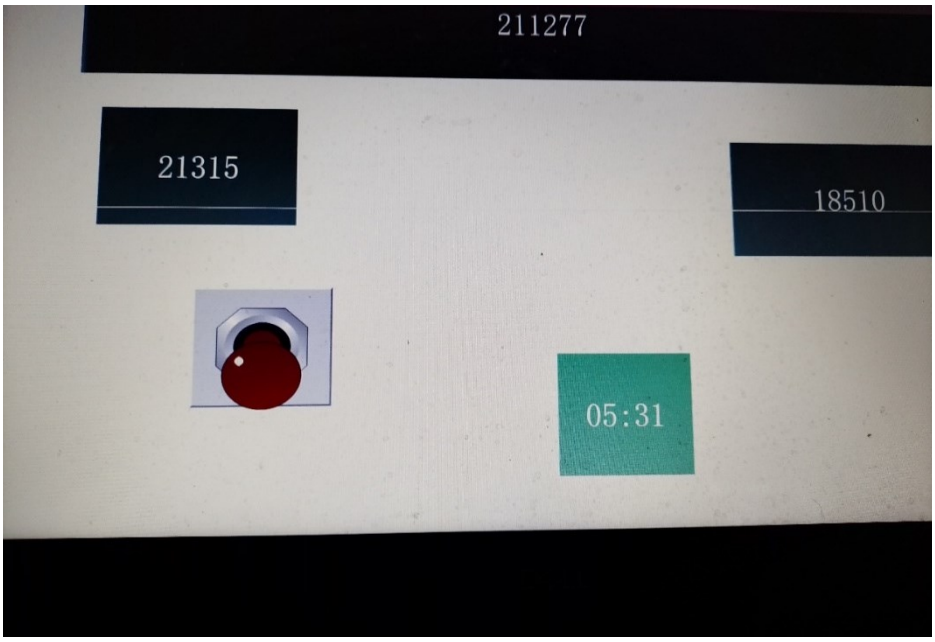


Figure 19 : result of reading one analyser.

3.4.6 Expand the technique for one panel.

Connect eighteen electric analysers according to Darcy's topology. It derives the analysers connect by applying a load to end of the circuit.

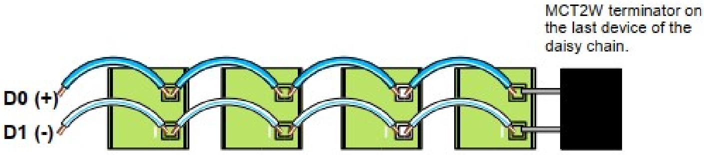


Figure 20 : Darcy's topology [15]

According to the above theory, Networked analysers read the Power and Energy.

Figure 21 panel bord

Figure 22 connected analysers.

.

3.4 ANALYSIS

All analysers connected according to daisy topology. The analyser network connects to gateway that converts Modbus data in form off MQTT. and upload it into a database. This procedure is done every time that it changed. If the user request data, find it from Database and send to user’s device. This is the general procedure of the system.

In analyser, Data received by two registers. Using JS code, converted two register values into one value. Figure 22 show the code written for that task. The fully code is in appex1

