FEASIBILITY STUDY OF HYBRID PV/DIESEL ENERGY SYSTEM AT INSTITUT KEMAHIRAN MARA JOHOR BAHRU

MOHD SAIFULIZAN BIN OMAR

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical – Power)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JANUARY 2015

To my beloved wife, for her sincere love,
support and encouragement.

ACKNOWLEDGEMENT

First and foremost, I would like to extend my grateful to Allah S.W.T, who answered my prayers in regard of my project. I deeply appreciate the wisdom that Allah had provided for me in this project.

I would like to express my deepest gratitude and appreciation to my project supervisor, Dr. Shahrin Md Ayob for his guidance throughout preparing the research project. Also, special gratitude to all my friends and who have contributed to the completion of this project. My great appreciation dedicated to the management staff of Institut Kemahiran MARA Johor Bahru for their contribution, guidance and assistance at various occasions.

Last but not least, I would like to express my appreciation to those who have been involved directly and indirectly in completing this project.

ABSTRACT

Nowadays, energy management wisdom is not measured by providing electricity solely. A well-established energy management characteristic should imposed a stable, reliable, sustainable, cost-wise, efficient and environmental health. One of the ideas to reinforce the need is to adopt renewable energy (RE) in the system i.e. solar, wind, tidal and etc. This work analyse the performance and feasibility of the hybrid PV/diesel energy system. The analyse will take account several constraints such as electricity consumption, trend of existing users, appropriate installation, return of investment (ROI) period, reduction to maximum power demand and total saving of bill payment to utility provider. The analysis will be carried out using well known software tool, HOMER software. Through the software, the technical feasibility is simulated and the optimal system configuration is determined. Three type of power system configurations are analysed; stand-alone system, hybrid PV/diesel without battery and hybrid PV/diesel with battery. Optimal energy system including energy production, cost of energy, net present cost and CO_2 emission also explained in this paper.

ABSTRAK

Pengurusan tenaga elektrik pada hari ini bukan sekadar diukur daripada hasil pengagihan elektrik semata-mata. Aspek pengurusan kini diukur dari segi kestabilan, kebolehpercayaan, kos pengurusan, kecekapan serta kesan kepada alam sekitar tenaga elektrik itu sendiri. Pelaksanaan tenaga boleh diperbaharui (RE) merupakan satu idea dalam mencapai misi pengurusan tersebut. Sebagai contoh sumber tenaga boleh diperbaharui ialah tenaga solar *photovoltaic* yang menjanjikan sumber bekalan dari matahari yang sentiasa mencukupi selagi matahari wujud, dapat menjimatkan kos bagi pihak pembekal dan bebas dari pencemaran. Beberapa perkara perlu diperhalusi sebelum pembangunan serta pelaksanaan sumber tenaga boleh diperbaharui ini dilaksanakan. Antaranya ialah, kadar penggunaan tenaga elektrik, pemasangan yang bersesuaian, jangkamasa pulangan atas pelaburan (ROI) serta kadar pengurangan ke atas permintaan tenaga maksimum dan bayaran bil kepada pembekal tenaga. Kertas laporan ini akan menganalisis komponen utama dalam membangunkan model sistem tenaga *Hybrid PV/Diesel* menggunakan perisian HOMER bagi mengoptimumkan hasil tenaga elektrik berdasarkan perkara yang tersebut di atas. Analisis model akan melibatkan tiga konfigurasi yang berbeza; *stand-alone* sistem, *Hybrid PV/diesel* tanpa bateri dan *Hybrid PV/diesel* dengan bateri. Pengurusan sistem tenaga secara optimum akan turut dibincangkan merangkumi aspek pengeluaran tenaga, kos bagi tenaga elektrik, kos bersih bagi pengeluaran tenaga dan juga kesan pencemaran karbon dioksida (CO_2).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

NPC	-	Net Present Cost
KeTTHa	-	Ministry of Energy, Green Technology and Water
UNDP	-	United Nations Development Programme
MBIPV	-	Malaysia Building Integrated Photovoltaic
PV	-	Photovoltaic
CO_2	-	Carbon Dioxide
HOMER	-	Hybrid Optimization Model for Electric Renewable
DC	-	Direct Current
AC	-	Alternating Current
FiT	-	Feed-in-Tarif
kWh	-	kilo Watt hour
IGBT	-	Insulated Gate Bipolar Transistor
UPS	-	Un-interruptible Power Supply
HVDC	-	High Voltage Direct Current
NREL	-	National Renewable Energy Laboratory
RESs	-	Renewable Energy Sources
TNB	-	Tenaga Nasional Berhad
kW	-	kilo Watt
DOD	-	Depth of Discharge
COE	-	Cost of Energy

