Faculty of Electrical Engineering

GREEN ENERGY MANAGEMENT SYSTEM (GreEMys)

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DECLARATION

I declare that this thesis entitled “Green Energy Management System” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :…….....

Student Name :…….....

Date :…….....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electrical Engineering (Power Electronic and Drive).

Signature :…….....

Supervisor Name :…….....

Date :…….....

DEDICATION

Specially dedicated to my family.

ABSTRACT

Tenaga Nasional Berhad (TNB) generates, transmits, distributes and sells the energy to consumer throughout Malaysia. With the global environment pollution and energy crisis, a renewable energy is playing a more and more important role in energy production. Solar energy is as a type of renewable energy. It is widely applied in manufacturing and living activities and the battery is the most common of energy storage for the solar system. Commonly, the system is already provided such Uninterruptible Power Supply (UPS) which is used as a backup power supplies while the utility system is out of stage. The battery bank from UPS is charge from the utility power supply and this system will increase the electricity bill. Nowadays, alternative way for reduce electricity bill is by using Renewable Energy (RE) such as solar energy. RE can be store into battery as a backup or it is also can used directly to the appliances. When using a multi power source, which one of the power source to be used first for optimal savings. Therefore, one system are need to make RE is first priority resource for the house and TNB are used after the battery is running out. The Green Energy Management System (GreEMys) is developed to manage the power supplies for house while the house owner used RE and TNB as a power supply. GreEMys will select either one power supply depend on the State of Charge (SOC) of battery. Through this system, while battery stored energy from GE until full, this system will choose RE for supply electricity to house and used until battery is weak, then the system will change to TNB for feed electricity to the house while waiting for the battery recharged by GE again until full. Moreover, this GreEMys can display the mode of power source either RE or TNB and also display the percentage of SOC. Through this system, GreEMys product increase electricity conservation by using solar energy at house as a priority used and TNB are used while RE from battery is exhausted.

ABSTRAK

Tenaga Nasional Berhad (TNB) menjana, menghantar , mengedar dan menjual tenaga kepada pengguna di seluruh Malaysia. Dengan pencemaran alam sekitar global dan krisis tenaga, tenaga yang boleh diperbaharui memainkan peranan yang semakin penting dalam pengeluaran tenaga. Tenaga solar adalah sebagai sejenis tenaga boleh diperbaharui. Ia digunakan secara meluas dalam aktiviti perkilangan dan hidup dan bateri adalah yang paling biasa penyimpanan tenaga untuk sistem solar. Biasanya, sistem sedia ada seperti tidak terganggu Bekalan Kuasa (UPS) yang digunakan sebagai bekalan kuasa sandaran sementara bekalan elektrik terputus. Bank bateri dari UPS akan dicaj daripada bekalan kuasa utiliti dan sistem ini akan meningkatkan bil elektrik. Pada masa kini, cara alternatif untuk mengurangkan bil elektrik adalah dengan menggunakan Tenaga Boleh Diperbaharui (RE) seperti tenaga solar. RE boleh menyimpan tenaga dalam bateri sebagai sandaran atau ia juga boleh digunakan terus kepada peralatan. Apabila menggunakan sumber kuasa yang berbagai, yang salah satu sumber kuasa yang akan digunakan yang perlu memberi keutamaan bagi penjimatan optimum. Oleh itu, satu sistem yang perlu membuat adalah menberikeutamaan kepada RE untuk rumah dan TNB digunakan selepas bateri kehabisan. Sistem Pengurusan Tenaga Hijau (GreEMys) dibangunkan untuk menguruskan bekalan kuasa untuk rumah apabila pemilik rumah menggunakan RE dan TNB sebagai bekalan kuasa . GreEMys akan memilih salah satu bekalan kuasa bergantung *State of Charge* (SOC) bateri. Melalui sistem ini , bateri menyimpan tenaga dari GE sehingga penuh , sistem ini akan memilih RE untuk bekalan elektrik ke rumah dan digunakan sehingga bateri lemah, maka sistem akan berubah kepada TNB untuk rumah sementara menunggu bateri dicaj semula oleh GE lagi sehingga penuh. Selain itu, GreEMys ini boleh memaparkan mode sumber kuasa sama ada RE atau TNB dan juga memaparkan peratusan SOC. Melalui sistem ini, GreEMys peningkatan produk pemuliharaan elektrik dengan memberi keutaman kepada tenaga solar untuk rumah dan TNB digunakan ketika kehabisan tenaga dari batteri.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

