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Simulation of Electrical Load in a Hospital Using Hybrid (Diesel/Solar)

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ABSTRACT: Photovoltaic/Diesel hybrid off-grid systems provide an effective solution to power supply demands for isolated and remote areas far from grid connections. With the rapid growth in renewable energy systems, the work here presents an optimization model of Photovoltaic/Diesel hybrid system to power a hospital in Abuja. A methodology is developed for calculating the correct size of a photovoltaic hybrid system and for optimizing its management. The simulation was done using HOMER and PVSyst find the optimum combination and sizing of the components.Based on electricity demand profiles and current costs, the analysis shows a payback time is still too long. However, with the declining costs of photovoltaic technology predicted for the next few years and the continuously increasing costs of diesel, the hybrid system tends to become economically viable.

Keywords: Renewable Energy, Hybrid System, Off-grid Electrification, Optimization Methods, Energy System Design, HOMER

I. INTRODUCTION

The most prominent feature at Enugu metropolis is the Udi plateau. The plateau is a cuesta running north-south with a bold east –facing escarpment and gentle dipping slopes. There are many seepages, springs, and streams on the foot of most of the hills and ridges. At the mines, most of the seepages, springs and stream emanate directly from the perennial flood water from the coal mines. From the oldest to youngest formation at the Enugu coal mines, the area is underlain by the Enugu Shale (Campanian), Mamu Formation (Lower Maestrichtian) and Ajali Sandstone (Middle Maestrichtian) (Fig. 1) Thus, stratigraphically of the three formations, the Ajali Sandstone overlies Mamu formation which in turn overlies Enugu Shale. The Mamu Formation is the most important geological formation with respect to coal formation, occurrence and mining. The Mamu Formation underlies Ajali Sandstone (aquiferous unit), but both are generally affected by late Cretaceous tectonism leading to fauting, folding and fracturing of the rock materials.

Power Design Criteria Below are the criteriafor our choice of design system to achieve the system configuration 1. The systemshould reduce the rate at which diesel is purchased, the operational time of the diesel generator thereby reducing operation andmaintenance cost providing long term cost savings[Ahmed and Ramesh,2011]. 2. The system should be able to provide power stability to the hospital for 24hrs (previously the generators operated for 15hours per day) so most critical loads in the hospital would not go off again even when there is grid failure. 3. The system should be able to cope with significant daily and weekly power as well as energy fluctuations during the day or the entire week collectively. 4. The system should guarantee ideal battery recharge schedules (maximize battery life) as well improve the system efficiency. 5. Reliability of the system is another important area so the system operation should be reliable in such a way that loss of load probability would be low. It should be robust enough to provide power continually as robustness has precedence over efficiency. It should also be robust under field conditions by coping with the required temperature and humidity. 6. The system should also be able to incorporate load growth in the design as well as system expandability if practicable.

II. RESULT, DISCUSSION AND QUALITY OF COAL

The coal within the Mamu Formation is bituminous and has high sulphur content. The shale within the Mamu Formation has also large quantities of sulphur stains in addition to high concentration of pyrite (FeS_2) flakes. Pyrite (FeS_2) can be called fool's gold, as the colour is brass yellow with hardness 6 – 6½. It is an important ore of sulfur; and sometimes mined for the associated gold or copper (Dictionary of geological terms, 1976). Pyrite (FeS2) is the most widespread sulphide mineral. It can be found as an accessory mineral in igneous rocks, in hydrothermal ore veins, contact metamorphic deposits, and anaerobic sediments. Mamu Formation exhibits cyclic sequences with five coal seams. Sandy horizons (from greater than 5m, but less than 15m thick) within the Mamu Formation constitute the confined aquifers. Stratigraphic logs reveal two to three prominent sandy horizons up to the base of the No. 3 coal seam. These aquiferous horizons are separated by thick intercalations of shale, coal seams and sandstone which form aquitards. The cumulative thickness of sandy beds (aquifers) up to no. 3 coal seam ranged from 12.5m to 70m with an average of 35m. The 35m is the effective thickness of the confined aquifer. The hydraulic properties (T and K) of the confined aquifer occur by direct infiltration from rainfall at the escarpment where sandy units are exposed at the earth surface and by vertical flow from the overlying unconfined aquifer through the connecting fractures. One of the major problems hindering the supply of potable water to Enugu and environs is the acid mine drainage pollution caused by coal mining activity. The mine water is polluted within the sumps in the floor of the long walls. The sumps act as oxidation chambers where groundwater from the fractures is mixed and subsequently reacted with sulphur-rich solutes released by coal mining activity. The shales of the Mamu Formation contain pyrite flakes and sulphur stains. The mine water contain iron and magnesium as major cations, but the major anion is sulphate. Thus, the water-type is mainly magnesium-sulphate type. The water that is not directly influenced by mining activity has bicarbonate as major anion (Tab.1). The acid mine drainage water in the Enugu coal mining area contains high iron, high magnesium, high sulphate, high total dissolved solids (TDS) and low pH . The mine water is acidic and thus corrodes mining and plumb equipment.

Table 1: Summary of Hydrochemistry of Enugu Coal Mines. (Ezeigbo and Ezeanyim 1993)

Constituent	Range (mg/1)		Average concentration	No of samples
	Max	Min.		
Ca^{2+}	24.05	1.60	6.04	32
Mg^{2+}	158.08	6.08	31.94	32
$Na^{+} + K^{+}$	20.88	3.52	7.13	30
SO^{2-}_4	420.00	14.80	136.39	32
SO^{2-}_3	0.60	2.20	1.38	19
Cl^{-}	17.37	1.99	4.86	32
$HCO_3 + CO^{2+}_3$	80.50	3.40	31.25	32
Free O_2	8.00	1.50	4.00	50
Free CO_2	230.00	4.00	51.68	30
Total Fe^{2+}	25.76	8.40	8.94	32
TDS	715.00	8.50	195.15	80

System Configuration The system consist of PV panels for the conversion of sunlight to electric energy, DG in the building, batteries for energy storage, inverters for the conversion of direct currentto alternating current to enable powering of the AC loads [Karasavvas, 2008]. The system also consist of a battery controller which is used to control battery charging by both the PV array and the generator. A maximum power point tracker (MPPT) is a system used to acquire the maximum output it could possibly get from the solar [Putrus, 2011].The DGs are usually connected at AC bus because it produces AC power whereas power from the photovoltaic energy source is DC power which requires inverter to convert DC to AC. Whenever there is less power from the photovoltaic energy source to meet the load demand, ideally the batteries power the load at that time instead of DG because of economical and environmental reasons as this would not consume fuel or cause emission of CO2. Technically, the DG tends to charge the batteries whenever it is switched on to meet load demand, so it meets the load demand and charges the batteries at the same time.

III. CONCLUSION

The environmental impact assessment of coal mining activity in Enugu metropolis and environs is very important and thus must be carried out at regular intervals. Hence, the unavoidable environmental problems are enumerated. Besides the rapid remarkable growth in population, industrialization, agricultural activity, mining activity, and employment opportunity in Enugu metropolis and environs, the environmental problem include water contamination, air pollution, faults reaction and devegetation. Air pollution, which is the least problem, endangers the health of mine workers and people within the vicinity of the mine areas. The effects of the acid mine water drainage on vegetation can be controlled by proper disposal of coal spoil wastes and acid mine water, while revegetation can be effected by seeding after blending alkaline overburden materials and agricultural limestone with acid spoil to cause in-place neutralization of the acid.

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