EVALUATION OF DIFFERENT ELECTRICITY FEED IN TARIFF IN REDUCING CO_2 EMISSION

AZFAR SATARI BIN ABDULLAH

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 2013

To my beloved father and mother

ACKNOWLEDGEMENT

With the Name of Allah, The Most Gracious and The Most Merciful. Thanks and praise The Mighty Allah who had given me the opportunity to study in here and to His steadfast love, care and guidance during the whole study period. I would also like to express my greatest thanks to The Almighty because with His bless, I am able to complete this final-year project within allocated time.

First and foremost, I would like to give my gratitude to my project supervisor, Dr MD Pauzi Abdullah for all of his sincere assistance and advices that had been given to me during the hard times of mine in the completion of this project. Every of his useful helps that were received had been used as guidance for me in order to overcome every obstacle until the final goal upon completing the project had been reached.

Next, I would also grateful to both of my beloved parents, as their encouragements and supports were never ended and they always keep me going to give my best efforts in this project.

Last but not least, my special praise is given to all my friends who had offered some contributions to this project. All of their goodwill will not been forgotten as they had ease my burden, and thus lead me to the successfulness of this project.

Thank you

ABSTRACT

One of people's life fundamental aspects is energy. Demand for energy is increasing from year to another year. The primary energy sources for the whole world are fossil fuel such as crude oil, coal and natural gas. However, the world is facing energy crisis because these sources are depleting because it is non renewable sources. It is projected by International Energy Outlook has projected that energy deman increase to 812 Exajoule in 2035 [31] . Burning fossil fuel to extract energy can contribute to global warming because burning these sources can produce GHG emission such as CO_2, NO_X and CO. Thus, renewable energy sources such as solar, wind and hydro is replacement for fossil fuel sources because RES can produce cleaner energy compare to fossil fuel sources. However, RES technologies are not mature yet and the technologies installing RES are still expensive. So, supporting mechanism is introduced to help promoting RES. One of the most successful supporting mechanisms is FiT. European countries such as Spain and Germany have many experiences in implementing FiT. For example, Germany is one of leading PV install country even though the geographical location of Germany has low solar radiation. This is due to Germany had introduced FiT in 2000 and this has transform PV industry in this country. Malaysia has introduced BIPV since July 2005 because solar is the most promising energy source in Malaysia due to geographical location is in equatorial region. Thus, 2011, Malaysia had implement FiT to support promoting RES. In this project, financial analysis result shows implementing FiT has give 15% to 20% IRR and 4 to 9 years payback period for rooftop PV system. At the same time, average reduction of CO_2 for 3 houses with PV system in Kuala Lumpur is 166.67 tonnes CO_2. Thus, this has showed that FiT can help promoting BIPV in Malaysia.