There are many reasons why people are now using Renewable Energy (RE) due to inexhaustible and pollution free renewable energy sources. For instance, solar energy attributes high durability and need no fuel. It is able to operate for lengthened period without maintenance. Therefore, solar energy is the best RE until now. The development and the use of RE have drawn extensive attention of the society. Thus, RE will be an additional source for recover the electricity usage in the home to reduce the electricity bill. Solar energy has far been considered the most easily and viable option. These make it economical for all types of applications of remote area.

1.2 Problem Statements

Currently, TNB is the primary resources for utilities. Rising energy prices and growing environment concerns are making RE system more attractive to society. Nowadays, the system are provided is as a backup power system for houses and industry such as Uninterruptible Power Supply (UPS) system. UPS systems might be used to provide uninterrupted, reliable, and high quality power for these sensitive loads. UPS provides backup power circuitry to supply vital systems when a power outage occurs. There is much type of UPS such as standby UPS is known as off-line UPS. It consists of an AC/DC converter, a battery bank, a DC/AC inverter, and a static switch. A passive low pass filter may also be used at the output of the UPS or inverter to remove the switching frequency from the output voltage.

Moreover, Online UPS also contains of converter, battery, inverter and fast static switch. Power to load is catered through conveter-inveter connection. Hence, converter should have capability to charging battery and supply load. This type of UPS is connected in series to load. Thus, this system is not the way for reduce power usage inside building but it will increase the bill that to be paid. Therefore, this project is developed as a management the power supply for user to reduce the cost of energy consumption. Through this system, it will automatic manage the power supply as a green energy is primary resources and TNB power supply as standby source while the battery is running out for reduce power consumption and also to optimize the used of battery.

1.3 Objectives

The objectives of this project are:

i. To develop an automatic management power supply from TNB or Renewable Energy (RE).
ii. To control the system based on state-of- charge (SOC) of battery (limit to 30%).

1.4 Scopes

The scopes of the project are:

i. This project only for single phase power supply.
ii. Supply voltage is 240 Volt with current rating 30 Ampere.
iii. This project measure the voltage and state of charge level on a battery that charge from the photovoltaic system.
iv. This system utilizes the ARDUINO as a microcontroller as the switching system.

1.5 Report Outline

This report contains of five (5) chapters start with the introduction chapter that consists of brief explanation of the research which is Green Energy Management System (GreEMys) and why it is proposed. The objectives, scope and the significant of the research also presented in this chapter. Other chapters in this report are arranged as follow:

CHAPTER 2 discuss about the literature review for this research. This chapter is including an explanation about the utility system, RE, SOC of battery and previous project. The various types of selector of power supply topologies and measurement of the SOC for battery also will be described in this chapter.

CHAPTER 3 discuss about the methodology for this project. All the methods used in accomplishing this research are explained and all the flowchart and milestone are presented in the earlier section of this chapter. The concept of GreEMys also will be discussed in details with the help of particular flow chart, figure, and block diagram. The diagram of circuit and implementation of hardware also will be presented.

CHAPTER 4 gathered all the results get from the testing of the circuit and coding are taken for analysis. The result gathered is discussed in details in this chapter.

CHAPTER 5 shows the conclusion and recommendation of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will be discussed regarding on literature review conducted in order to gain enough information that can be used to complete the research. All the data are included in this chapter are taken from journals, thesis, books and any academic articles that are related to the research topic and will be clearly cited. The National Energy knowledge, solar system installation and calculation SOC of battery are discussed in subsequence so that it can be clearly understood. The related previous work such as Uninterruptible Power Supply (UPS) system also presented.

2.2 National Energy

Tenaga Nasional Bhd (TNB) is a largest supplier electricty in Malaysia. There are consist of three main core activities for manage the power supply namely generation, transmission and distribution. TNB also commite with the renewable energy and has been diversifying generation from mix source energy. The genertaion are mix from the fossil fuel, hydro and Renewable Rnergy (RE) such as solar energy and also being efforts producing electricity using biogas and biomass. Figure 2.1 shows the electricity network illustration tie into house from generation plant to the distribution and load [1].

