Proposing Mixed Coupled Hybrid Renewable Energy Sources for Mwanza International Airport

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Abstract: **Mwanza International Airport (MIA) consumes about 18 MVA annually. It is expensive to depend totally on the grid and the backup diesel generator (DG) alone. Therefore, this paper proposes a mixed coupled hybrid renewable energy sources (MCHRES) to power the airport. The considered energy mix are solar photovoltaic (PV), wind, DG and a battery. The energies are estimated based on the site data, and the power system components are designed and their prices are presented. The project costs are reasonable and the justification is the potential of the estimated energy.**

Keywords**: MCHRES, solar PV, wind, airport power**

1. Introduction

The demand for reliable electric energy in support of investments in large social and economic developmental activities has been an agenda worldwide. Generally, both governments and private sector have been using conventional methods for generating electrical power. Boubekri and Shaikh (2012) presented that, globally about 78–80% of the world commercial energy comes from fossil fuels. Non-renewable fuels such as, petroleum, coal and natural gas to generate electric power with drawbacks such as discharge and dielectric losses, heating effects of the conductor over a long distance as well as affects environment negatively through carbon dioxide emissions and therefore, contribute to the global warming through destruction of ozone layer. Additionally, most of these centralized conventional methods of generation require transmission systems, which add complexity of the system and have resulted into systems, which looks unplanned, and with poor power quality (Deshpande et al., 2016).

In Tanzania, since its independence the demand of electrical energy keeps on increasing due to industrialization. The government policies are currently towards revival and enhancement of transport infrastructure especially airport. Hybrid renewable energy system can be in stand-alone or grid-connected modes. Stand-alone system must have a large storage to handle the load. While in a grid-connected mode, the storage can be small, and the deficient power acquired from the grid (Ferdous et al., 2016). The grid-connected mode must have a power electronic controller for load sharing, voltage, harmonic and frequency control for power distribution.

According to (ICAO, 2016), airport systems have high electrical energy demand for lighting, cooling (air conditioning), lift, security checking system, baggage handling systems and power at gates. Airport airside needs electricity for airfield grounding lighting, auxiliary power units, passenger board bridge, aircraft ground energy systems, ground-handling equipment's, firefighting services and hangar. The existing power supply for Mwanza International Airport (MIA) is three phase underground service line supplied by Tanzania Electrical Supply Company Limited (TANESCO) at 11 kV. The power is terminated at switchgears with single point metering which is distributed to various services after stepping down to 415 V through power transformers and low voltage (LV) distribution panels. For operations of essential services during power disruption from TANESCO, the power supply through Diesel Generator (DG) Set is provided with Auto Transfer Switch (ATS). The Diesel Generator is set such that it provides power within 15 seconds of mains power failure from TANESCO. The current total load of Mwanza International Airport (MIA) is 350 kVA. This energy requirement translates to 18 MVA annual consumption. This power requirement has to be met at affordable costs, therefore drawing from an energy mix of renewables (hybrid renewable) available at site and non-renewables (DG).

2. Design of the Mixed Coupled Hybrid Generation

Mixed coupled hybrid renewable energy system (MCHRES) can be designed based on different technical topologies to harvest the available renewable and nonrenewable energy potentials to meet the required load (Sterl et al., 2019). In this paper, this MCHRES shown by Fig. 1 was designed. The system consists of two buses such as AC-and DC-buses. AC sources such as wind and diesel generators feed to AC bus while battery bank and solar photovoltaic (PV) systems are connected on the DC bus with bidirectional converter linking the two buses. All loads are assumed to be AC loads connected from AC-bus. Compared with other MCHRES design topologies, mixed-coupled power system design maximizes diesel efficiency, possible decrease in fuel and battery capacity (Kabeeche et al., 2010), optimal power generation and controllability (Bahta, 2013).

