Comparative Analysis between Net and Gross Metering for Residential PV System

Samara Alasadi
School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia
Johor Bahru, Malaysia
samara.alasadi@yahoo.com

Md Pauzi Abdullah
Centre of Electrical Energy Systems (CEES)
Institute of Future Energy (IFE)
Universiti Teknologi Malaysia
Johor Bahru, Malaysia
mpauzi@utm.my

***Abstract*— In this paper, comparative assessment of the previous feed-in tariff (FiT) and the new net energy energy metering (NEM) scheme for residential PV system in Malaysia is carried out. The study used two different load profiles of two different residential houses for fixed rooftop PV system. The analysis is performed by using Homer software. The electricity tariff for Malaysia is used to compare the FiT and NEM in terms of financial benefit to consumers. This paper considers several financial factors such as payback period, Net Present Cost (NPC) and Cost of Electricity (COE). For comparison, the similar analysis is conducted by using Electricity tariff in another country in Europe i.e. Portugal. The comparative results indicated that FiT provides better financial return as compared to NEM for residential consumer in Malaysia.**

Keywords*— *FiT scheme, Net metering system, RE, COE, NPC

I. INTRODUCTION

The primary solution for the world issue on the depleting of gas and oil is to provide a continuous energy supply to cover all needed electricity demand. For any developed or developing county, energy demand is increasing rapidly due to huge consumption from domestic and commercial customers. To overcome this problem, the use of renewable energy (RE) need to be improved. Many developed countries have applied RE technology to provide free and clean electricity to reduce the consumption of fossil fuel. There are various RE resources such as solar, wind, geothermal hydroelectric and biomass to use instead [1]. However, the penetration of RE in most countries is still low. To encourage the use of RE, many schemes have been introduced.

II. FEED-IN TARIFF AND NET ENERGY METERING SCHEMES

Different techniques have been used not only to encourage investors but also to encourage residential customers to use Renewable Energy System (RES) partially to generate electricity for their own usage or inject it to the grid. These protocols vary from one country to another. In, Malaysia the previous feed-in tariff is base on gross metering, whereas the new Net Energy Metering (NEM) is base on net metering.

A. Feed-In Tariff (FiT)

Feed-In Tariff (FiT) scheme considered as one technique that is used to encourage people to invest and install RE sources technologies. FiT is a policy which allow the investors to earn money from installing RES. This considered the most effective way to attract many customers to be involved in installing RES. The concept of FiT is to provide a guaranteed price to the electricity generated from the RE resources and the grid is pledged to buy it according to defined rate. FiT was firstly introduced in Germany and it was successfully implemented, which made other developed and developing countries to follow and apply it as well. FiT, which is also known as Gross metering mechanism, provides a superior guarantee earning to the renewable electricity producer for a long period of time. Which has been as a method to encourage the use of RE technology for electricity generation.

FiT metering involves connecting the installed RES to the power lines and selling of the generated electricity to the grid. In certain areas there are specific agreements that allow individuals and companies to supply power to the grid and get paid some amounts of money per the injected kWh. This money that the investors claim comes from precise known tariffs. In advance, any customer who wishes to install PV system to supply power to the grid, a special contract between the customer and the grid will be signed. This contract assures the rights for the two parties and it involves the amount of tariff used according to the capacity of the installed PV system. Also a need of two meters is required to be installed along with the PV system. One meter measures the consumed electricity from the grid and the other measures how much electricity has been injected to the utility grid. At the end of the month, the customer will pay the usual monthly bill for the consumed electricity and will get paid for the produced electricity from the installed PV system. The major advantage of FiT schemes is the long-term contract that guarantees continuous of financial support, which reduces the risk of the investment significantly [2].

B. Net-Metering

Net Metering is also considered to be an electricity policy which allows customers to sell some or all of their produced electricity that generated from RE source (in this case using residential PV system) to the grid. On the other hand, Net metering only required one meter to be installed that has the ability to record the energy flows and to spin in both direction, for example, it will spin forward when power is being drawn from the grid but it will twist in reverse when electricity is sent back to the grid. At the end of the month, the client is charged only for the net electricity utilized. Depending on the grid policy, the customer will either get paid for the injected electricity or it will be saved as a credits for the next billing cycle or it can be banked and used later for a definite period or it will be granted back to the grid [3].

