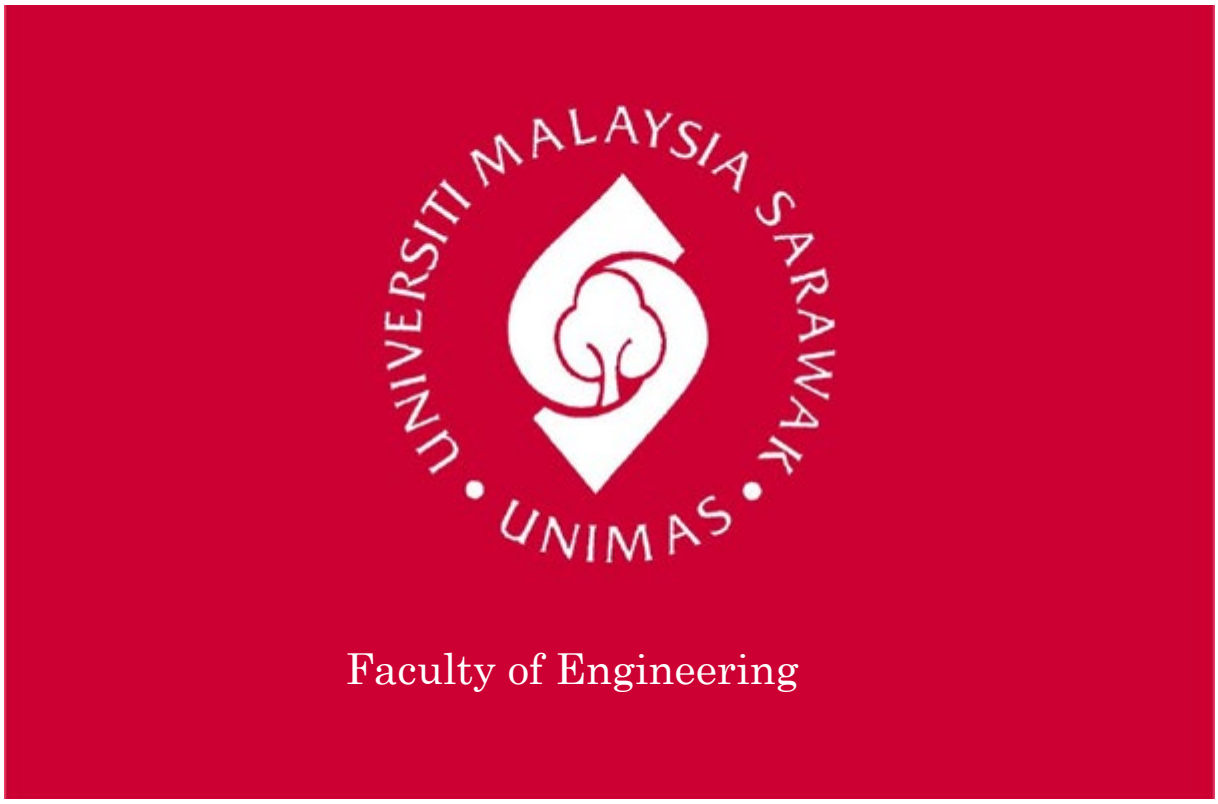

SMART METERING AS SMART ELECTRIC ENERGY MANAGEMENT

Chin Jing Heng

65645

Bachelor of Engineering

Electrical and Electronic Engineering

With Honours

2022

SMART METERING AS SMART ELECTRIC ENERGY MANAGEMENT

CHIN JING HENG

A dissertation submitted in partial fulfilment

of the requirement for the degree of Bachelor of Engineering

Electrical and Electronic Engineering

With Honours

Faculty of Engineering

Universiti Malaysia Sarawak

2022

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report ☐

Masters ☐

PhD ☐

DECLARATION OF ORIGINAL WORK

This declaration is made on the ……..day of……..20.