ABSTRAK

Tenaga adalah salah satu keperluan asas yang penting bagi manusia. Dari tahun ke tahun, permintaan terhadap tenaga semakin bertambah kerana tenaga boleh membantu pertumbuhan sosial dan ekonomi sesebuah negara. Sumber utama tenaga di seluruh dunia ini ialah bahan api fosil seperti gas asli, minyak mentah dan batu arang. Akan tetapi, sumber tenaga ini semakin berkurangan kerana ianya bukan sumber tenaga yang boleh diperbaharui. International Energy Outlook telah meramal sebanyak 812 Exjoule permintaan tenaga pada tahun 2035 [31]. Pembakaran bahan api fossil boleh menyumabangkan pemanasan global.kerana pembakaran ini boleh melepaskan gas kesan rumah hijau seperti CO_2, NO_X dan CO. oelh itu, sumber diperbaharui telah mengganti bahan bakar fossil sebagai sumber tenaga kerana tenaga yang dihasilkan adalah bersih dan tidak menyumbangkan kepada kesan rumah hijau. Namun demikian, teknologi sumber diperbaharui sangat mahal dan ini menyebabkaan FiT diperkenalkan untuk membantu mempromosikan sumber tenaga diperbaharui. Banyak negara di Eropah telah berpengalaman dalam FiT. Sebagai contoh, Jerman ada peneraju suria PV di dunia walaupun negara tersebut tidak terletak di kawasan khtulistiwa. Ini kerana Jerman telah memperkenalkan FiT pada tahun 2000 dan ini telah membangunkan sistem tenaga PV di Jerman. Malaysia telah memperkenalkan projek BIPV pada tahun 2005. Dan pada tahun 2011, FiT telah diperkenalkan di Malaysia. Dalam projek ini, kajian ekonomi telah dikaji terhadap sumbangan FiT dalam mempromosikan BIPV. Hasil daripada kajian tersebut pulangan balik sebanyak 15% ke 20% dan pulangan modal selama 4 ke 9 tahun apabila FiT dijalankan dalam sistem BIPV di perumahan. Dalam masa yang sama, 3 buah rumah di Kuala Lumpur boleh mencapai purata pengurangan sebanyak 166.67 tan CO_2. Oleh itu, FiT telah membantu mempromosikan BIPV di Malaysia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ARTs	-	Advance Renewable Tariffs
BIPV	-	Buliding Integrated Photovoltaic
CDM	-	Clean Development Mechanism
CH_4	-	Methane
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
DSO	-	Distribution System Operator
EEG	-	Renewable Energy Sources Act
FIAHs	-	Feed in Approval Holders
FiT	-	Feed in Tariff
GHG	-	Greenhouse Gas
GJ	-	Giga Joules
GWP	-	Global Warming Potential
IRR	-	Internal Rate of Return
KeTTHA	-	Ministry of Energy, Green Technology and Water
kW	-	kilo Watt
kWh	-	kilo Watt hour
kWp	-	kilo Watt peak
MEA	-	Metropolitam Electricity Authority
MEMR	-	Ministry of Energy and Mineral Resources
MW	-	Mega Watt
NASA	-	National Aeronautics and Space Administration

NEC	-	National Energy Committee
NGTP	-	National Green Technology Policy
NO_X	-	Nitrogen Oxide
NPV	-	Net Present Value
PED	-	Primary Energy Demand
PLN	-	Perusahaan Letrik Negara
PV	-	Photovoltaic
RE	-	Renewable Energy
REP	-	Renewable Enery Payment
RES	-	Renewable Energy Sources
RM	-	Ringgit Malaysia
SEDA	-	Sustainable Energy Development Authority
SO_2	-	Sulphur Dioxide
SP	-	Simple Payback
TNB	-	Tenaga Nasional Berhad
USA	-	United State of America
USD	-	United State Dollar
VSPP	-	Very Small Power Producer
WFC	-	World Future Council

LIST OF SYMBOLS

$\tilde{C}$	-	Boundary layer thickness
n	-	Number of years/ credit escalation rate
r	-	Discount rate
C_{ener}	-	Annual energy saving
C_{capa}	-	Annual capacity saving
C_{RE}	-	Annual renewable energy production
C_{GHG}	-	GHG reduction income
I	-	Incentive
G	-	Grant
e_{base}	-	Base GHG emission factor
e_{prop}	-	Proposed case GHG emission factor
E_{prop}	-	Proposed case annual electricity produced
λ_{prop}	-	Fraction of electricity lost in transmission and distribution
e_{cr}	-	GHG emission reduction credit fee
e_{CO_2}	-	Emission factor for CO_2
e_{CH_4}	-	Emission factor for CH_4
e_{N_2O}	-	Emission factor for N_2O

