Chapter 23
Energy Optimization of Power Station for a Small Research Institute

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ABSTRACT

Renaissance University, Agbani has a research institute with internet facility that accommodates 200 computers for student training, research and browsing. This facility becomes impossible to run due to the inability of the public utility to provide steady, reliable and efficient power. A 250KVA generating set was denoted by the school Administration and latter installed for this facility. After the installation, the facility cut off from public utility and depends wholly on Diesel generator. From experience with the performance of the existing generating sets as regards emissions and operating costs due to high cost of maintenance and diesel, a hybrid system (Diesel-Solar PV) was proposed. This paper investigates and analyzes the economic and environmental benefits of the proposed project to existing diesel generator. From the analyses, the proposed system (solar PV-diesel) has less total net present cost and less emission as a result of less fuel consumption and higher efficiency operation of the diesel genset when compared to the existing system (diesel only).

INTRODUCTION

Nigeria is the largest country in Africa, it has a population of 167 million and it is still growing. A lot of people don't have a job and as a matter of fact 70% of the Nigerian population earns less than one dollar a day (Population, 2012). The education in Nigeria starts to improve though one third of the adults are illiterate. Due to low incomes, health cannot be a priority and these results in a life expectancy of only 47 years (World Health Organisation, 2012). The large scale corruption, caused by the poverty in the country also affects energy supply in Nigeria. Stable energy supply is

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of vital importance for the wealth of a country. Energy is needed in hospitals to keep vaccines cool, energy is needed to light schools and energy is needed to keep companies going. Most of the electricity is provided by generators, since the central electricity grid in Nigeria is very unstable with power failure being more rule than exception.

The irony of this situation is that Nigeria is endowed with very abundant renewable energy resources that remained unexplored and unexploited for alternative energy solutions for power stations particularly for the largely populated rural areas in the country. Nigeria lies along the Equator, with abundant sunshine all the year round. According to Bala, Ojosu, and Umar (2000), Nigeria is endowed with an annual average daily sunshine of 6.25 hours, ranging between about 3.5 hours at the coastal areas and 9.0 hours at the far northern boundary. Similarly, it has an annual average daily solar radiation of about 5.25 KW/m^2/day, varying between about 3.5 kWm^2/day at the coastal Area and 7.0kW/m2/day at the northern boundary. Nigeria receives about 4.851x 10^{12} KWh of energy per day from the sun. This is equivalent to about 1.082 million tons of oil equivalent (mtoe) per day, and is about 4 thousand times the current daily crude oil production, and about 13 thousand times that of natural gas daily production based on energy unit. This huge energy resource from the sun is available for about 26% only of the day. Based on the land area of 924 x 10^3 km^2 for the country and an average of 5.535 kWh/m^2/day, Nigeria has an average of 1.804 x 10^{15} kWh of incident solar energy annually (Chendo, 2002). There is therefore a great promise for alternative renewable energy for the power stations in Nigeria, if only the country could endeavour to explore and exploit these available resources. This study is part and perhaps the beginning of this endeavour. Its major goal is to progressively increase the generation of renewable and clean energy so as to migrate research institutes away from a dependence on fossil fuel energy. The aim of this paper is to design an optimized hybrid energy system that will produce the desired power needs of the research institute while minimizing the financial expenditure and emission; to investigate and analyze the benefits of the proposed hybrid energy system to existing energy system.

RENEWABLE ENERGY

Renewable technologies are designed to run on a virtually inexhaustible or replenishable supply of natural "fuels." By definition, it is a strategy for sustainable growth, since operation of the facilities does not deplete the earth's finite resources. In reality, alternative energy means anything other than deriving energy via fossil fuel combustion (SOLUTIONS PAPER, 2007). The introduction of renewable energy-based technologies to replace old systems is seen as playing an important role in reducing unsustainable fossil fuels consumption, and in addition greatly improves local environmental and health conditions. Renewable energy facilities enhance the value of the overall resource base of a country by using the country's indigenous resources for electricity generation.

The use of stand-alone solar electricity generation systems is limited to remote areas as solar resource is site dependent and depends on the season. Thus, stand-alone solar Photovoltaic (PV) energy systems do not produce usable energy for a considerable length of time during the year. A PV-based hybrid system (using wind and/or hydro and/or diesel generator) is an option to address this barrier and supply electricity to remote areas that are far from the grid (Elhadidy, 2002; Protogeropoulos, Brinkworth, & Marshall, 1997; Fortunato, Mummolo, & Cavallera, 1997; Raja, & Abro, 1994; Lipman, 1994; Lundsager, & Bindner, 1994; Woodell, & Schupp, 1996). As the wind does not blow all the time nor does the sun shine all the time, solar PV and wind power alone are poor power sources. Hybridizing solar