Student's Declaration:

I ----------
(PLEASE INDICATE STUDENT'S NAME, MATRIC NO. AND FACULTY) hereby declare that the work entitled ---------- is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

_____ _____

Date submitted Name of the student (Matric No.)

Supervisor's Declaration:

I---------- (SUPERVISOR'S NAME) hereby certifies that the work entitled ----------(TITLE) was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of ---------- (PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: _____ Date:_____

(Name of the supervisor)

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*****
☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*****
☐ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirm with free consent and willingly declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature _____ (Date)

Supervisor signature: _____ (Date)

Current Address:

_____

_____

Notes: ***** If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

DEDICATION

This dissertation is sincerely dedicated to

My supervisor Mr. Azfar Satari Bin Abdullah for the guidance and consultation throughout this project.

Next, to my parent that provide me with tons of encouragement to keep going forward.

To my brother, relatives, mentor, friends, and course mates who shared their opinion about my project.

And lastly, to the Almighty God, thank you for providing me the strength, protection, and a healthy state of mind. All of these, we offer to you.

ACKNOWLEDGEMENT

The contentment, which comes along the accomplishment of this project, is incomplete without the mention of few important person. I take this chance to acknowledge the effort of these key individuals who aided me make this project achievable.

First and foremost, I would like to express my sincere gratitude to my supervisor, Mr. Azfar Satari Bin Abdullah, a lecturer in the Department of Electrical and Electronics Engineering at the University of Malaysia Sarawak, for his unwavering support and encouragement throughout the completion of this project. His plan and execution aimed to give this project pragmatism and character, and they also encouraged idealistic proposals for how I could conduct this research. Despite his busy schedule, his guidance, encouragement, and participation in several discussions with me led to the creation of this initiative.

Additionally, I want to express my sincere gratitude to my family for their ongoing moral support and encouragement as well as their financial and spiritual support throughout my college studies.

A particular appreciation also goes out to my fellow classmates and friends who have supported me over the course of the study. I would not have made it this far or been able to complete my project successfully without their sincere aid and constructive criticism.

A sincere thank you goes out to everyone else who has helped me, whether explicitly or implicitly, by lending their important time. It would have been challenging to do this without their attention because the experience is novel.

ABSTRACT

Increase of consumption of electricity due to this High-Tech Era, energy saving become very important as power generation still highly depending on non-renewable energy. The only electricity usage measurement tool installed in everyone house which is electric meter only capable of displaying cumulative energy consumption. This conventional type of electric meter causes people clueless about their electricity consumption as it is difficult to track and determine which electrical appliances contribute to that amount of electricity consumption. Therefore, in this project Smart Electric Meter System (SEMS) is designed to ease the process of monitoring the power consumption of electrical appliances and manage their appliances. The SEMS consists of Smart Electric Meter (SEM) that monitor the electricity usage of all the load at home and Smart Electric Plug (SEP) to monitor single electrical appliances. The main component of this project is components that are widely available in market such as ESP 8266, PZEM004T, Real Time Clock Module DS3231, Solid-state Relay, and OLED display. In this project, experiment is done by using incandescent bulb and ballast as load to test the accuracy of voltage and current measurement of SEM and SEP by comparing it to Flukes 317 True RMS Clamp Meter. The error for voltage measurement of SEM is ranging between 0.177%-0.279% and error for current measurement is ranging from 4.274% to 6.279%. For SEP the error of voltage measurement is between 0.045% and 0.124% while error of current measurement is between 4.167% and 7.477%. The SEP in this project also provide energy management feature which been tested in this research that it is capable of saving 57.35% of electricity and 45.86% of cost for electricity when compared to load that connected to a normal power plug.