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, the world is facing energy crisis. The sources of energy especially fossil fuel is depleting because it is non-renewable energy. The projection for the exhaustion of fossil fuel sources is 30-50 years. However, the world is still depending on fossil fuel as energy sources as the primary energy. Example of fossil fuel energy sources are crude oil, natural gas and coal. The world consumption is shown in **Figure 1.1**. As shown in **Figure 1.1**, in 2010, 86.9% of energy consumption is from the fossil fuels where 33.5% are from crude oil, 23.8% are from natural gas and the remaining is contributed by coal. 5.22% of energy consumption is from nuclear energy, 6.46% is from hydroelectric while renewable energy contributes 1.3%. In Malaysia, natural gas demand is 60.3% of primary energy demand (PED) in 2010 followed by crude oil 1.1%, coal at 30.4% and hydro at 5.4% share of PED [1]

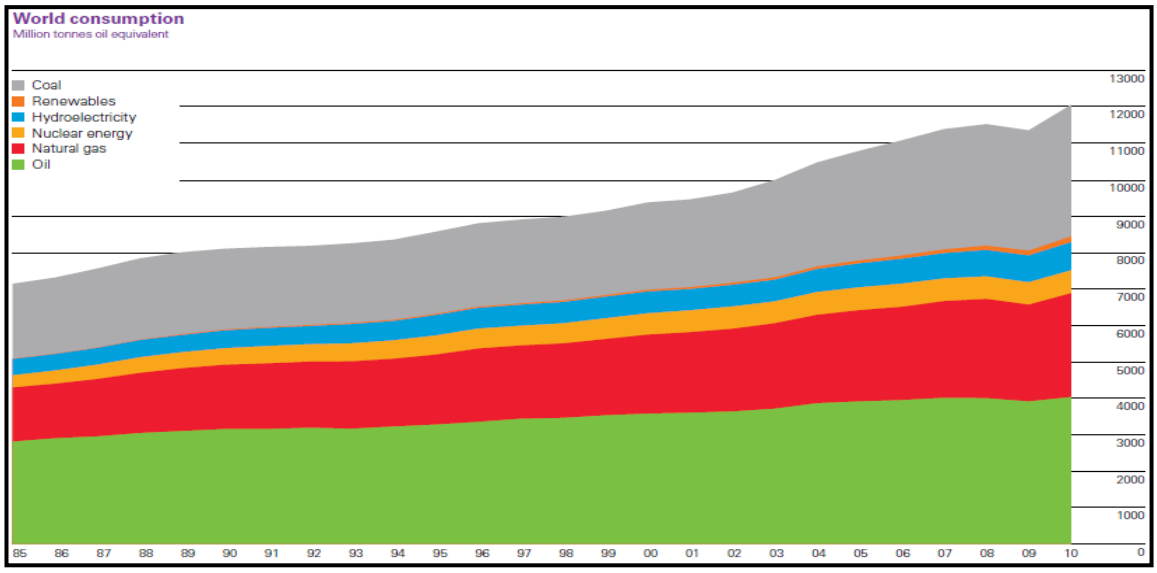

Figure 1.1: World Consumption [2]

Besides that, the combustion of fossil fuel in energy sector contributes to the emission of greenhouse gas (GHG) such as sulfur oxide and carbon dioxide where the GHG emission will give the impact to global warming. **Figure 1.2** shows the emission of CO_2 by fuel. In order to reduce the emission of GHG, renewable energy is the most suitable replacement for fossil fuel in energy sector.