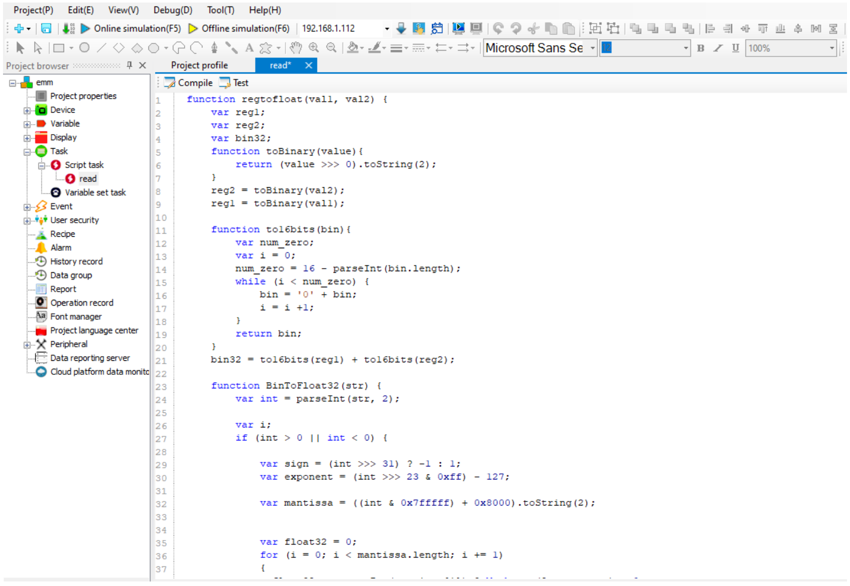


Figure 23 : gateway's code

Then compared the received data with values shown in analyser. Then figured out the values that sent from the analyser are in correct manner.

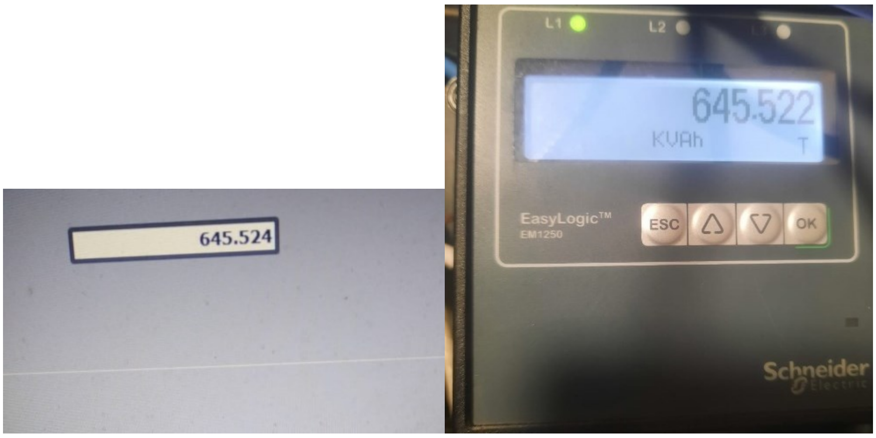


Figure 24 : comparison values

3.5 ETHICS AND LIMITATIONS

IEMS is more deadly consider about ethical behaviours of the system. For development of the system, did not use any sort of crack software and prevent the works that attack or harmful to others IP. Thus, This system care about cyber-attacks and other hazardous. Hence, there are security layers for becoming secure from those encounters. So, this can be identified as a system that goes with ethical manners.

Imitation is the boundaries that impact the scope project. There are some limitations that are related to vehicle parking management systems in a firm. Those are listed as following,

- Time constraints

  This is a fully complex and has dome innovative features. Spend more time for builds those features because of lack of knowledge and complexity of the system. Hence time was a challenged but how ever with limited time, can be able to complete this project.

- Ordering equipment

  These projects conducted under economic crisis. So, the inflation rate was at a heigh level. Hence, the budget for equipment was raised in an

  unexpected manner. Because of that, some components replace available electronics devices and technologies. Because of that there were so many times spend for order the equipment and delivers that apparatus. But stile could not receive every device that ordered.

- Permission legacy

  Because of the rule and regulation of the company, this application could not be able to publish as myself. It has a long procedure. Until the procedure finish, the system cannot host in any of cloud base application.

However, all objectives were developed and tested. All function are working in more attractive efficient and accurate manner..

Chapter 4: Experiment and Results

This report provided detailed information about IEMS and their behaviour. This result section includes the entire outcomes from the research of vehicle parking management system. In this section, includes qualitative or quantitative description related to the vehicle management system. Hence, This Result and experiment chapter provides details of experiment and result as well as evaluation terms of cost, Environment impact, manufacturability ethics, health and safety and sustainability.

This project was implemented to Hemas Manufacturing and built suitable for industrial uses as describe in methodology chapter. This supposed IEMS provide details about energy usage, Cost for significant activities that required to monitor and evaluate. Furthermore, it provides insight by visual graphs for electric energy consumption and compares it with previous month. Through that, it allows to identify necessary steps and operation to mitigate the usage, waste and cost. This system allows.