2.1 Estimation of electricity generation at Mwanza International Airport

Mwanza International Airport is approximately 10 km outside the city of Mwanza, latitude -2° 26' 24.08" S, and longitude 32° 55' 34.55" E; at an elevation of 1151 m, depicted by the map of Fig. 2. This airport handles both national and international flights. Due to the high electricity tariff of Tanzania (Kihwele et al., 2012), there is a need to develop alternative cheaper energy sources for powering the MIA. One of the options is the use of renewables such as solar PV and wind energy conversion systems. Fusion reactions occurring within the sun causing temperatures of 15 million °C (Cotar and Filicic, 2012). According to (Chiras, 2010), the solar energy received on earth's surface each year is roughly 10,000 times which is more than enough to supply the energy requirement of the world. Therefore, one can use the solar radiation databases to estimate the solar PV energy potential at MIA depicted in Fig. 3 for the optimum angle. Then, one can record the wind speed data for the site from 10 m to 20 m height from the ground of MIA. The wind energy potential at the airport was estimated using data provided by Tanzania Meteorological Authority (TMA) as depicted in Fig. 4.

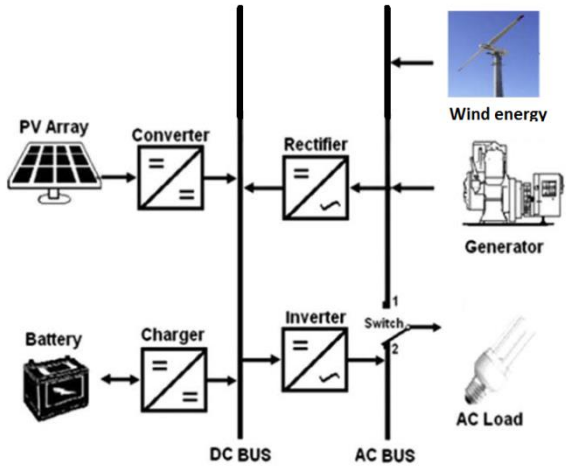


Figure 1: MCHRES topology



Figure 2: Map showing location of Mwanza International Airport

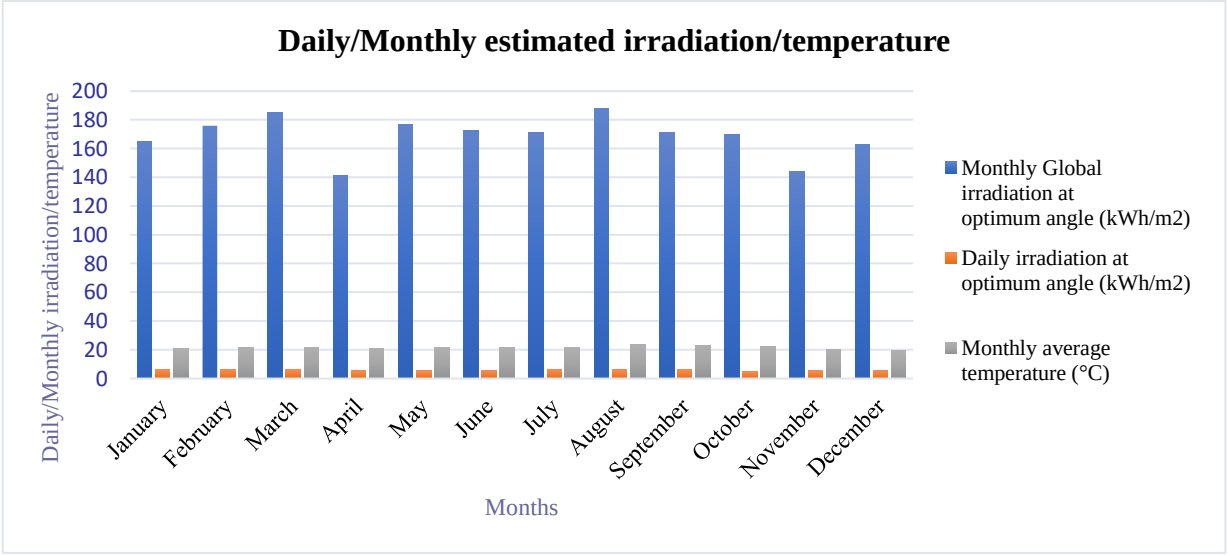


Figure 3: Daily and monthly estimated irradiations and temperature at MIA site

2.2 Component size specifications and cost data

Several designs were attempted, and surveys of prices of the components were obtained for the 18 MVA MCHRES, which are conveniently shown by Table 1, detailing the rating; capital cost (CC); operation and maintenance (O&M) cost; replacement costs (RC); and expected lifetime of the component. This paper adopted some methods from Lal (2011). Note the TZS stands for the Tanzanian Shillings.