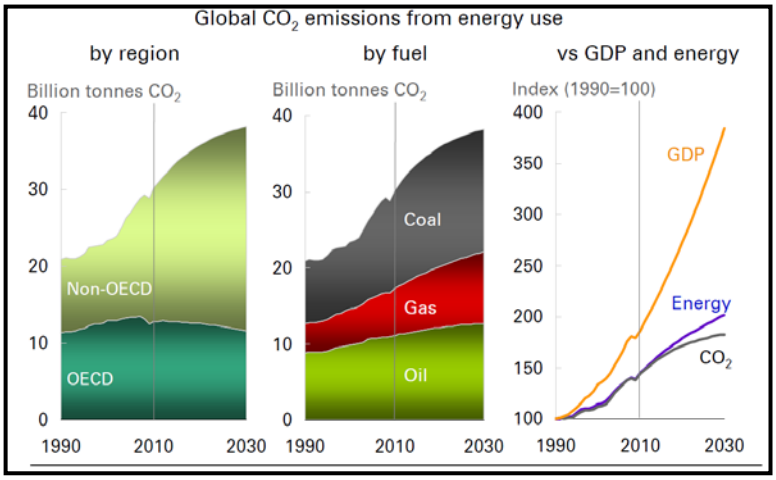

Figure 1.2: Global CO_2 Emissions [2]

Mostly electricity in Malaysia is fueled by fossil fuels sources such as natural gas and coal. However, there are some major concerns in using fossil fuels as primary energy such as GHG emission and fossil fuel depletion. It is estimated that Malaysia will reach 339 million tones of CO_2 in 2030. According to [3], energy

sector is the biggest contributor to the emissions of CO_2 (GHG) with 42% followed by transportation 28% and industry sector 20% as shown in **Figure 1.3**. The GHG emissions are contributing to global warming.

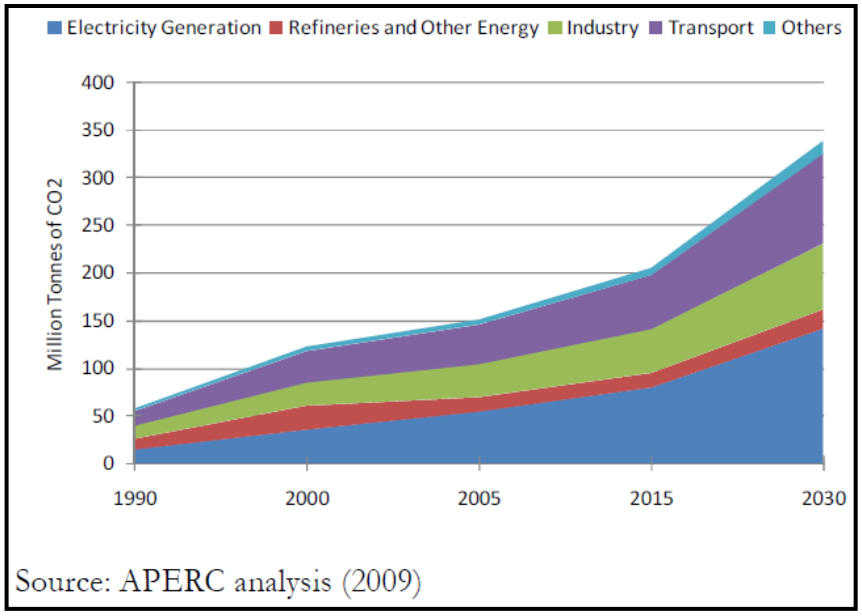

Figure 1.3: CO_2 Emission by Sector [3]

Malaysia will be net importer for crude oil in 2014 [4]. This is due to the fluctuation price of crude oil. Due to the strong growth demand in transportation and industrial sector, import dependency is expected to reach 32% in 2030 from a net exporting position of 54% in 2002 [3].

Natural gas is projected to deplete by 2027 in Malaysia [4]. For global, natural gas will be exhausted in the next 50 years. The reliability and sustainability of natural gas is a major problem to electricity sector as this source is one of the primary energy in Malaysia. Meanwhile, for coal, this source is 100% imported from Indonesia, China and Australia [4] [5]. The import dependency will rising from 24Mteo in 2002 to 33.4Mteo in 2030. It also has been projected that coal will be exhausted for the next 100 years.

Government of Malaysia is concern about GHG emission and depletion of fossil fuel. The GHG emission is increasing as demand for energy increasing. Thus, the demand for fossil fuel is also increasing in order to satisfy the consumers demand. In 2009, Malaysia introduced National Green Technology Policy (NGTP) in order to reduced demand for fossil fuel in Malaysia. This policy conserves the

natural environment and resources by minimizing the negative impact of human activities. This can be done by green technology that refers to development and application of products, equipments and systems that give less harm on environment.