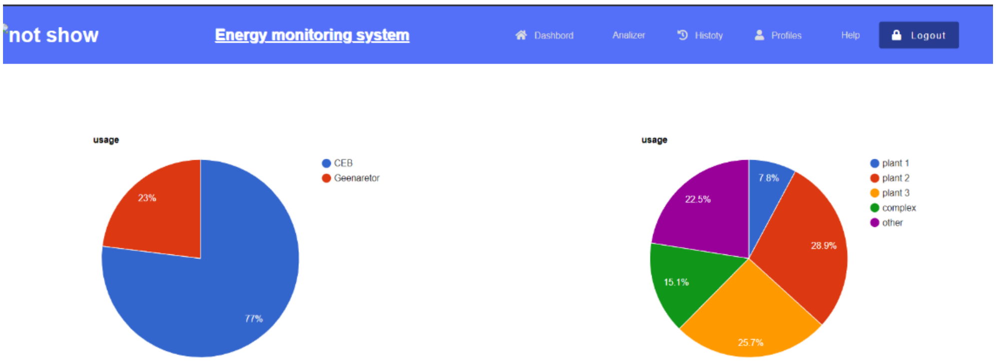


Figure 25 analytical dashboard

Figure 21 shows the usage from CEB and Generator. The right-hand side graph represents plants electric energy consumption and cost for the electricity in selected month. The following table shows data about daytime electric energy consumption and figure 22 shows the analytical report for that.

	_id	_dbTime	_terminalTime	_groupName	e2	e3	e4	e5	e6	e7	e8	e9	e10	e11	e12	e13	e14
Edit Copy Delete	1	2022-12-29 09:01:35	2022-12-29 09:01:23.284	mqtt_day	176705	525378	114415	48569.8	2349.38	106164	3220.75	921.201	3139.05	161392	966.114	20930.8	124408
Edit Copy Delete	2	2022-12-29 09:01:53	2022-12-29 09:01:53.284	mqtt_day	176705	525378	114415	48569.8	2349.38	106164	3220.78	921.201	3139.05	161392	966.114	20930.8	124408
Edit Copy Delete	3	2022-12-29 09:02:23	2022-12-29 09:02:23.284	mqtt_day	176705	525378	114415	48569.9	2349.38	106164	3220.81	921.201	3139.05	161393	966.114	20930.8	124408
Edit Copy Delete	4	2022-12-29 09:02:53	2022-12-29 09:02:53.284	mqtt_day	176705	525378	114415	48569.9	2349.38	106164	3220.81	921.201	3139.05	161393	966.114	20930.8	124408
Edit Copy Delete	5	2022-12-29 09:03:23	2022-12-29 09:03:23.284	mqtt_day	176806	525479	114515	48970	2369.38	106170	3230.81	921.201	3199.05	161422	966.114	20930.8	1244500

Table 7 : energy usage

By analysing the above insights, can be able to evaluate the daily usage and able to get the decision to reduce the cost for energy.

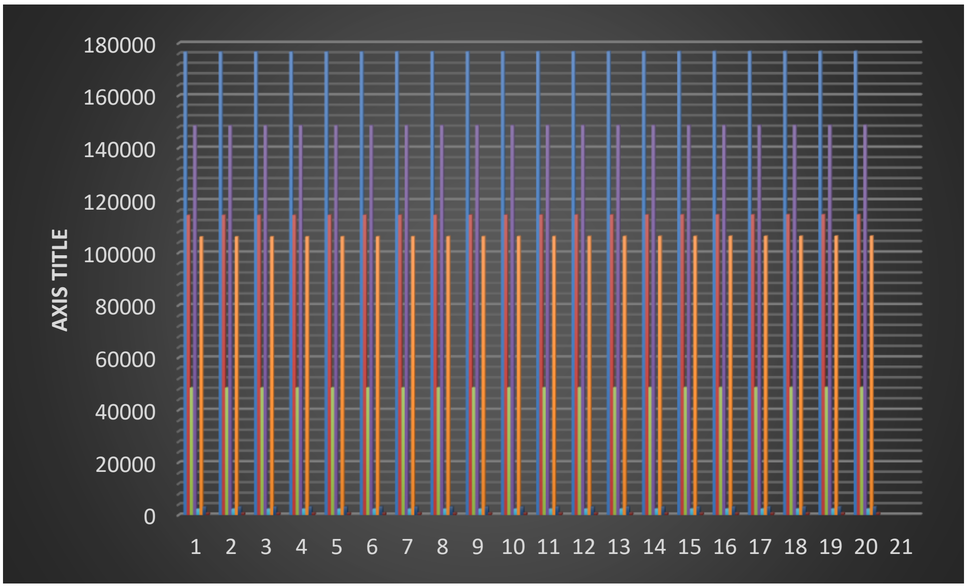


Figure 26 : daily usage

This system gives beneficiaries in different manners. consequence, this system is more useful, effective for industrial perspectives. The rest of part described it beneficiaries in term of,