ABSTRAK

Peningkatan penggunaan tenaga elektrik disebabkan Era Teknologi Tinggi ini, penjimatan tenaga menjadi sangat penting kerana penjanaan kuasa masih sangat bergantung kepada tenaga yang tidak boleh diperbaharui. Satu-satunya alat pengukur penggunaan elektrik yang dipasang di rumah setiap orang iaitu meter elektrik sahaja yang mampu memaparkan penggunaan tenaga terkumpul. Meter elektrik jenis konvensional ini sering kali menyebabkan orang ramai tidak tahu tentang penggunaan elektrik mereka kerana sukar untuk mengesan dan menentukan peralatan elektrik yang menyumbang kepada jumlah penggunaan elektrik itu. Oleh itu, dalam projek ini Sistem Meter Elektrik Pintar (SEMS) direka untuk memudahkan proses pemantauan penggunaan kuasa peralatan elektrik dan menguruskan peralatannya. SEMS terdiri daripada Smart Electric Meter (SEM) yang memantau penggunaan elektrik semua beban di rumah dan Smart Electric Plug (SEP) untuk memantau peralatan elektrik tunggal. Komponen utama projek ini ialah komponen yang boleh didapati secara meluas di pasaran seperti ESP 8266, PZEM004T, DS3231, Solid-state relay dan OLED display. Dalam projek ini, eksperimen dilakukan dengan menggunakan mentol dan balast sebagai beban untuk menguji ketepatan voltan dan pengukuran arus SEM dan SEP dengan membandingkannya dengan Flukes 317 True RMS Clamp Meter. Kesilapan pengukuran voltan SEM adalah antara 0.177%-0.279% dan kesilapan pengukuran arus adalah antara 4.274% hingga 6.279%. Bagi SEP kesilapan pengukuran voltan adalah antara 0.045% dan 0.124% manakala kesilapan pengukuran semasa adalah antara 4.167% dan 7.477%. SEP dalam projek ini juga menyediakan ciri pengurusan tenaga yang telah diuji dalam penyelidikan ini bahawa ia mampu menjimatkan 57.35% tenaga elektrik dan 45.86% kos elektrik jika dibandingkan dengan beban yang disambungkan kepada palam kuasa biasa.