Both of FiT and Net metering systems guarantee the use of RE resources to provide green, free and clean energy production. Both mechanisms have their advantages and disadvantages. In summary, Net scheme is easy to implement, no contract needed, only paying for the used

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Life-Cycle Cost Analysis and Optimization of Health Clinic PV System for a Rural Area in Oman

Hussein A Kazem, *Member, IAENG*, Samara Qasim Ali, Ali H A Alwaeli, Kavish Mani and Miqdam Tariq

***Abstract*—Solar energy resources are the highest in rural desert areas in Oman so that Photovoltaic (PV) system could represent a suitable choice for electricity generation as stand-alone power system. In this research a 9 kW solar PV system have been designed to supply health clinic in Oman. The average daily load demand is 24.307 kWh/day and details loads are listed. The energy that is generated by the PV system has been estimated using real weather data for Sohar-Oman. Basic principles of designing a quality PV system have been used to design the system. HOMER software is used to analysis and estimate the life cycle of the PV system. The cost of PV system energy is calculated with different sizes for PV, battery and converter. The results indicate that the solar energy utilization is an attractive option with initial cost, net present cost of the system, and energy cost are 96,470 $, 3046 $/year and 0.418 $/kWh, respectively, in comparison with diesel generator operating cost 0.558 $/kWh. We conclude that using the PV system for these types of applications in Oman is justified on technical and economic grounds.**

***Index Terms*— Photovoltaic Cell Sizing and Optimization, Solar Energy System, Electricity Cost, Rural Electrification**

I. Introduction

THE PV solar power represents one of the most promising renewable energy in the world [1]-[2]. Oman has one of the highest solar densities globally. The high solar energy density is available in all parts of the country. This is because of its location in the Middle East, on the eastern edge of the Arabian Peninsula. The latitude and longitude of Sohar-Oman, the second large city, is 24 20 N, 56 40 E. The climate is generally very hot, with temperatures reaching 54 °C (129.2 °F) in the hot season, from May to September. In addition, the climate of Oman remains dry and particularly hot, but also is humid in the coastal region, 1,700 km long, throughout most of the year [3]-[7]. The coastal areas in the southern part of Oman have the lowest solar density and areas of highest solar density are the desert areas [8]-[10].

This paper reports the evaluation of solar energy cost per kWh using different sizes of PV and battery at Sohar-Oman. Environmental Monitoring Station (EMS) has been used for acquiring data of the ambient conditions to measure: hourly (global horizontal irradiance) global irradiance, relative humidity, ambient temperature, direction wind and speed. EMS recorded data for 2012 have been used to assess solar energy potential in Oman as shown in Figure 1. The EMS found that the average global horizontal solar resource (July 2012) is 6.19 kWh/m^2/day and the average daily number of sunshine hours in Oman is about 12 hours.

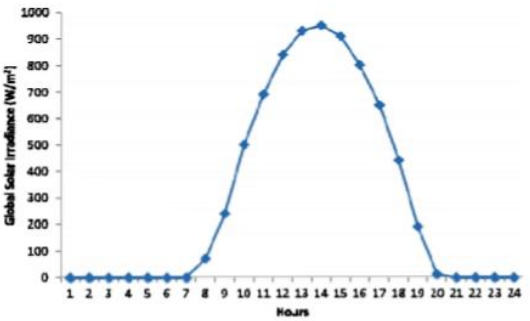

Fig. 1 Global solar irradiance in Sohar-Oman on July 2012

II. Feasability of PV System in Oman

The proposed system designed used to power the health clinic was done according to the solar international design manual [11]. The feasibility of the PV system analyzed using HOMER software developed by the National Renewable Energy Laboratory (NREL). HOMER is a computer model that simplifies the task of evaluating design options for distributed-generation, remote, and stand-alone applications. HOMER's optimization and sensitivity analysis algorithms allow one to evaluate the technical and economic feasibility of a large number of technology options. HOMER contains a number of energy component models and evaluates suitable technology options based on cost and availability of resources. HOMER models a power system's physical behavior and its life-cycle cost. HOMER

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Hussein A Kazem is with Sohar University, PO Box 44, Sohar, PCI 311, Oman (corresponding author: +96826720101; fax: +96826720102; e-mail: h.kazem@soharuni.edu.om).

Samara Qasim Ali with Sohar University, PO Box 44, Sohar, PCI 311, Oman.

Ali H A Alwaeli with Sohar University, PO Box 44, Sohar, PCI 311, Oman.

Kavish Mani with Sohar University, PO Box 44, Sohar, PCI 311, Oman.

Miqdam Tariq with University of Technology, Baghdad, Iraq.