- Cost

  IEMS directly impact to manufacturing cost reduction by analysing the consumption and give resalable, cost effective and effective solution for minimize the cost for electricity. After the 2023 cost arising the cost was rapidly increase in unexpected manner. By implement this system It could be minimized in considerable manner. This is main aim of the application. Through implementing the system, it was successfully achieved. The future development of the project is predict cost for energy by using ML (Machine learning algorithm) .It will open the probability to preauction for electric energy cost reduction.

The cost of the total project is shown in the following table.

Equipment Name	Price (Rs)
1. Energy monitor (Analyzers)	50,000*19=450,000/=
2. Gateway	9,000*10=90,000/=
3. servers	30,000
4. plc/controller	90,000
5. cables	50 000
6. other	20,000
Total	**730,000/=**

Table 8 : budget

- Environmental impact

  Another most effective term of this system is Environment impact. The considerable portion of electricity is generally generated from fusil fuel and Coal and nuclear gases.

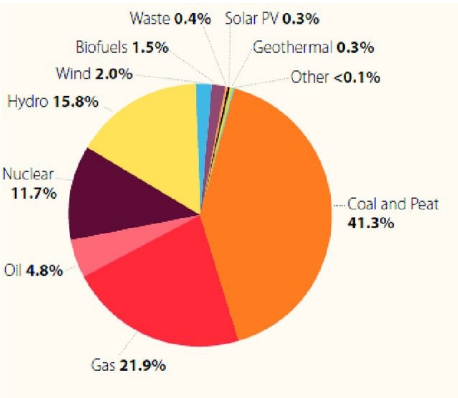


Figure 27 : energy generation sources [16]

When Electricity produces from fuel or coal produce Carban dioxide, Carban monoxide and other green gases. Similar, if the nuclear power plant damage it will produce considerable damage for environment If electric energy consumption is high, that mean if produce more Croton footprint and green gases to environment as well as if the concussion is low, the impact for negative environment minimized. Consequence. this system provides bast environment effectors.

- Manufacturability

Manufacturability is the capability to produce the product that can be effectively in term of cost, design, and distribution requirement. This system has capability suitable and implementable with existing architectures. This system is compatible with different kinds of analyser. Hence Manufacturability of IEMS is at very heigh state.

- Ethics

IEMS is more deadly consider about ethical behaviours of the system. For development of the system, did not use any sort of crack software and prevent the works that attack or harmful to others IP. Thus, This system care about cyber-attacks and other hazardous. Hence, there are security layers for becoming secure from those encounters. So, this can be identified as a system that goes with ethical manners.

- Social and Political Impact

This EMS is collaborating Hardware and Software subject and produces grateful benefits. This system led to an increase in the profit of the firms the open the doors for receives economic advantages for workers as well as supply chains. So, it gives benefits in terms of social impact factor.

- Health and Safety

IEMS has a safeguard feature to become a more secure system. When consider about safety, mainly consider about tow aspects

  - Safety of human

    This system prevents humans from power panels and other location that has high risk via remote monitoring and control function.

  - Safety of machine

    When machine receive high voltage machine and work continuously will damage. sometime machine will work without any valuable reason. that leads to reduce machine durability, reliability. Also, it occurs a maintenance before the planes time slot. This application reduces the chance to explore those kinds of issues.

- Safety of data

  This is a system based on the internet. Hence should consider the security of data. Thus, this system has a backup mechanism for face that consideration.

- Sustainability.

  Energy and sustainability have a core relationship. This application is used for monitoring energy. When energy usage is low the sustainability is heigh. that means this system support to achieve great sustain during manufacturing operations.

