POTENTIAL OF SOLAR FARM DEVELOPMENT AT UTM CAMPUS FOR GENERATING GREEN ENERGY

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DEDICATION

Glory and praises be to God the Almighty
for the completion of this project report

To my beloved mother and father
who have been my inspiration. Without their love and support
this project would not have been made possible

Thank you for all love and inspiration
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ABSTRACT

Energy is an important element in human life. Previous study discovered that buildings consumed more than 40% of global energy mainly electricity and emit 1/3 of global greenhouse gas through combustion of fossil fuels for generating electricity. Nowadays, global warming is a major issue facing the world and it leads to a better awareness about renewable energies as alternatives in generating electricity. In certain countries, solar farm is adopted as an alternative in producing electricity. UTM spent millions of money yearly for electricity bills and UTM could consider solar farm as an energy option in generating green electricity due to suitable climate and huge land bank. Government's incentives and decreasing PV panel price are opportunities to be appreciated for UTM to implement solar farm. However, high initial investment is needed to construct the solar farm. Additionally, decision will be based on financial benefits of the construction. The aim of this study is to identify potential of solar farm implementation in generating green electricity. Data was acquired via literature review, questionnaire survey, record review, and expert interview. The data from questionnaire surveys were analysed by using Statistical Packages for Social Science (SPSS) and Average Index Value have been utilised for the analysis. Calculations on payback period and NPV were made based on interview data to identify potential of investment for solar farm. The study outlines the benefits, challenges, and suitability factors for UTM to implement solar farm, at the same time financial benefits of solar farm implementation is portrayed. This study revealed that high education institution such as UTM has a big influence to increase public awareness on solar energy. Furthermore, the research discovered that 1 MWp capacity of solar farm will cost approximately RM 9 million for initial investment with payback period less than 10 years and it is more profitable compared to investment with 7% annual return based on NPV calculation.

ABSTRAK

Tenaga ialah satu elemen yang penting dalam kehidupan manusia. Berdasarkan kajian, didapati bangunan-bangunan menggunakan lebih 40% daripada tenaga global yang kebanyakannya ialah tenaga elektrik dan merupakan penyumbang kepada 1/3 daripada pembebasan gas rumah hijau global melalui pembakaran bahan api fosil untuk penjanaan tenaga elektrik. Kini, pemanasan global menjadi isu utama yang melanda seluruh dunia yang sekaligus meningkatkan kesedaran mengenai tenaga boleh diperbaharui sebagai alternatif dalam penjanaan elektrik. Di sesetengah negara, ladang solar telah dipraktikkan sebagai alternatif untuk menjana elektrik. Setiap tahun UTM membelanjakan jutaan ringgit untuk tenaga elektrik. Oleh itu, ladang solar ialah satu potensi bagi UTM untuk menjana elektrik berdasarkan kesesuaian cuaca dan rizab tanah yang luas. UTM harus memanfaatkan peluang yang ada antaranya insentif dan galakan daripada kerajaan dan penurunan harga panel PV. Namun, jumlah pelaburan yang besar diperlukan bagi pembinaan ladang solar. Keputusan bagi pembinaan ladang solar diputuskan berdasarkan jangkaan potensi pelaburan. Sasaran utama kajian ini adalah untuk mengenal pasti potensi bagi pembinaan ladang solar untuk menjana elektrik. Data-data telah dikumpulkan melalui beberapa kaedah seperti soal selidik, kajian rekod (record review), dan temuramah pakar (expert interview). *Statistical Packages for Social Science* (SPSS) telah digunakan untuk menganalisis data yang diperoleh melalui kaedah soal selidik dan *average index value* diaplikasikan dalam analisis tersebut. *Payback period* dan *net present value* dikira berdasarkan nilai anggaran yang diperoleh melalui sesi temuramah dengan pakar-pakar bagi menentukan potensi pelaburan dalam ladang solar. Kajian ini menyenaraikan manfaat, cabaran, faktor kesesuaian, serta potensi pelaburan bagi UTM untuk membina ladang solar. Kajian ini menunjukkan institusi pengajian tinggi seperti UTM mempunyai pengaruh yang besar untuk meningkatkan kesedaran orang ramai mengenai tenaga solar. Kajian ini juga mendapati ladang solar yang berkapasiti 1 MWp akan menelan belanja kira-kira RM 9 juta untuk pelaburan awal dengan *payback period* kurang daripada 10 tahun dan ia lebih menguntungkan berbanding pelaburan dengan 7% pulangan tahunan berdasarkan kepada pengiraan *net present value*.