Now, the question is how to increase the usage of renewable energy sources (RES) among the consumer? There are several ways to introduce RES. The government can give more education about RES to the people. They can do advertisement and give subsidies to consumer who uses RES to satisfy their demand on energy. Thus, by doing these steps, the usage and demand for RE can be increased. However, the major concern is how efficient the consumer can use energy supplied by RES and how to give confidence to the consumer that RES is profitable to them. The most effective solution to these issues is by introducing feed in tariff (FiT). FiT has been used by many developed countries such as Germany, Denmark, Spain, USA and Canada. It is an effective way to increase RES demand.

1.2 Problem Statement

FiT had been applied in many developed countries. Thus, many designs have been introduced to improve FiT in order to achieve their target in CO_2 reduction and total capacity of renewable energy produce for their country.

However, Malaysia is still new in FiT. The efficiency of FiT in Malaysia is still being questioned. Introducing FiT in RES is to attract more investor to invest in RES. However, the investors in Malaysia still feel unsecure in this investment because the RES technology is very expensive. Financial impact towards investor is a major concern in this investment even though there are government incentives and subsidiaries. Thus, how far can FiT help to attract more investor and at the same time promoting the RES like Germany, a successful country in implementing FiT.

The reduction of CO_2 is a major concern. Implementing renewable energy sources (RES) can reduce the emission of CO_2 from energy sector. FiT is claimed can help to promote RES installation and at the same time increase the reduction of CO_2 emission. The main concern is how far FiT can help Malaysia in achieving CO_2

reduction. However, effectiveness of FiT to help Malaysia in promoting RES needs to be study and analyze.

1.3 Objectives

1. To study different approach of FiT designs in different country.
2. To analyze the impact of FiT design towards investor financial and reduction of CO_2 emission order
3. To compare effectiveness of Malaysia FiT design with other country.

1.4 Scope of Projects

In this project, the design of FiT from different selected countries (developed and developing) will be studied and compared with FiT in Malaysia. There are many eligible technologies for FiT in Malaysia. The most promising RES was solar power energy. Malaysia was promoting BIPV (building integrated photovoltaic) in order to increase photovoltaic (PV) energy system by introducing attractive FiT rate. This project is only concentrated on implementing FiT to BIPV for residential in Malaysia. Thus, the effect of implementing FiT towards financial and environment (CO_2 reduction) is studied and analyzed. Financial effect for Malaysia is compared with Germany BIPV (residential), one of the most successful countries in implementing FiT.

1.5 Structure of Thesis

Chapter 1: This chapter describes the introduction to the energy demand and why diversion from conventional energy to renewable energy as the sources of alternative energy. In addition to that it provides introductory explanations about problem statement, project objectives and scope of project.

Chapter 2: A review of the topic literature in the previous researches is presented in this chapter, which includes the basic designs of FiT and some reviews of selected countries experience in FiT.

Chapter 3: This chapter describes the methodology of this project. The steps and procedures to analyze effect of FiT in BIPV will be discussed. The steps of setting RETScreen and important input data are showed in this chapter.

Chapter 4: This chapter discusses and analyzes the results of FiT. The effect in financial and environment will be discussed and analyzed.

Chapter 5: The project is concluded in this chapter. Recommendations for future works were also discussed in this chapter.

REFERENCES

[1] M. Daud, "Future for Nuclear in Malaysia," Kuala Lumpur, 2010.

[2] B. Petroleum, "BP Statistical Review of World Energy Outlook," BP, 2011.

[3] APEC, Energy Demand and Supply Outlook, 4th ed., APEC, Economy Review 2009.

[4] D. Mohamad, "Future for Nuclear in Malaysia," Sheraton Imperial, Kuala Lumpur, 9th August 2010.