Chapter 5: Conclusion/Discussion

Energy monitoring system is an application used to measure and monitor power, energy and cost for the defined location or machine. This system sufficiently, necessarily, successfully, and efficiently addresses the problem and answers it in a more reliable manner. This system has two major parts. Hardware part and software part. The hardware part consists of analysers and gateways and communication protocols. Electric analysers measure the power and energy associated with the machine or department. Also, it transfers values to gateway through Modbus protocols. Then, gateway converts Modbus data to MQTT data and uploads it to database. In the software part, there is a web-based application. There are m users in that application (Admin user, engineering user and viewer). Those users log in to the web application and the real time energy values, graphs and analyser management as well as change their user details. This is the working principle of the system.

This proposed system has following special characteristics when comparing existing application,

- Undependability with device type
- Calculate cost for given period (Generally one month)
- Monitor and show energy, power that consume as a category of machine, section, plant, and whole firm.
- Information backup facility
- Simple dashboard
- Add and manage analysers easily.
- User management facility
- Concerned about security of the system.

With these features, this system will perfume more successful and unique manner.

5.1 LIMITATION OF THE SYSTEM

Imitation is the boundaries that impact the scope project. There are some limitations that are related to vehicle parking management systems in a firm. Those are listed as following,

- **Time constraints**

  This is a fully complex and has dome innovative features. Spend more time for builds those features because of lack of knowledge and complexity of the system. Hence time was a challenged but how ever with limited time, can be able to complete this project.

- **Ordering equipment**

  These projects conducted under economic crisis. So, the inflation rate was at a heigh level. Hence, the budget for equipment was raised in an

Imitation is the boundaries that impact the scope project. There are some limitations that are related to vehicle parking management systems in a firm. Those are listed as following,

- **Time constraints**

  This is a fully complex and has dome innovative features. Spend more time for builds those features because of lack of knowledge and complexity of the system. Hence time was a challenged but how ever with limited time, can be able to complete this project.

- **Ordering equipment**

  These projects conducted under economic crisis. So, the inflation rate was at a heigh level. Hence, the budget for equipment was raised in an

5.2 FUTURE DEVELOPMENT

In this section use to state the features that implement as future development. The following feature will apply in the future.

- Mobile app interconnection
- Prediction about next month usage
- Use blockchains to store the information in a more secure manner.

Through those options, this system can be able to provide reliable, secure, effective information to the top management. Then, the top management can be able to make proper decision about waste reduction, cost reduction and impro their KPIs (Key performance indicators) as well as sustainability of the firm.

5.3 RECOMMANDATIONS

This proposed system can implement any industries for measure and monitoring the electric consumption. Thus, the application more suitable any kind of analysers as well as gateways which used in industry. Furthermore, if there is a requirement for monitor electric energy in the home or any kind of premises, this system can be used.

References

[1] John Smith, Jane Doe, “Smart Energy Management for Industrial IoT: A Review,” 2019.

[2] https://www.energyly.com/, “energyly.vom,” energyly, 2021. [Online]. Available: https://www.energyly.com/. [Accessed 10 1 2023].

[3] S. C. William Adams, “Challenges in Implementing Electric Energy Monitoring Systems in Large-Scale Industries,” IEEE.

[4] Emma White, John Taylor, “Energy Management Strategies for Demand-Side Management in Manufacturing Plants,” Resherch gate, 2021.

[5] a. brandly, “add.com,” alen bradly, [Online]. Available: https://new.abb.com/industrial-software/sustainability/energy-management-system-enms/energy-monitoring-and-reporting. [Accessed 22 03 2023].

[6] Andrew Wilson, Sarah Moore, “renwable energy monitoring,” IEEE.

[7] Robert Johnson, Laura Smith, “IoT-Based Monitoring and Control of Industrial Electric Energy Consumption”.

[8] g. grid, “getgridsolution.com,” ggsolution, [Online]. Available: https://www.gegridsolutions.com/panels_engineered/digital-control-systems/iems.htm. [Accessed 10 6 2023].

[9] I. e. association, “energy banchmarking,” IEEE, 2020.

[10] R. J. Sarah White, “Wireless Sensor Networks for Industrial Electric Energy Monitoring"”.

[11] : Emma Roberts, Michael Lee, “Challenges and Solutions in Data Security for Industrial Energy Monitoring Systems,” 2022.