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LIST OF ABBREVIATIONS

CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
DL	-	Distribution Licensee
EIA	-	Energy Information Administration
FD	-	Fixed Deposit
FiT	-	Feed in Tariff
GHG	-	Green House Gas
H	-	Average Monthly Solar Radiation
HVAC	-	Heating, ventilation, and air conditioning
IPCC	-	Intergovernmental Panel on Climate Change
LED	-	Light Emitting Diode
KeTTHA	-	Ministry of Energy, Green Technology and Water
MW	-	Mega Watt
MWp	-	Mega Watt peak
NASA	-	National Aeronautics and Space Administration
NPV	-	Net Present Value
O&M	-	Operational and Maintenance
PNB	-	Permodalan Nasional Berhad
PSS	-	Power Systems Study
PV	-	Photovoltaic
RE	-	Renewable Energy
RES	-	Renewable Energy Source
SD	-	Sustainable Development
SEDA	-	Sustainable Energy Development Authority

SPSS	-	Statistical Packages for Social Science
SREP	-	Small Renewable Energy Programme
TNB	-	Tenaga Nasional Berhad
TPES	-	Total Primary Energy Supply
UiTM	-	Universiti Teknologi MARA
UPM	-	Universiti Putra Malaysia
UTM	-	Universiti Teknologi Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Research Background

According to several researches, it is found that 40% of global energy is consumed by buildings and most of them in form of electricity. Based on a research carried out by UNEP's Sustainable Buildings & Climate Initiative (SBCI), it is discovered that the buildings' energy consumption leads to one third of global Greenhouse Gas (GHG) emissions. Buildings consume most of the energy during operational phase to meet various energy needs by occupants. Research shows that 80% of GHG is emitted during operation of home appliances such as heating, ventilation, and air conditioning (HVAC), water heating, lighting, entertainment and telecommunications in the building (Junnila, 2004; Suzuki and Oka, 1998; Adalberth *et al.*, 2001).

Over the last decade, world recorded a significant population increases. On the other hand, global economy grew dramatically especially in developing countries for example China and India. These environments lead to rising of global demand for energy. An estimation made by experts indicate that in 2030, world's energy needs could be 50% higher than they are today and the world still depends on fossil fuels as

the main energy sources (IEA, 2012a). This is a scary estimation as the fossil fuels are finite resources and there is only a limited supply of them in the earth's crust. Fossil fuels are non-renewable energy sources and took over millions of years to be form from the remains of dead organisms. Fossil fuels took so long time to form that they cannot be replaced once they have been used up. Limited reserves of fossil fuels and increase in worldwide energy demands will lead to high price of energy sources in future.

Most of global Carbon Dioxide (CO_2) is emitted by fossil fuelled power stations. Fossil fuelled power stations contribute to one-quarter of global emissions based on more than 50 000 power plants and 4 000 power companies in every country (CARMA, 2012). In a normal practise, a fossil-fuel power station generates electricity by burning fossil fuels such as coal, natural gas or petroleum. In many countries, central station fossil-fuel power plants are designed on a large scale for continuous operation to provide most of the electricity needs. It is a common practise to directly discharge flue gas from combustion of the fossil fuels especially CO_2 to atmosphere.