[5] O. TH, P. SY and C. SC, "Energy Policy and Alternative Energy in Malaysia: Issues and Challenges for Sustainable Growth," *Renewable and Sustainable Energy Reviews*, vol. 14, no. 4, pp. 1241-1252, 2010.

[6] P.Komor, "Renewable Energy Policy," New York, Diebold Institute, 2004, p. 2.

[7] S. J.P.M, "The Performance of Feed in Tariffs to Promote Renewable Electricity in European Countries," 2002.

[8] P. Monthorst, K. W. G. and P.Noergaard, "Policy Instruments for Regulating the Development of Wind Power in a Liberated Electricity Market," Roskilde, Denmark, Riso National Laboratory, 1999, pp. 7-12.

[9] KeTTHA, "Handbook on the Malaysian Feed in Tariff for Promotion of Renewable Energy," KeTTHA, March 2011.

[10] M. Mendoca, D.Jacobs and B.Sovacool, Powering Green Economy: The Feed in Tariff Handbook, UK&USA: Earthscan, 2010.

[11] WFC, "World Future Council," 2007. [Online]. Available: http://www.worldfuturecouncil.org/renewableenergy.html. [Accessed 20 April 2012].

[12] M. Ragwitz, A. Held, G. Resch, T. Faber, T. Haas, C. Huber, R. Coenraads, M. Voogt, G. Reece, P. Morthorst, S. Jensen and I. a. H. Konstantinaviciute, "Assessment and Optimisation of Renewable Energy Support Schemes in the

European Electricity Market," OPTRES, Karlsruhe, 2007.

[13] R. Coenraads, G. Reece, M. Voogt, M. Ragwitz, G. Resch, T. Faber, R. Haas, I. Konstantinaviciute, J. Krivosik and T. Chadim, "Progress Promotion and Growth of Renewable Energy Sources and System," Utrecht, Netherkands, 2008.

[14] E. Commission, "The Support of Electricity from Renewable Energy Sources," Communication from the Commission, Brussels, 2005.

[15] T. Khatib, A. Mohamed, K.Sopian and M. Mahmoud, "Optimal Sizing of building integrated hybrid PV/diesel generator system for zero load rejection for Malaysia," *Energy and Buildings,* vol. 43, p. 13, 2011.

[16] S. P. -. Mart, "Solar Power - Mart," 2007. [Online]. Available: http://solarpower-mart.com/bipv/feed_in_tariff. [Accessed 15 October 2012].

[17] RETScreen, Clean Energy Project Analysis, Third Edition ed., Canada: Minister of Natural Resources Canada, 2005.

[18] Investopedia, "Investopedia," 2012. [Online]. Available: http://www.investopedia.com/terms/n/npv.asp#axzz2ElISLZ7v. [Accessed 15 November 2012].

[19] D. M. P. Abdullah, "Introduction to DSM Lecture," December 2011.

[20] Haris and A.H, "Malaysia's Latest Solar PV Market Development," *Clean Energy Expo Asia 2010*, pp. 1-32, 2010.

[21] F. Muhammad-Sukki, R. Ramirez-Inigues, S. H. A. Bakar, S. G. McMeekin and B. G. Stewart, "An Evaluation of Installation of Solar Phototvoltaic in Residential Houses in Malaysia: Past, Present and Future," *Energy Policy,* vol. 39, pp. 7975-7987, 2011.

[22] S. Chua, T. Oh and W. Goh, "Feed in Tariff Outlook in Malaysia," *Renewable and Sustainable Energy Reviews,* vol. 1, no. 15, pp. 705-712, 2011.

[23] A. S. Qiang Zhai, H. Cao, S. Zhao and C. Yuan, "Strength Analysis of International Feed in Tariff Promotion of Clean Energy Applications for Greenhouse Gas Emission Migitation," *2010 IEEE International Symposium on Sustainable Systems and Technology*, pp. 1-6, 2010.