TABLE OF CONTENTS

DEDICATION i

ACKNOWLEDGEMENT ii

Abstract iii

Abstrak iv

TABLE OF CONTENTS v

LIST OF TABLES ix

LIST OF SYMBOLS xiii

LIST OF ABBREVIATIONS xiv

Chapter 1 INTRODUCTION 1

1.1 Project Background 1

1.2 Problem Statement 3

Project objectives 4

1.3 Scope of Research 4

1.4 Research Significance 5

Chapter 2 LITERATURE REVIEW 6

2.1 Introduction 6

2.2 Electricity usage in Malaysia 6

2.3 Global Warming 7

2.4 GHG reduction 8

2.5 Energy Management 8

2.6 Internet of Things 9

2.7 Types of electric meter 11

2.7.1 Electromechanical Meter 11

2.7.2 Electronic Power Meter 13

2.7.3 Smart Electric Meter 14

2.8 Fundamental laws of electricity 15

2.8.1 Ohm's law 15

2.8.2 Types of power 15

2.8.3 Power Factor 16

2.8.4 Power consumption calculation 18

2.9 Electricity Tariff in Sarawak 18

2.10 Previous works 19

2.10.1 Design and Analysis of Smart Metering Technology to implement pricing surge [32]. 19

2.10.2 A Prototype Design for 3-phase Smart Energy Meter [33]. 20

2.10.3 Design and Implementation of IOT Based Smart Energy Meter [34] 21

2.10.4 Wireless IoT-based Metering System for Energy-Efficient Smart Cities [36]. 22

2.10.5 Design and Operation of Smart Energy Meter for Effective Energy Utilization in Smart Cities [37] 23

2.10.6 Research Gap 23

2.11 Summary 25

Chapter 3 METHODOLOGY 26

3.1 Introduction 26

3.2 Project layout 26

3.3 Software Utilize 27

3.3.1 Arduino IDE 28

3.3.2 Fritzing Software 29

3.3.3 Blynk Application 30

3.3.4 XAMPP 31

3.4 Components and Materials 33
3.4.1 NodeMCU ESP8266 33
3.4.2 PZEM – 004T -100A Module 34
3.4.3 Solid State Relay 35
3.4.4 4- pin 0.96”128x64 OLED display 35
3.4.5 Real Time Clock Module (DS3231) 36
3.5 Conceptual Design 37
3.6 Basic Flowchart for Programming 41
3.6.1 Flowchart for SEM Programming 41
3.6.2 Flowchart for SEP programming 44
3.7 Calibration 60
3.7.1 Flukes 317 True RMS Digital Clamp Meter 60
3.7.2 Calibration Method 61
3.8 Application Procedure 63
3.8.1 Blynk Application Installation and Setup Procedure 63
3.9 Safety precautions 66
3.10 Cost of Components 66
3.11 Summary 67
Chapter 4 RESULT and discussions 68
4.1 Introduction 68
4.2 Development of hardware and software 68
4.3 Smart Electric Meter Coding 47
4.4 Smart Plug Coding 55
4.5 Analysis of the accuracy of voltage and current measurement 75
4.6 Comparison of SEM and SEP Power factor Measurement with Theoretical calculation 83

4.6.1 Theoretical calculation of the combination of incandescent bulb and Ballast 83

4.7 Analysis on the Energy Management Features 85

4.7.1 Electricity usage for 1 week without Energy Management. 85

4.7.2 Electricity usage for 1 week with Energy Management. 85

4.8 Database for recording electricity bill details. 89

4.8.1 Coding for inserting electric bill data into database 91

4.9 Summary 92

Chapter 5 Conclusion and Recommendations 93

5.1 General conclusion 93

5.2 Recommendation and future improvement work 94

REFERENCES 95

Appendix A 100

Appendix B 108

Appendix C 112

Appendix D 114

LIST OF TABLES

Table **Page**

Table 1: The wireless communication protocol[19]. 11
Table 2: Sarawak Energy Domestic Electricity Tariff[7]. 18
Table 3: Summary of Previous works 24
Table 4: NodeMCU Specification [40]. 33
Table 5: The Specification of PZEM-004T-100A[42]. 34
Table 6: Specification of 128x 64 OLED display[43]. 36
Table 7: The Specification of Flukes 317 True RMS Digital Clamp Meter[45]. 60
Table 8: Table to record measurement from SEMS and Clamp Meter. 61
Table 9: Total Blynk Energy used. 63
Table 10: Total cost of components 66
Table 11: Function of the library used in Smart Electric Meter Coding. 47
Table 12: Library Used in SEP coding 55
Table 13: Measurement of SEM and Fluke's Clamp Meter for 100W Incandescent Bulb. 75
Table 14: Measurement from SEM and Fluke's Clamp Meter 317 for 100W Incandescent Bulb connected in parallel with 36W ballast. 76
Table 15: Measurement from SEM and Fluke's Clamp Meter 317 for 100W Incandescent bulb and 2 36W ballast in parallel connection. 77
Table 16: Measurement of SEP and Fluke's Clamp Meter for 100W Incandescent Bulb. 78
Table 17: Measurement from SEP and Fluke's Clamp Meter 317 for 100W Incandescent Bulb connected in parallel with 36W ballast. 79
Table 18: Measurement from SEM and Fluke's Clamp Meter 317 for 100W Incandescent bulb and 2 36W ballast in parallel connection. 80
Table 19: Measurement of PZEM for 100-Watt bulb with 1 Ballast. 83
Table 20: Electricity usage for 1 week without Energy Management System. 85
Table 21: Electricity usage for 1 week with Energy Management System. 85
Table 22: Gantt Chart for FYP1 114
Table 23: Gantt Chart for FYP 2. 115