Global warming is a crucial phenomenon facing by the world and it is mainly caused by greenhouse effect where water vapour, CO_2, methane and other atmospheric gases absorb outgoing infrared radiation resulting in the raising of the temperature. CO_2 is a major contributor to global warming based on observations over the last 100 years because it is the most significant pollutions produced by human (IPCC, 2007). One of the most significant activities regarding CO_2 emission is fossil fuel burning where it has produced about three-quarters of the increase in CO_2 from human activity over the past 20 years (Pearson P.N. and Palmer M.R., 2000).

Current trend shows that energy demands keep increasing to capture economic growth around the world and at the same time the world are facing with limited quotes of fossil fuels. Hence, renewable energy sources (RES) are the

alternatives in electricity generation issues. Renewable Energy (RE) is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Alternatives in electricity generation can be from solar power, geothermal power, wind power, tidal power, hydroelectric power, and etc. (IEA, 2012a).

RE provides 19% of electricity generation worldwide with 16% of global electricity coming from hydroelectricity and 3% from new renewables such as small hydro, modern biomass, wind, solar, geothermal, and biofuels (REN21, 2011). Some countries get most of their power from renewables, including Iceland (100%), Norway (98%), Brazil (86%), Austria (62%), New Zealand (65%), and Sweden (54%) (REN21, 2010).

Worldwide RE capacity for many technologies recorded significant grew annually. Growth was accelerated rapidly in 2009 relative to the previous years for many renewable technologies especially solar power and wind power. However, grid-connected PV increased the fastest of all renewables technologies, with a 60% annual average growth rate in 2009 (REN21, 2010).

According to a 2011 projection by the International Energy Agency, solar power generators may produce most of the world's electricity within 50 years, dramatically reducing the emissions of greenhouse gases that harm the environment. Photovoltaic (PV) and solar-thermal plants may meet most of the world's demand for electricity by 2060 and half of all energy needs. Wind, hydropower, and biomass plants may supply much of the remaining generation of electricity. PV and concentrated solar power together can become the major source of electricity (IEA, 2012a).

1.2 Problem Statement

In Malaysia, previous record shows that 94% of our electricity is generated using fossil fuels, and it is expected that there will be not much change over the next decade. In 2011, electricity generation by Tenaga Nasional Berhad (TNB) consisted of gas (45%), coal (44%), hydropower (5.7%), distillate (2.5%), oil (2.5%), and the remaining 0.3% was direct electricity imported from Singapore (The Star, 2012). Therefore, process of producing electricity contributes to emission of greenhouse gases such as CO_2 and Carbon Monoxide (CO) that can cause global warming and pollution to environment. UTM use a lot of electricity that generated by TNB and hence by constructing solar farm, it will help to reduce emission of carbon and other pollutions.

In order to response to global trend of renewable energy, the Government of Malaysia offers attractive incentives to energy producers and users in Malaysia to encourage the generation of RE and to enhance national economic growth for the future. The Ministry of Energy, Green Technology and Water (KeTTHA) hold full responsibility to implement national policies regarding to renewable energy. The ministry targets to accelerate the adoption of RE initiatives in Malaysia. Companies which generate energy using RE resources such as biomass, biogas, hydropower and solar power either for generation of electricity to sell to local utility providers or for their own consumption are eligible to apply for the fiscal incentives offered by the government, for examples (KeTTHA, 2009):

i) Pioneer Status with income tax exemption 100% of statutory income for 10 years; OR
ii) Investment Tax Allowance (ITA) of 100% on qualifying capital expenditure incurred within a period of 5 years. This allowance can be set-off against 100% of statutory income for each year of assessment; AND
iii) Import duty and sales tax exemption on equipment used to generate energy from renewable sources not produced locally and sales tax exemption on equipment purchased from local manufacturers.