[12] Jennifer Wilson, Robert Taylor, “Integration of Building Energy Management Systems with Industrial Facilities,” resherch gate, 2023.

[13] S. electrical, “manual 1250xx series”.

[14] S. electrcal, “schinder easy logic 1250”.

[15] S. electric, “topology,” 2019.

[16] u. o. califonia, “enery sources,” reserch gate, 2020.

[17] J. Zhang, “Indoor Parking Method Based on Cooperation of Intelligent,” ICAITA 2020, 2020.

[18] oreilly, “IR sensors,” oreilliy.com, 3 5 2023. [Online]. Available: https://www.oreilly.com/library/view/internet-of-things/9781788627405/efd92619-1f31-42b7-a938-

10fd3192f445.xhtml#:~:text=There%20are%20basically%20two%20types,an%20infrared%20source%20to%20operate.. [Accessed 8 8 2023].

[19] R. V. B. a. M. R. L. Md. Shahriar Bin Shahin, “Automatic Car Parking System Using Arduino:,” https://www.researchgate.net/publication/371971001, 2020.

[20] maxbotix, “ultrasonic sesors,” maxbotix.com, 5 5 2022. [Online]. Available: https://maxbotix.com/blogs/blog/how-ultrasonic-sensors-work#:~:text=An%20ultrasonic%20sensor%20is%20an,information%20about%20an%20object's%20proximity.. [Accessed 08 08 2023].

[21] M. M. M. M.M. Mohamed Asjath1, “Automated Vehicle Parking Slot Recognition and Monitoring using,” Department of Physical Science, Faculty of Applied Sciences, University of Jaffna., 2022.

[22] W. contributors, “ESP32,” 29 06 2023. [Online]. Available: https://en.wikipedia.org/w/index.php?title=ESP32&oldid=1167739175. [Accessed 08 08 2023].

[23] C. E. BOARD, “CEYLON ELECTRICITY BOARD ,Second Electricity Tariff Revision 2023,” 1 july 2023. [Online]. Available: https://www.ceb.lk/. [Accessed 1 Auguest 2023].

[24] Paulo R. Lisboa de Almeida∗, Jeovane Honorio Alves ´ ∗, Luiz S. Oliveira∗,, “Vehicle Occurrence-based Parking Space Detection,” https://www.researchgate.net/publication/371684507, 2023.

[25] Maritzol Tenemaza1, Roger Laza1, Jonathan Vargas1,, “Tourist Recommendation Systems: solving mobility in a private vehicle,” in *https://www.researchgate.net/publication/372283979*, 2023.

[26] Yamamoto, Kotaro; Teng, Rui; Sato, , “Simulation Evaluation of Vehicle Movement Model Using,” in *https://doi.org/10.36227/techrxiv.21785870.v1*, Kenya, 2022.

[27] Jennifer Brown, Michael Johnson, “Real-Time Monitoring of Power Quality in Industrial Networks,” IEEE, 2019.

[28] Petr Dzurenda ,Florian Jacques,Manon Knockaert,Maryline Laurent , “Privacy-Preserving Solution for Vehicle Parking,” gatereseach , 2022.

[29] E. T. John Wilson, “Sustainable Energy Management in Data Centers using Dynamic Power Allocation,” IEEE.