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Electricity energy in Malaysia

Nowadays, the global issues that are often discussed related to renewable energy sources for electricity generation is a hybrid power system. This hybrid power system is a priority to the production of renewable technologies and carbon reduction resulting from conventional power generation or fossil fuel based. In addition, most of the countries in the world are now beginning to realize the importance of technology which is more environmentally friendly and willing to invest millions of dollars in developing this hybrid power system technology.

Due to rapid growth in world's population and development, conventional power generation using fossil fuel i.e. coal and gases is widely used for power generation. Since fossil fuel is not renewable sources, therefore increasing in electrical generating demand at the same time decreasing in source supply, will cause huge problems in generating electricity as the price for energy sources will raise drastically. Hence, exploitation of renewable sources of energy is imperative to mitigate energy crisis and eventually to minimise environmental degradation due to burning of fossil fuels in the future.

Malaysia is using mixed generation to provide the power supply needed by domestic, commercial and also industries. The generation fuel mix is 46.8% gas, 45.6% coal, 3.8% oil & distillate and 3.8% from hydro and other forms of source [1]. In order to manage with the increasing electricity consumption trends, it is desirable to explore every possible avenue for generating more energy. One of the options to overcome this profound energy issue is by exploitation of indispensable renewable sources of energy such as solar energy.

In Malaysia, solar energy is one of the attractive renewable energy since Malaysia climate is favourable for solar energy development and solar is identified as the cleanest renewable energy. Averagely, Malaysia receives 4.21-5.56kWh/m2 daily solar irradiation with 12 hours of daily sunlight [4]. Since 2005, Ministry of Energy, Green Technology and Water Malaysia (KeTTHa) collaborate with United Nations Development Programme (UNDP), Global Environment Facility and private sector in promoted grid-connected PV applications through Malaysia Building Integrated Photovoltaic (MBIPV) Project [7]. Based on Energy Balance Report 2011, installed capacity for solar energy in Peninsular Malaysia is 0.80 MW while Sarawak is 0.02 MW [13].

In spite of abundant availability of solar energy, a PV system alone cannot satisfy load on a 24 hour basis especially at night and due to unexpected condition of day like cloudy or rainy and also when it needs to supply electricity for large energy demand. Thus, research has been conducted to optimize PV system such as hybrid PV/diesel system. Hybrid PV/diesel is a combination of solar with diesel generator set and battery as storage devices for purpose of supplying maximum load on a 24 hour basis and lower the installation costs because such projects require large capital investments and exhibit high costs of production. This system have an advantages of reducing the operation and maintenance cost besides reduce carbon dioxide (CO_2) emission. In hybrid PV/diesel system, primary source that supply energy to the consumer is solar and excess energy will be stored in battery bank, while secondary source is generator set and will be operate when needed [11].

Hybrid PV/diesel system usually used as off-grid power generation to supply energy at remote or rural area whereby geographical structure are not suitable for developing grid system. In Malaysia, this hybrid system have been installed at a few area such as five islands of Mersing (Johor), aborigines village Kampung Denai (Pahang), middle and top station of Langkawai Cable Car (Langkawi), Pulau Kapas (Terengganu) and many more [11].

1.2 Problem Statement

Due to the increasing of world populations especially in Malaysia, the needs for electricity have been crucial. Thus the generation costs of electrical energy by using conventional fossil fuel were increase every year. Therefore, development of hybrid generating systems that are low in pollutions, operating cost and use a renewable energy sources has to be investigated. Based on utilities bill, Institut Kemahiran MARA Johor Bahru (IKM JB) spends over RM 300 thousands annually on electricity cost [2]. Nowadays, people increase the intelligent in energy resources with focusing on reliable, high efficiency, wise-cost and health environmental. This idea is supported by many other country already implement the solar PV as the alternative energy.

1.3 Objectives

The main objective of this project is to develop the alternative energy system by using hybrid PV / diesel system to suit with power demand in IKM JB. Besides,

to design and simulate the whole system of hybrid PV / diesel by using suitable software known as Hybrid Optimization Model for Electric Renewable (HOMER). Apart from that, the performance obtained from the simulation are analysed in terms of economic and CO_2 emission.