There are several projects done by some entities to response with PV technology in generating electricity. One of the projects is Cypark solar farm that located on a closed 26ha landfill in Pajam, Negeri Sembilan, with an installed capacity of 8MWatt (Bernama, 2012). On the other hand, the State of Melaka will build a 5MWp solar PV farm at the Melaka World Solar Valley in the Rembia Industrial area (New Straits Times, 2012). Many entities in Malaysia show their interest in generating electricity by applying PV technology. Therefore, UTM as a leading university in engineering in Malaysia should initiate an action towards utilising solar energy to be benefitted by all the populations so that it can be a role model to other parties in Malaysia.

Every University is a model of small city where it has many buildings, labs, offices, and hostels. Each of these facilities consumes much electricity for the daily life activities of the populations. Universiti Teknologi Malaysia (UTM) itself has many building where most of them are equipped with HVAC system which consumes most of the electricity for the buildings. Previous records show that UTM spent around RM 20 million annually for electricity bills and any action to generate electricity from free renewable sources would give significant result to UTM.

Annual UTM's electricity consumption exceeds $50x10^6$ kW/h. Many actions have been taken by UTM to reduce electricity consumption. For instance, retrofit action by changing to T5 tube and LED street lighting, energy management by centralising air conditioner, and energy saving campaign. However, these actions were unable to record significant reduction in electricity consumption. In order to respond to low carbon campus, UTM may consider green energy as an alternative and solar farm is one of the green energy power plant. Thus, UTM will play a role in reducing carbon emissions and pollutions.

Nowadays, cost for installation of PV cell solar panel for generating electricity is decreasing as a result of mass production of PV cell and enhancement of technologies in producing PV cell that lead to reduction of the price for installation

of solar energy system (Wells K., 2012). UTM should take the opportunity from this situation to adopt PV technology in generating electricity for the consumption of whole campus by constructing solar farm in UTM compound. This research will determine cost benefit of solar farm in generating electricity for UTM's consumption.

Preliminary studies need to be carried out to evaluate the potential of solar energy in UTM to determine how it can benefit UTM for long term cost. Payback period for the investment of solar farm need to be determined in order to develop level of confidence among UTM's top managements to shift towards better energy options. On the other hand, advantages of solar farm towards environment and carbon reduction during production of electricity will be determined.

1.3 Research Aims

The aim of the study is to identify potential for UTM to develop solar farm to generate green electricity.

1.4 Research Objectives

The objectives for this study are stated as followings:

i) To investigate benefits and challenges of solar farm implementation in Malaysia
ii) To determine suitability factors for UTM to develop solar farm
iii) To determine payback period and net present value of solar farm development

1.5 Scope of Research

The study is about potential of solar PV farm in Universiti Teknologi Malaysia, Skudai campus to generate green electricity. All of the installation, operation, and maintenance costs were estimated by 3 different companies based on 2013 market price for 1 MWp capacity. UTM Skudai campus is selected as the potential case study due to huge land bank reserves. However, there is no specified project site for this solar farm and land development cost was estimated based on experts' experiences. Besides, general weather conditions in UTM compound was used to predict electricity generated. Electricity generated was determined by each company based on proposed system efficiencies and general data of solar radiation in UTM. Generated income was calculated based on FIT offered in 2013.

1.6 Brief Research Methodology

There were several methodologies used in various stages of this research. In preliminary study stage, literatures from journals and articles were reviewed to formulate research scope, aim, and objectives of the research. On the other hand, literatures were also reviewed to explore concept of renewable energy, PV system, and solar farm. After that, data was collected from several different parties through several different methodologies such as expert interview, questionnaire survey, and record review. In this research, expert interviews were conducted with consultants and contractors in RE industry. In addition questionnaire survey forms were distributed to respondents that involve solar energy such as Sustainable Energy Development Authority (SEDA), KeTTHA, engineers from UTM, UiTM, UPM, and other companies that involve in solar energy. Meanwhile, record review was conducted with Pejabat Harta Bina (PHB), UTM to get the information regarding electricity consumption and available land reserves. Then, all the data obtained was analysed according to the objectives that have been outlined in this research. Based on data analysis, discussion was made according to the objectives. Finally, conclusion was prepared to conclude the findings and appropriate recommendations were proposed for future studies.