LIST OF FIGURES

Figure	**Page**
Figure 1-1: Source of Energy in Malaysia [6].	2
Figure 2-1: Emission of GHG (tons) of a different plant.	7
Figure 2-2: Three-Layer IoT Architecture	10
Figure 2-3: Five-Layer IoT Architecture	10
Figure 2-4: The electromechanical induction meter [21].	12
Figure 2-5: The schematic diagram of the electromechanical induction meter [21].	13
Figure 2-6: Electronic Power Meter [22].	14
Figure 3-1: The overall project workflow.	27
Figure 3-2: Arduino IDE interface	28
Figure 3-3: Arduino IDE Library manager	29
Figure 3-4: Fritzing Application.	29
Figure 3-5: Blynk application	30
Figure 3-6: Widget box of Blynk application	31
Figure 3-7: XAMPP control panel.	32
Figure 3-8: PhpMyAdmin	32
Figure 3-9: NodeMCU ESP 8266 [40].	33
Figure 3-10: PZEM-004T-100A [41].	34
Figure 3-11: The schematic of the 5V relay module.	35
Figure 3-12: 4- pin 0.96”128x64 OLED display [43].	36
Figure 3-13: RTC module [44]	36
Figure 3-14: Conceptual Design of the SEMS.	39
Figure 3-15: The Schematic diagram of Smart Electric Meter.	40
Figure 3-16: The Schematic diagram of Smart Electric Plug.	40
Figure 3-17; Flowchart of the programming in the Smart Electric meter.	42
Figure 3-18: Flowchart for the algorithm to calculate the electric bill.	43
Figure 3-19: Flowchart for the programming of the SEP.	45
Figure 3-20: The flowchart of remote switching and scheduling function	46
Figure 3-21: Flukes 317 True RMS Digital Clamp Meter[45]	60
Figure 3-22: The coding about the SSID, password, and Auth Token.	64
Figure 3-23: Blynk widget setup for SEM.	65

Figure 3-24: Blynk Widget Setup for SEP. 65
Figure 4-1: Hardware of SEM. 70
Figure 4-2: Hardware of SEP. 71
Figure 4-3: The Blynk application SEM. 72
Figure 4-4: The Blynk application of SEP 72
Figure 4-5: The OLED display of SEM. 73
Figure 4-6: The OLED display of SEP. 73
Figure 4-7: MySQL database for storing Electricity consumption and bill. 74
Figure 4-8: Library used in SEM coding **Error! Bookmark not defined.**
Figure 4-9: Setup coding. 48
Figure 4-10: Declaration of the variables used in SEM. 48
Figure 4-11: void setup of the SEM coding. 49
Figure 4-12: Void loop coding of SEM. 49
Figure 4-13: Code to billing details to a phpMyAdmin database. 50
Figure 4-14: Code to send a post request to phpMyAdmin. 50
Figure 4-15: Function in else statement. 51
Figure 4-16: Content of the writeScreen function. 52
Figure 4-17: Content of getReading function. 53
Figure 4-18: If and else statement for energy tariffs. 53
Figure 4-19: Code to upload data to Blynk. 54
Figure 4-20: Library used in Smart plug coding. 55
Figure 4-21: Variable in Smart Plug coding. 56
Figure 4-22: Code to get data from Blynk virtual pin. 57
Figure 4-23: void setup for SEP. 57
Figure 4-24: Coding for SEP to get data from PZEM. 58
Figure 4-25: Code to upload data to Blynk Server. 58
Figure 4-26: Code to display data at the OLED display. 59
Figure 4-27: The void loop of SEP coding. 59
Figure 4-28: The graph of the Percentage difference between the PZEM module of SEM and SEP compared to the Clamp meter against load current. 81
Figure 4-29: Graph of Electric consumption for 7 days without using energy management system. 86
Figure 4-30:Graph of Electric consumption for 7 days using energy management system. 86

Figure 4-31: MySQL database for storing Monthly electric bill details 89
Figure 4-32: The Email Monthly Electric bill from Blynk. 89
Figure 4-33: SEM coding for inserting data into MySQL database. 90
Figure 4-34: Code to insert billings details into database. 91
Figure 4-35: Test input function. 91