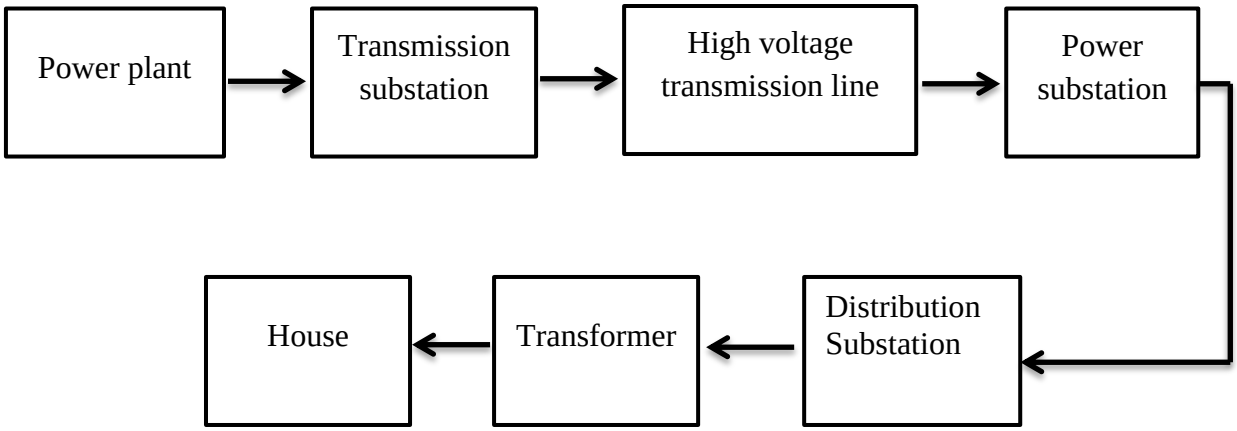

Figure 2.1: The electricity network illustration tie into house.

2.3 Renewable Energy (RE)

RE is a source comes from naturally such as biomass, biogas, solar, wind and mini-hydro. Malaysia is well rich natural resources due to an extremely moderate climate around the years. Most of these energy resources are yet to be exploited. Thus, RE technology could be the alternative source for the energy production include water (hydroelectric and marine energy), solar (thermo and photovoltaic), wind (single turbine or wind field), Geothermic sources and biomass. Geographically, Malaysia is located at the equator and solar energy resources are abundant and readily available for this project [1].

2.3.1 Photovoltaic (PV) Power System

PV power system consists of Photovoltaic panel, inverter and load as a receiver as shown in Figure 2.2. Photovoltaic panel are convert energy from sunlight into electricity in Direct Current (DC) power without any intermediate step. Inverter is required to convert Direct Current (DC) into Alternating Current (AC) power for house appliances. The power is provided by the PV panel which is proportional to PV size. This system is not maintenance free to keep it running optimally but a minimum level of maintenance is needed. To ensure the system operate efficiently, maintenance is a solution to prevent problem in future [2].

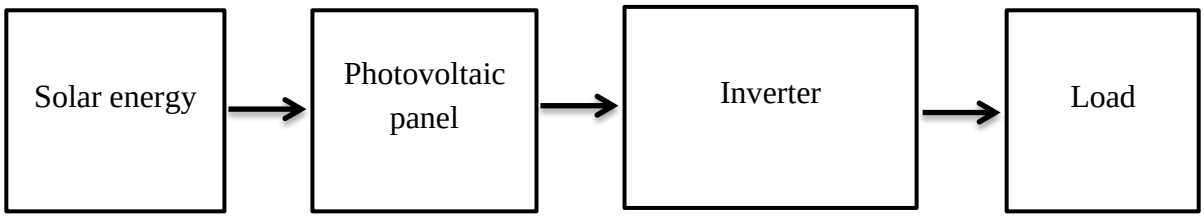

Figure 2.2: The basic home solar system.

2.4 Energy Storage

Energy can be store into battery by holding difference electro-chemical active materials. Therefore, battery can be generated and stored free electrons for a long periods of time. Existing of the chemical inside the battery allows battery to store energy chemically as bi-product of a chemical reaction. Since electrical charge has a polarity, a battery also contains positive terminal (+ve) and negative terminal (-ve). If it polarity is opposite of its own polarity, the charge at battery will try to travel towards the polarity [4].