Appendices

Appendix A

code for analysers

```
function regtofloat(val1, val2) {
   var reg1;
   var reg2;
   var bin32;
    function toBinary(value){
        return (value >>> 0).toString(2);
    }
    reg2 = toBinary(val2);
       reg1 = toBinary(val1);

       function to16bits(bin){
         var num_zero;
           var i = 0;
           num_zero = 16 - parseInt(bin.length);
           while (i < num_zero) {
               bin = '0' + bin;
               i = i +1;
           }
           return bin;
       }
       bin32 = to16bits(reg1) + to16bits(reg2);

       function BinToFloat32(str) {
           var int = parseInt(str, 2);

           var i;
           if (int > 0 || int < 0) {

               var sign = (int >>> 31) ? -1 : 1;
               var exponent = (int >>> 23 & 0xff) - 127;

               var mantissa = ((int & 0x7fffff) + 0x8000).toString(2);


               var float32 = 0;
               for (i = 0; i < mantissa.length; i += 1)
               {
                 float32 += parseInt(mantissa[i]) ? Math.pow(2, exponent) : 0;

                 exponent-- ;
               }
               return float32 * sign;
           } else {
           return 0;}
       }
       return BinToFloat32(bin32);
   }
   $InternalVariable_1.e2=regtofloat($Modbus_1.e1,$Modbus_1.e2)/1000;
   $InternalVariable_1.l1=regtofloat($Modbus_1.pl1,$Modbus_1.pl1_2);
   $InternalVariable_1.l2=regtofloat($Modbus_1.pl2,$Modbus_1.pl2_2);
   $InternalVariable_1.l3=regtofloat($Modbus_1.pl3,$Modbus_1.pl3_2);
```

```
    $InternalVariable_1.active_power=regtofloat($Modbus_1.active_power,$Modbus_1.active_power2);


    $InternalVariable_1.e3=regtofloat($Modbus_3.e1,$Modbus_3.e2)/1000;
    $InternalVariable_1.e4=regtofloat($Modbus_4.e1,$Modbus_4.e2)/1000;
    $InternalVariable_1.e5=regtofloat($Modbus_5.e1,$Modbus_5.e2)/1000;
    $InternalVariable_1.e6=regtofloat($Modbus_6.e1,$Modbus_6.e2)/1000;
    $InternalVariable_1.e7=regtofloat($Modbus_7.e1,$Modbus_7.e2)/1000;
    $InternalVariable_1.e8=regtofloat($Modbus_8.e1,$Modbus_8.e2)/1000;
    $InternalVariable_1.e9=regtofloat($Modbus_9.e1,$Modbus_9.e2)/1000;
    $InternalVariable_1.e10=regtofloat($Modbus_10.e1,$Modbus_10.e2)/1000;

    $InternalVariable_1.e11=regtofloat($Modbus_11.e1,$Modbus_11.e2)/1000;
    $InternalVariable_1.e12=regtofloat($Modbus_12.e1,$Modbus_12.e2)/1000;
    $InternalVariable_1.e13=regtofloat($Modbus_13.e1,$Modbus_13.e2)/1000;
    $InternalVariable_1.e14=regtofloat($Modbus_14.e1,$Modbus_14.e2)/1000;


    // ---------------------------------------------------------------------------------------------------------
    // -------------------------------------POWER LINE--------------------------------------------------------
    // ---------------------------------------------------------------------------------------------------------



    $InternalVariable_1.p3=regtofloat($Modbus_3.p1,$Modbus_3.p2)/1000;
    $InternalVariable_1.p4=regtofloat($Modbus_4.p1,$Modbus_4.p2)/1000;
    $InternalVariable_1.p5=regtofloat($Modbus_5.p1,$Modbus_5.p2)/1000;
    $InternalVariable_1.p6=regtofloat($Modbus_6.p1,$Modbus_6.p2)/1000;
    $InternalVariable_1.p7=regtofloat($Modbus_7.p1,$Modbus_7.p2)/1000;
    $InternalVariable_1.p8=regtofloat($Modbus_8.p1,$Modbus_8.p2)/1000;
    $InternalVariable_1.p9=regtofloat($Modbus_9.p1,$Modbus_9.p2)/1000;
    $InternalVariable_1.p10=regtofloat($Modbus_10.p1,$Modbus_10.p2)/1000;

    $InternalVariable_1.p11=regtofloat($Modbus_11.p1,$Modbus_11.p2)/1000;
    $InternalVariable_1.p12=regtofloat($Modbus_12.p1,$Modbus_12.p2)/1000;
    $InternalVariable_1.p13=regtofloat($Modbus_13.p1,$Modbus_13.p2)/1000;
    $InternalVariable_1.p14=regtofloat($Modbus_14.p1,$Modbus_14.p2)/1000;


    $InternalVariable_1.ptot=$InternalVariable_1.p3+$InternalVariable_1.p4+$InternalVariable_1.p5+$InternalVariable_1.p6+$InternalVariable_1.p7+$InternalVariable_1.p8+$InternalVariable_1.p9+$InternalVariable_1.p10+$InternalVariable_1.p11+$InternalVariable_1.p12+$InternalVariable_1.p13+$InternalVariable_1.p14;
```