1.4 Scope of Project

The scope of this project is to design and simulate the alternative energy system via HOMER software and obtain the best performance from three (3) different power system configurations that will be proposed to IKM JB. The scope is then narrowed to analyse the system that can be cope the energy demand on management building *(Bangunan Integrasi)* at IKM JB.

1.5 Expected Benefits

These results obtained from this research would be used as a guideline when implementing hybrid PV / diesel energy system. Implementation of solar hybrid energy system can improve reliability and energy services, reduced emissions and pollutions, provide continuous power supply, reduces cost and more efficient use of power.

1.6 Thesis Outline

This thesis comprises of 6 chapters. Chapter 1 discusses the energy scenario in Malaysia as well as the electricity demand trend and the potential of renewable energy in future. Chapter 2 will discuss briefly about the basic operation of PV / diesel hybrid power systems. This chapter discussed in detail about PV modules, generator set, inverter, battery and simulation tools.

In chapter 3 discussed in detail the research methodology applied in the project. Chapter 4 describes system design overview also discuss energy load profile, specification of components and system configuration.

Chapter 5 presents the results and analyse the system configuration designed. This chapter analyse three types of power system configuration which are standalone system, hybrid system with battery and without battery. In addition, optimal energy system including energy production, cost of energy, net present cost and CO_2 emission also explained in this chapter. Finally, chapter 6 will summarize the results and discussions from previous chapter and some ideas were propose for future works.

REFERENCES

[1] Investor Relation & Management Reporting Department – TNB Group Finance Division, *Invest Malaysia 2013 – Asean's Multinational Marketplace* Shangri-La Hotel, Kuala Lumpur, June 2013.

[2] Haji Jasni B. Kulop-PPTK IKM Johor Bahru, *Expenses Report of IKM JB Management & Planning Meeting Bil. 5/2012*.

[3] Dr. Tan Chee Wei, *MEP 1683 – Alternative Energy Technology System lecture note*, Department of Energy Conversion, Faculty of Electrical Engineering.

[4] The Malaysian Meteorological Department website. [Online]. Available: http://www.met.gov.my/2013.

[5] The KeTTHA website. [Online]. Available: http://www.kettha.gov.my/.

[6] Annual Report 2011, *Sustainable Energy Development Authority Malaysia*.

[7] S. Shaari, A.M Omar, A.H. Haris & S.I. Sulaiman. *Solar Photovoltaic Power: Designing Grid-Connected Systems*, 1st ed.,Ministry of Energy, Green Technology and Water, Malaysia/MBIPV. Putrajaya, Malaysia, 2010.

[8] REN21 – Renewable Energy Policy Network for the 21st Century, *Renewables-Global Futures Report 2013*.

[9] Dihrab, S. S. and K. Sopian, *Electricity generation of hybrid PV / wind Systems in Iraq*, 2010.

[10] Yamegueu, D, Y. Azoumah, et al, *Experimental study of electricity generation by Solar PV/diesel hybrid systems without battery storage for off-grid areas*, 2011.

[11] Rahimuddin Baharudin, Mohd Azhar Abd. Rahman, *Renewable Energy Technology for Off-Grid Power Generation Solar Hybrid System*, TNB Energy Services Sdn Bhd, 2008.

[12] Bernal-Agustín, J. L. and R. Dufo-López, *Simulation and optimization of stand-alone hybrid renewable energy systems*, 2009.

[13] The Energy Commission website. [Online]. Available: http://meih.st.gov.my/.

[14] A. Y. Azman , A. A. Rahman, N. A. Bakar, F. Hanaffi, A. Khamis, *Study of Renewable Energy Potential in Malaysia* IEEE First Conference on Clean Energy and Technology CET, 2011.

[15] H. Fayaz, N.A. Rahim, R. Saidur, K. H. Solangi H. Niaz, M.S. Hossain, *Solar Energy Policy: Malaysia VS Developed Countries* IEEE First Conference on Clean Energy and Technology CET, 2011.

[16] Bernal-Agustín, J. L. and R. Dufo-López (2009). *Simulation and optimization of stand-alone hybrid renewable energy systems* Renewable and Sustainable Energy Reviews 13(8): 2111-2118.