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Feasibility Study of Photovoltaic/Wind/Battery Hybrid System for Oman

Samara Qasim Ali Al-Asadi
Faculty of Engineering -Sohar University
PO Box 44, PCI 311
Sohar, Oman

Hussein A Kazem
Faculty of Engineering -Sohar University
PO Box 44, PCI 311
Sohar, Oman

Abstract— **This paper addresses the need for electricity to supply 880 km road from Nizwa to Salalah in Oman. Feasibility study of a Photovoltaic/Wind/Battery system has been proposed for the highway energy requirements. The investigations found that 26,400,00 OMR required to installing overhead line system, 46,704,487.5 OMR for the cost of electricity for 25 years with total cost of 73,104,488 OMR excluding the cost of diesel generator and the PV system found costing 24,523,211 OMR only for 25 years. It's about one third of the cost if we used diesel generator to generate the required electricity, where it is a noticeable results. The study presents an evaluation of conventional, diesel and PV/Wind/Battery Hybrid system used for highway energy requirements such as lighting, SOS, billboard, etc. According to the result of the optimization, optimum numbers for solar panels, batteries and the number of stations has been decided. Also, the performance parameters of the proposed system are evaluated in term of sensitivity analysis. Moreover, the analysis shows that using PV system instead of diesel generator will prevent green house gases emission 27,325,762 kg/year of CO2, 67,450 kg/year of CO, 601,860 kg/year of NOx, 7,471 kg/year of HC, 54,875 kg/year of SO2, and 5,085 kg/year of Particulate matter 1,129,371 kg/year of suspended particles.**

Keywords-Hybrid system; photovoltaic; wind; feasibility; cost of energy

I. INTRODUCTION

Depleting oil and gas reserves, combined with the growing concerns about global warming, have made it inevitable to seek renewable energy sources. The integration of renewable energies such as solar energy is becoming increasingly attractive and is being used widely, for substitution of oil-produced energy, and eventually to minimize atmospheric degradation [1]-[2]. Many researches, field work and papers have been published and performed to encourage the use of renewable energy depending on the excellent result they have found. Some PV system design and evaluation work done for different applications can be found in [3-8]. In [3], the authors present the requirement of PV solar system to provide power to a health clinic in the rural areas in southern Iraq. They used HOMER software computer model to estimate the best economic system. The proposed system designed with a daily load of 31.6 kWh which is composed of 6-kW PV modules, 80 batteries (225 Ah and 6 V), and a 3-kW inverter. The total initial cost, net present cost, and cost of electricity produced from the system are 50,700 US$, 60,375 US$, and 0.238 US$/kWh, respectively. The results shows that the price of electricity produced from the diesel generator is four times greater than the one produced from the PV system, which considered as the best system to be used in remote areas. The results also shows that using PV system instead of diesel generator can prevent the release of 14,927 kg/year of CO2, 36.8 kg/year of CO, 329 kg/year of NOx, 4.08 kg/year of HC, 30 kg/year of SO2, and 278 kg/year of suspended particles. In [4], the authors climates that if they use an optimization solution of a hybrid system of renewable energy by using the Homer software for remote areas in Tunisia. The Hybrid systems have combination of different energy sources like wind/battery, PV/battery, wind/PV/battery, wind/PV /diesel/battery. The climatic data are for specific area of Hawaria in Tunisia. The optimal configuration of the hybrid system wind/PV/diesel/battery used for reliable load supply and also considered the meteorological data changes is inferred from two optimal configurations chaises: (wind/PV/battery) and (diesel/battery). For the wind/PV/ battery the optimal configuration is composed by 8 kW panel PV, 118 batteries, 2 wind turbine and 12 kW power converters. The initial cost and the operation cost 165.450 US$, 2.102 US$/yr respectively. The total net present cost 189.559 US$ and the cost energy produced 0.540 US$/kWh. For the diesel / battery the optimal configuration is composed by 5 kW diesel generator, 18 batteries and 2 kW power converters. The initial cost and the operation cost 11.934 US$, 10.707 US$/yr, respectively. The total net present cost 134.747 US$, the cost energy produced 0.382 US$/KWh and the diesel 11.269 L. For the wind/PV/diesel generator/battery with the load of 85 kWh/d the optimal configuration is composed by 8 kW panel PV, 2 wind turbine, 118 batteries, 5 kW diesel generators and 12 kW power converters. The authors find that the combination of a diesel generator, as buck-up source, with the hybrid wind/PV/battery system can be considers as the best solution for reliable supply without interruption of the load under the climatic data change. Reference [5], discussed the efficient system of sustainable renewable energy for domestic used and its total cost in Khartoum in Sudan. The method used by the author was to collect of the basic data of solar radiation, wind speed and