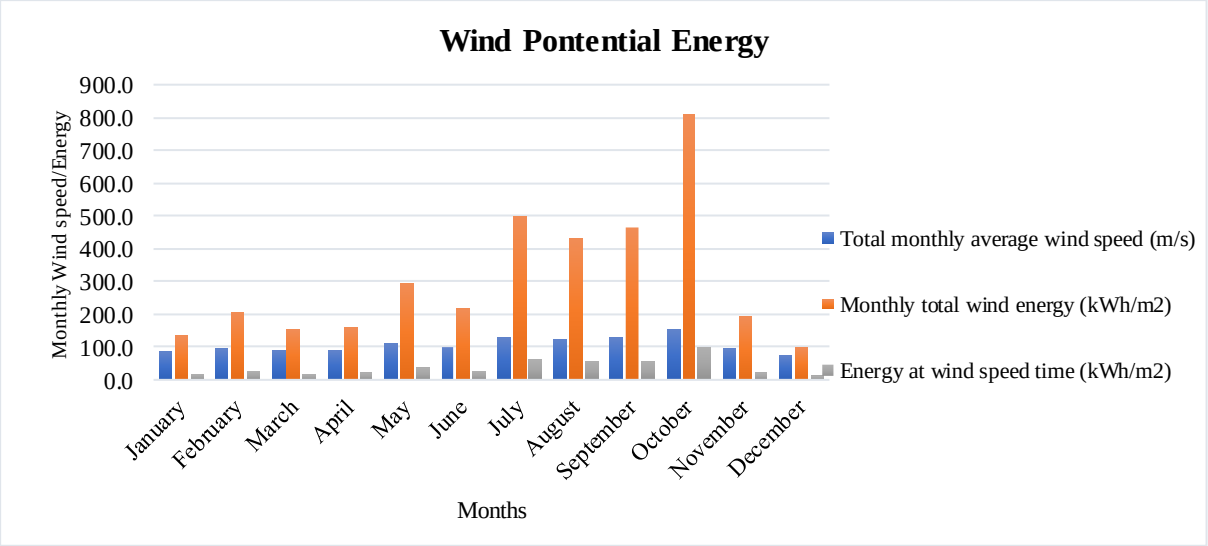


Figure 4: Wind energy potential at the MIA site

Table 1: Components cost data and size specifications

Component	Rating	CC (TZS)	O&M (TZS)	RC (% of CC)	Lifetime (years)
Solar PV panel	200 W	200,000	20,000	70	25
Wind turbine	10 kW	5,500,000	200,000	70	20
Battery	400 Ah, 12 V	1,020,000	20,000	70	15
DG	40 kVA	41,742,000	2,092,387	100	15
Converters	10 kVA	4,400,000	50,000	70	15

3. Discussion

Figure 4 has shown that there is an average of 6 kWh/m^2 of the wind energy potential to be harnessed at MIA site, so that the solar PV panel rated in Table 1 is reasonable. Figure 4 has shown that there is an average of 20 kWh/m^2 at the wind speed time that is able to be converted to electricity by the 10 kW wind turbine in Table 1. The intermittency is taken care of by the DG and the battery designed at 40 kVA and 400 Ah respectively. The power conversion between AC to DC or DC to DC is done through the converters rated 10 kVA, using the method by Wang (2006) and Wu et al. (2014).

4. Conclusion

This paper has presented the proposal for developing a MCHRES topology for the MIA and gave the initial design costs that can be incurred, which is reasonable and justifiable by the energy potential. In future, it is expected to have all the detailed designs and costs of all components involved.

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