1.7 Significance of Study

This research give ideas to UTM and other higher institutional about generation of electricity from solar energy, a green RE instead of traditional fossil fuels. Furthermore, the research is going to provide better knowledge to the entire campus community regarding the benefits of solar farm construction in UTM campus. This research also provides parameters to UTM's top managements and energy facilities manager to make decisions regarding green energy in UTM campus.

Moreover, the research provides the estimated payback period and Net Present Value (NPV) for solar farm implementation as a tool for investment decision making.

REFERENCES

Abolfazl S.P. (2012). *Cost-Benefit Analysis of Potential Photovoltaic Technology Implementation for Institutional Buildings in Malaysia*. Master of Science, Universiti Teknologi Malaysia, Skudai.

Adalberth, K., Almgren, A., and Petersen, E. H. (2001). Life Cycle Assessment of Four Multi-family Buildings. *International Journal of Low Energy and Sustainable Buildings,* 2, 1-21, Royal Institute of Technology, Stockholm, Sweden.

Adams (2006). The Future of Sustainability: Re-thinking Environment and Development in The Twenty-first Century. *The IUCN Renowend Thinkers Meeting.*

British Petroleum BP (2009). *Statistical review of word energy*. [Brochure].

British Petroleum BP (2010). *Statistical Review of World Energy*. [Brochure]

Carbon Monitoring for Action (CARMA) (2012). *Power Plants*. Retrieved November 16, 2012, from http://carma.org/plant

Charters, W.W.S. (2001). Developing Markets for Renewable Energy Technologies. *Renewable Energy*, 22, 217–222.

Chuah, D. G. S., and Lee S. L. (1981). Solar Radiation Estimate in Malaysia. *Solar Energy.*

Coal and gas it is for now. (2012, August 14). *The Star*. Retrieved November 15, 2012, from http:// thestar.com.my

Craig Stevens, A.T. *et al.* (2011). *Solar Electricity Prices*. Retrieved April 2, 2011, from http://www.solarbuzz.com

CYPARK concluded renewable energy power purchase agreement with TNB. (2012, March 29). *Bernama*. Retrieved June 19, 2012, from http://www.bernama.com.my

Demirbas, A. (2008). Energy Issues and Energy Priorities. *Energy Sources, Part B: Economics, Planning and Policy*, 3 (1), 41–49.

Dincer, I. (1999). Environmental Impacts of Energy. *Energy Policy.* 27, 845–54.

Dunlop, J.P. (2012). *Photovoltaic Systems*. (3rd ed.). USA: ATP.

Dutt, G., and Glioli, F. (2007). Coping with Climate Change. *Economic and Political Weekly*. October, 2012. 4239–4250.

Energy Information Administrator EIA, U.S Department of Energy (2010). *International Data for Electricity*. [Brochure]

Intergovernmental Panel on Climate Change IPCC (2007). The Physical Science Basis: Summary for Policymakers. *Contribution of Working Group I to The Fourth Assessment Report of The IPCC.*

International Energy Agency IEA (2007). World energy outlook 2007 [Brochure]

International Energy Agency IEA (2012a). Key World Energy Statistics [Brochure]

International Energy Agency IEA (2012b). World energy outlook 20012 [Brochure]

Jefferson, M. (2008). Accelerating the Transition to Sustainable Energy Systems. *Energy Policy,* 36(11), 4116-4125.

Junnila, S. (2004). *An Environmental Impact of an Office Building Throughout Its Life Cycle*. Doctoral Dissertation, Helsinki University of Technology Construction Economics and Management, Espoo.

Lior, N. (2008). Energy Resources and Use: The Present Situation and Possible Paths to The Future. *Energy.* 33, 842–857.