2.4.1 Battery for Solar Energy

Lead-Acid Battery is chosen to store energy from PV panel for this project. It calls Lead-Acid Battery because the electrode and grids are made from lead and the electrolyte is sulfuric acid. The plate polarity is determined by an active material from some formulation of lead oxides. It is because an active material is placed in physical contact with the grid. Basically, the most common purpose of battery is to start an engine. It is use to energize the starter motor that turns on internal combustion engine. Second, the battery used as stand-by-mode waiting to provide backup power for substation. Third is a deep-cycle application such as the battery can deliver the majority of its capacity repeatedly, possibly on a daily basis. Typically use for Electric Vehicle (EV) application is like a combination of engine start and deep-cycle. Therefore, deep-cycle is suitable for this solar system while charge and discharge sequence are do rapidly [8].

2.4.2 Battery Measuring Method

The lead-acid battery is widely used in stand-alone solar power systems. For reliable operation for this GreEMys system, it is importance to know the amount of battery remaining in the battery at any point of time. The life of the battery will be reduced due to the deep cycle. Damaging effect is also happened to battery while the battery frequent overcharging. Thus, it is necessary to indicate the State of Charge (SOC) of battery to utilize the battery.

SOC of battery indicates the amount of available energy expressed as the percentage of the rated energy. The SOC of the battery is between 0% and 100%. The SOC for fully charged battery is 100% and for an empty battery is 0%. The variation in the battery voltage is very small [3]. Hence SOC can be expressed by the available capacity (AHr) as the percentage of the rated capacity (AHr).

$$SOC = \frac{Ah\ capacity\ remaining\ in\ the\ battery}{Rate\ Ah\ capacity} \times 100\% \qquad (2\text{-}1)$$

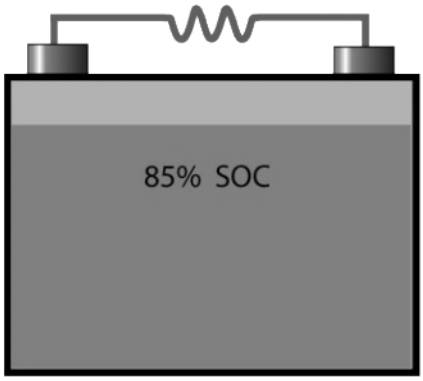

Figure 2.3: The illustration for the SOC of battery.

Through this project, specific gravity method, open circuit voltage method and current integration method have been proposed to determine the SOC of battery. The battery voltage and current have to be monitor to ensure that battery never operated in an unsafe region. The accuracy calculation of SOC can be effect to the system because the SOC value is used to control GreEMys system. These methods are discussed below [3].

A. Specific Gravity Method.

For this method, give the concentration of acid in electrolyte. The concentration of active material and the active material is consumed when the battery discharged. Available capacity of the battery by using specific gravity method can be obtained in direct indication. The measurement of this method is involved by removing the electrode from the battery. The acid specific gravity and charge level is indicated in the Figure 2.4. According to the graph, it show that overcharged for specific gravity is above 1.3 per cell and very low capacity from 1.13 until 1.15 per cell while discharged for specific gravity is below than 1.12 per cell.

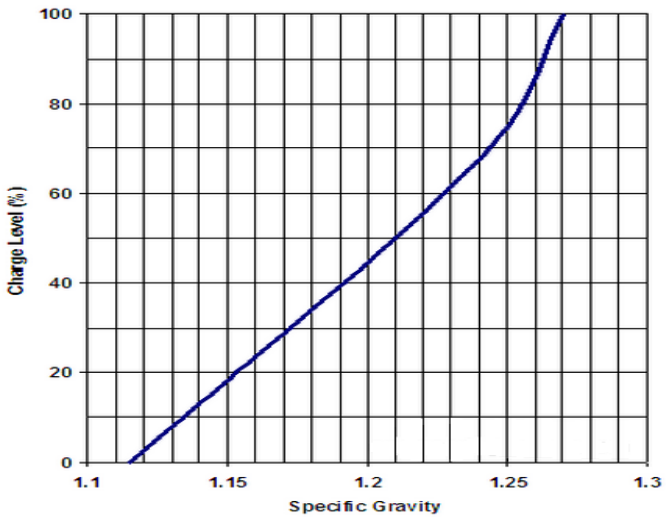

Figure 2.4: Acid Specific Gravity and charge level.