LIST OF SYMBOLS

Φ : Phase difference	18
i(t): Amplitude of current at the time, t	16
I: Current	15
Irms: Root-mean-square Current	17
kWh: kilowatt-hour	18
p(t): Instantaneous Power	16
P: Active Power	16
Pavg: Average power	16
pf: Power Factor	17
R: Resistance	15
S: Apparent Power	17
T: Period of time	15
v(t): Amplitude of the voltage at the time, t	16
V: Voltage	15
VAR: Reactive Power	17
Vrms: Root-mean_square Voltage	17

LIST OF ABBREVIATIONS

ADC: Analog to digital converter	23
AMR: Automated Meter Reading	13
GDDRAM: Graphic Display Data RAM	36
GDP: Gross Dosmetic Product	8
GHG: Greenhouse Gases	6
GSM: Global System for Mobile Communication module	20
HEMS: Home Energy Management System	9
IoT: Internet of Things	6
LCD: Liquid Crystal Display	20
MDAS: Meter Data Acquisition System	15
OLED: Organic Light Emitting Diode	36
RE: Renewable Energy	8
RFID: Radio-Frequency identification technology	9
RTC: Real- Time Clock	37
SEM: Smart Electric Meter	2
SEP: Smart Electric Plug	2
SMES: Smart Electric Meter System	2
SMETS: Smart metering Equipment Technical Standards	13
SMS: Short Message Service	20

CHAPTER 1

INTRODUCTION

1.1 Project Background

The electric meter is an instrument to measure the energy consumption of a building. The electric meter is used in residential, commercial, and industrial buildings to record the energy consumption so that power companies in Malaysia such as Tenaga Nasional Berhad (TNB), Sarawak Energy Berhad, and Sabah Electricity Sdn. Bhd (SESB) can issue electricity bills to its customers. The common type of electric meter is the analog electric meter, digital electric meter, and smart electric meter. Most Malaysian residential electricity users are still using analog electric meters or digital electric meters whose function is only to record energy consumption. Smart electric meters not only record users' energy consumption but also allow the user to remotely monitor energy consumption through their smartphone. The power company can also access customers' energy consumption information with the smart meter from remote. On 30 June 2021, about 1.22 million TNB customers own a smart electric meter in Klang Valley, greater Kuala Lumpur, and Melaka [1]. The installation of the smart meter installation program will be continued by the TNB till 2026 to install more smart meters in 9.1 million households [1]. In Sarawak about 1700 smart meters are installed in Kampung Gita and 6000 meters are installed at Tabuan Jaya Baru an Jalan Kempas in 2019 [2].

Based on the research done on [3], Malaysian know the energy efficiency but do not or less practice it in daily life. Increasing the efficiency in terms of electricity generation, supply, and transmission is not enough as awareness among consumers also needs to be emphasized [4]. To increase the awareness of the public about energy-saving, a smart electric meter can be used. The smart electric meter can help users to visualize how is their energy consumption behaviors contribute to their electricity bill as it updates power consumption normally at half-hourly manners. Unlike the traditional types of electric meters where the total energy consumption information is obtained from the monthly bill. Therefore, smart electric meters can provide a convenient way for the user to access energy consumption information which can increase their awareness about energy saving.

Energy saving is very important in Malaysia as the primary source of energy are natural gas, coal, and hydropower while a secondary source of energy is wind, solar, and fuel cells [5]. In 2019, petroleum and other liquids fuel lead in the energy production sector which is 37% of the total energy production [6]. Natural gas comes in second in terms of energy generation which is 36% of the total energy production [6]. 21% of electricity production comes from coal and 6% of electricity comes from renewable energy [6]. In 2002, Five Fuel Diversification Policy has been introduced by the Malaysian Government to address issues on climate change and emissions issues and reduce the dependency on the conventional source of energy such as crude, gas, coal, and hydropower [5]. Based on Figure 1-1, the source of energy in Malaysia is still dominated by the combustion of fossil fuel despite the improvement of renewable energy technologies over the years. Malaysian government aim to expose renewable energy in the range of 5% in the energy mix in 2010 but the renewable energy consumption is still low (1.8%) because of technical obstacles and lack of infrastructures [5].