[24] S. Pietruszko, "Feed in Tariff: The Most Successful Support Programme," *IEEE 4th World Conference on Photovoltaic Energy Conversion,* vol. Conference Record of the 2006, pp. 2524-2527, 2006.

[25] T. Kubota, S. Jeong, D. H. C. Toe and D. R. Ossen, "Energy Consumption and Air Conditioning Usade in Residential Buildings of Malaysia," *Journal of International Development and Coperation,* vol. 17, no. 3, pp. 61-69, 2011.

[26] M. Y. Choong, "The Star," 16 October 2012. [Online]. Available: http://thestar.com.my/lifestyle/story.asp?file=/2012/10/16/lifefocus/11510836&sec=lifefocus. [Accessed 1 November 2012].

[27] F. A. Farret and M. Simoes, Intergration of Alternative Sources of Energy, United State of America: Wiley-Interscience (John Wiley & Son), 2006.

[28] L. Nippon Koei Co., "Study on the Solar Photovoltaic Power Generation Projects in the Federation of Malaysia," ORIX Coporation, 2012.

[29] SEDA, "Feed in Tariff rates," 2012. [Online]. Available: http://seda.gov.my/. [Accessed 3 May 2012].

[30] I. Mundi, "Malaysia Inflation Rate," 2011c. [Online]. Available: http://www.indexmundi.com/malaysia/inflation_rate_(consumer_prices).html. [Accessed 15 November 2012].

[31] F. Muhammad-Sukki, A. B. Munir, R. Ramirez-Inigues, S. H. A. Bakar, S. H. M. Yasin, S. G. McMeekin and B. G. Stewart, "Solar Photovoltaic in Malaysia: The Way Forward," *Renewable ad Sustainable Energy Reviews,* vol. 16, pp. 5232-5244, 2012.

[32] I. Mundi, "Malaysia- Electricity Transmission and Distribution Losses," 2011b. [Online]. Available: http://www.indexmundi.com/facts/malaysia/electric-power-transmission-and-distribution-losses. [Accessed 15 November 2012].

[33] T. E. "Germany," 2012. [Online]. Available: http://www.tradingeconomics.com/germany/inflation-cpi. [Accessed 15 November 2012].

[34] I. Mundi, "Germany Central Bank Discount Rate," 2011a. [Online]. Available: http://www.indexmundi.com/germany/central_bank_discount_rate.html. [Accessed 15 November 2012].

[35] IRENA, "Solar Photovoltaic," FSC, June 2012.

[36] T. Star, "The Star Online," 12 May 2012a. [Online]. Available: http://biz.thestar.com.my/news/story.asp?file=/2012/5/12/business/11225440&sec=business. [Accessed 25 October 2012].

[37] T. Star, "The Star Online," 14 September 2012b. [Online]. Available: http://thestar.com.my/news/story.asp?file=/2012/9/14/nation/12027005&sec=na

tion. [Accessed 15 November 2012].

[38] P. M. B. Master Prospectus of Public Series of Shariah-Based FUnds 201/2011, Kuala Lumpur, Malaysia: Public Mutual Berhad, 2010.

[39] P. N. B. ASNB Master Prospectus 2010/2011, Kuala Lumpur, Malaysia: Permodalan Nasional Berhad, 2010.

[40] Bernama, "EPF Declare 5.8 Percent Dividend Rate for 2011," 21 February 2011. [Online]. Available: http://thestar.com.my/news/story.asp?file=/2011/2/21/nation/8105549&sec=nation. [Accessed 25 October 2012].

[41] C. B. B. "Basic Saving Account [Home page of CIMB Bank,Malaysia]," 2011. [Online]. Available: http://www.cimbbank.com.my/index.php?ch=ci_per_st&pg=ci_per_st_sav&ac=3&tpt=cimb_islamic. [Accessed 20 November 2012].