B. Open Circuit Voltage

This method is concentration of acid near electrodes. The SOC of this method is linear function of the open circuit voltage. The length stabilization method time is same with specific gravity method. Refer to Figure 2.5, 2.10 volts/cell is considered to be fully charge and completely discharge when voltage is 1.95 volts/cell. Thus, variation of open circuit voltage is linear to the SOC of battery [3]. SOC can be calculated by using the relation below (2-2) where, Voc is the open circuit voltage of the cell.

$$soc = \left[\frac{200}{3} \times V_{oc}\right] - 1300 \qquad (2\text{-}2)$$

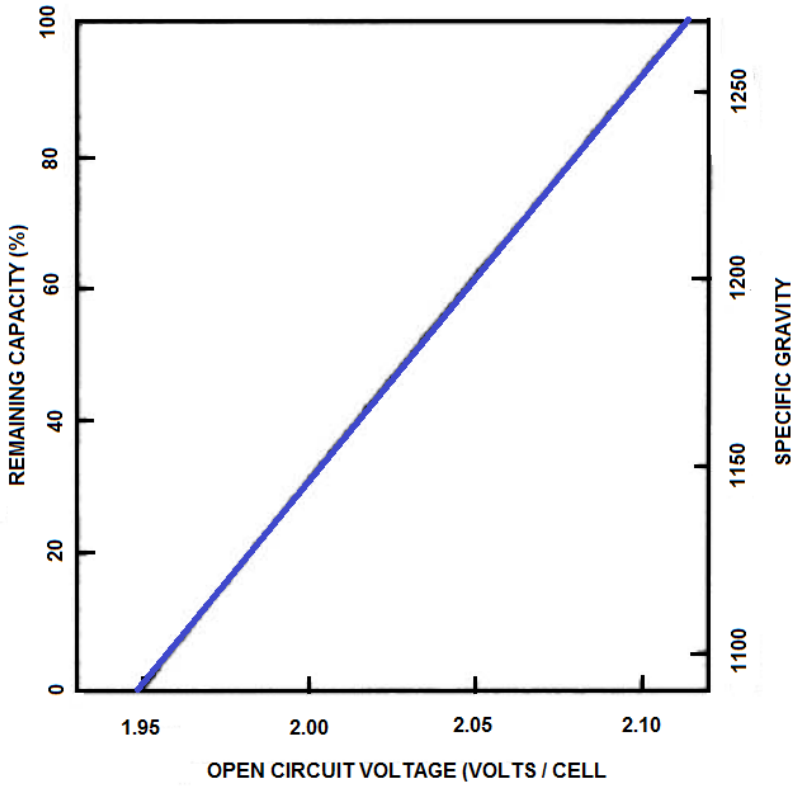

Figure 2.5: Open circuit voltage versus remaining capacity and specific gravity method.

C. Current Integration Method

It is a process of summing the amount of capacity taken from current flowing or out of a battery. Integration method for this current over time is in order to determine the battery capacity [3]. The integration of current is referred as Coulomb counting can be mathematically represented as:

$$SOC = 100\left(1 - \frac{1}{Q}\int_{t0}^{t} i\,(t)\,dt\right) \quad (2\text{-}3)$$

Where, Q is the capacity of the battery and i(t) is the current flowing or out of a battery over time.

2.4.3 Efficiency of Battery

Table 2.1 shows the limitation of SOC for charge and discharge battery. It is importance to care life span and efficiency of battery. For longest life, limitation for battery discharge should stay in the 40% of SOC and above. Sometime near to 30% or 20% of SOC are not harmful, but continuously discharge until these levels will be shortening battery life considerably. If the batteries discharge until 10%, it will harm the battery. The voltage measurements are only approximate but the best to determine the SOC is by using specific gravity method [5].

Table 2.1: The approximate of SOC and voltage per cell by using specific gravity method.

SOC (%)	Battery level (volt)	Volts per Cell
100	12.73	1.277
90	12.62	1.258
80	12.50	1.238
70	12.37	1.217
60	12.24	1.195
50	12.10	1.172
40	11.96	1.148
30	11.81	1.124
20	11.66	1.098
10	11.51	1.073