Lior, N. (2010). Sustainable Energy Development: The Present (2009) Situation and Possible Paths to the Future. *Energy*. 35(10), 3976-3994.

Lund, P. D. (2009). Effects of Energy Policies on Industry Expansion in Renewable Energy. *Renewable Energy*. 34, 53–64.

Malacca to build solar farm. (2012, August 4). *New Straits Times*. Retrieved November 13, 2012, from http://www.nst.com.my

MBIPV (2012). *Malaysia Building Integrated Photovoltaic Project*. Retrieved November 13, 2012, from http://www.mbipv.net.my

Ministry of Energy, Green Technology and Water (KeTTHA) (2009). *Incentives for Renewable Energy & Energy Efficiency in Malaysia*. [Brochure]

Nuofu Chen, Xiulan Zhang, Yiming Bai, and Han Zhang (2012). Environmental Friendly PV Power Plant. *Energy Procedia.* 16, Part A (0), 32-37.

Panwar, N.L., Kaushik, S.C., and Kothari, S. (2011). Role of Renewable Energy Sources in Environmental Protection: A Review. *Renewable and Sustainable Energy Reviews*. 15(3), 1513–1524.

Pearson, P.N., and Palmer, M.R. (2000). Atmospheric carbon dioxide concentrations over the past 60 million years. *Nature*. 406 (6797), 695–699.

Renewable Energy Policy Network for the 21st Century (REN21) (2010). *Renewables 2010 Global Status Report*. [Brochure]

Renewable Energy Policy Network for the 21st Century (REN21) (2011). *Renewables 2011: Global Status Report*. [Brochure]

Smith *et al*. (1998). *Economic Development*. (2nd ed.). Basingstock: Macmillan.

Sopian, and Othman (1992). Estimates of Monthly Average Daily Global Solar Radiation in Malaysia. *Renewable Energy*. 2(3), 319-325.

Suruhanjaya Tenaga (2012). *Malaysia Energy Information Hub*. Retrieved November 15, 2012, from http://meih.st.gov.my/statistics

Sustainable Energy Development Authority (SEDA) (2013a). *Feed in Tariff*. Retrieved January 26, 2013, from http://www.seda.gov.my

Sustainable Energy Development Authority (SEDA) (2013b). *Power System Study*. Retrieved January 26, 2013, from http://www.seda.gov.my

Suzuki, M., Oka, T. (1998). Estimation of life cycle energy consumption and CO2 emission of office buildings in Japan. *Journal of Energy and Buildings*. Vol 28, 33-41.

UNDPI (2005). "2005 World Summit " United Nations Department of Public Information.

United Nations (1978). *Report of The World Commission on Environemnt and Development*.

Wells, K. (2012, October 25). Solar energy is ready. The U.S. isn't. *Bloomberg BusinessWeek*. Retrieved November 1, 2012, from http://www businessweek.com

Wikipedia (2012). *Sustainable Development*. Retrieved October 13, 2012, from http://en.wikipedia.org/wiki/Sustainable_development.

World Commission on Environment and Development (2011). Our Common Future, *Chapter 2: Towards Sustainable Development*.

Desta, M., (1998). Sustainability and Sustainable Development: Historical and Conceptual Review. *Elsevier Science Inc*. New York

Philip, R. B., and Maria, M.C. (2007). Are We Planning for Sustainable Development? *Journal of the American Planning Association*. American Planning Association. Chicago.

Daly, E.H. (1996). *Beyond Growth*. Boston: Beacon Press.

Jacobs, M. (1994). The Limit to Neoclassicism: Towards an Institutional Environmental Economics. *In Social Theory and the Global Environment*. London: Routledge.

Dincer, I. (2000). Renewable Energy and Sustainable Development: A Crucial Review. *Renewable and Sustainable Energy Reviews*.

Kamil, K., Abdullah, K., (2001). Renewable Energy and Sustainable Development in Turkey. *Renewable Energy*. 25 (2002), 431-453. Pergamon.