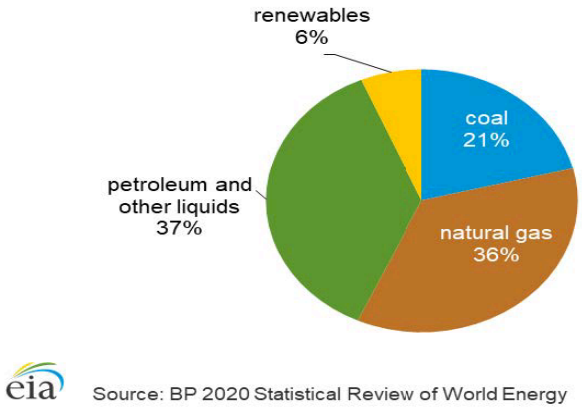

Figure 1-1: Source of Energy in Malaysia [6].

This project is to develop a Smart Electric Meter System (SMES) for a single-phase power system that can help users remotely monitor their energy consumption through the smartphone application. This device can reduce the hassle of reading the energy consumption from the display of the normal electric meter. This Smart Electric Meter (SEM) is designed to integrate with the Smart Electric Plug (SEP) at home to measure the energy consumption of individual electrical appliances. This can provide more energy consumption information for the user to easily manage their usage of energy. Besides that, the smartphone application of SEMS also incorporates a feature to remote control and schedule the electrical appliances connected to the SEP. The energy consumption information measured by the SMES will be stored in the database so that it can be accessed by the electricity providers.

1.2 Problem Statement

The main function of the existing version of the smart electric meter is to measure energy consumption and provide remote monitoring of energy consumption for the user. The measurement of energy consumption by the smart electric meter is the total energy consumption of all electrical appliances at the user's house. The individual energy consumption of individual electrical appliances is not given by a normal smart electric meter. The information given by the existing smart meter is so limited makes it user difficult to determine which electrical appliances at their home are using more energy or inefficient. This increases the difficulty for the user to have energy management as they do not know which electrical appliances contribute to more energy consumption. Even though it is possible by switching off all other electrical appliances to detect the energy consumption of the appliances that need to be measured. But the process is tedious because it is time-consuming.

Next, the existing smart electric meter does not provide enough mechanism for the user to manage their electrical appliances for energy saving. The mechanism of remote control and schedule of electrical appliances is not provided by the normal smart electric meter. Without this function, electrical appliances need to be controlled manually by users. This can cause a situation such as forgetting to switch off electrical appliances that are not in use because of carelessness or laziness. Unlike the proposed device in this project, it provides remote control of electrical appliances which allows the user to switch off appliances when they are not at home. The proposed design also provides a schedule load feature to make sure the energy usage is more consistent and can prevent wastage of energy.

Lastly, the conventional smart electric meter does not show parameters such as voltage, current, power factor, active power, and other parameters. These parameters can be useful for diagnosing or checking the condition of electrical appliances at home. By monitoring these parameters, users can easily detect faulty appliances.

Project objectives

The objectives of this research are:

- To design a Smart Electric Meter System (SEMS) that can provide real-time monitoring of voltage, current, Active power, frequency, power factor, active energy, and estimates electric bill at home.
- To design a user interface in the Blynk Application for monitoring the energy consumption and remotely managing load.
- To design a database for an electricity provider to monitor, manage and record bills from the Smart Electric Meter System (SEMS).

1.3 Scope of Research

This project aims to design a Smart Electric Metering System (SEMS) for real-time monitoring of voltage, current, real power, and power factor, kilowatt-hour (kWh) of a single-phase power system. The Smart Electric Metering system is divided into Smart Electric Meter (SEM) to measure the energy consumption of a single-phase power system of the whole house and Smart Electric Plug (SEP) to measure the energy consumption of specific electrical appliances. The design of the SEP will have the ability to interact with the SEM wirelessly by sending and receiving data to and from the SEM. The data transmitted by the SEP to the SEM will be the parameter measurement of the electrical appliances and the data received by the SEP from the SEM will be the command to switch on and off the appliances connected. The SEMS will implement the Sarawak Energy domestic type electricity tariff [7] to calculate the electricity bill. The smaller resistive and inductive load will be created to mimic the electrical appliances used in the household such as lighting, fan, electric water heater, and others.

The Blynk application is used to design the user interface that can receive real-time information of the total and individual load, and schedule or manually switch ON and OFF the load. The Blynk application allows energy consumption monitoring and manages the electrical load from everywhere with the connection of the internet. The design of the SEM and SEP will incorporate the PZEM module to measure the voltage, current, active power, and power factor of the load. ESP 8266 will be used as a microcontroller for both SEM and SEP. The application of ESP 8266 allows the connection of the Wi-Fi network for uploading of energy consumption data of the SEM and SEP to the Blynk server and displaying it on Blynk mobile application. Blynk application can also be used to connect and disconnect the load connected to the SEP.

The data of the SEMS also transmit data to MySQL database designed for the electricity provider for monitoring, managing, and billing purposes. There will be a specially designed webpage to display the data of the customers to simplify the works of the electricity provider to manage and provide bills to their customers. The webpage also provides the function to connect and disconnect their customer power supply when the electric bill is not paid in time.

1.4 Research Significance

The intentions of this project is to create an SEM that can be connected to the main power supply of the house to monitor the voltage, current, real power, and power factor in real-time. This design will serve as the replacement for the traditional electric meter in most people's houses in Malaysia. SEM design can interconnect with the SEP at home to become SEMS and provide monitoring for specific electrical loads. The information about the energy consumption of each load collected will help users to figure out the opportunities and ways to manage their electricity consumption. The design of this project can also help people to monitor the electricity consumption of their premises remotely with help of the internet. The design also provides the user interface for the user to connect and disconnect their load remotely. This feature helps the user to control their load even when there are not at home to achieve their energy-saving goal with ease. The design also eases the process of billing, managing, and monitoring for the electricity provider by providing a webpage and database to display customers' information.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Firstly, the electricity usage in Malaysia will be presented. Next, the source of electricity in Malaysia and the problem faced during the implementation of renewable energy will be discussed. Later, the information about the Greenhouse Gases (GHG) emission due generation of electricity and how it contributes to global warming will be presented. A series of plans to reduce GHG emissions related to this project in the Twelfth Malaysian Plan will also be discussed. The following part of chapter 2 will include the introduction of energy management, Internet of Things (IoT), type of electric meter available, the basic laws of electricity, and the electricity tariff in Sarawak. The last part will include the summarization of works from others research related to this project. This summary will include the material and method used, advantages and disadvantages of the method.

2.2 Electricity usage in Malaysia

Based on the Malaysian Department of Statistics, there was an increase of 4 million of the population of local citizens and foreigners from the year 2010 to 2020 from 28 million to 32 million [8]. The electrical demand of Malaysia also rises due to the incrementation in population. The situation is even worst when the increased reliability on the electrical appliances to help improve human life. Appliances such as fans, air conditioners, computers, refrigerators, washing machines, and many others have become part of our life as if one of these technologies disappeared humans will have a hard time living without it. The quality of life is improved with the help of an electrical gadget, but the energy consumption of all these appliances had gone over the board. Based on [5], Malaysia's total amount of power consumption was 4.3 billion megawatts and is expected to increase by 4.75% by 2030 and at one point in time, it will exceed 11.4 billion megawatts of Malaysia's energy supply. The region of Peninsular Malaysia, Sabah, and Sarawak shows a similar pattern for energy generation [5].