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Performance evaluation of a stand-alone PV-wind-diesel-battery hybrid system feasible for a large resort center in South China Sea, Malaysia

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ABSTRACT

The tourist sectors in South China Sea, Malaysia (SCSM) completely depend on diesel generators for 24 h power supply. The emissions from diesel based power plants are environmentally risky for tourist spots. In this research article, a multi-optimal combination of stand-alone hybrid renewable energy system (HRES) for a large resort center located in SCSM has been proposed with detailed operational performance analysis. Hybrid Optimization Model for Electric Renewable (HOMER) software is used for economic and technical analysis of the system. The estimated peak and average load per day for the resort are 1185 kW and 13,048 kW respectively. The best optimized stand-alone hybrid energy system comprises of PV, wind, diesel generator, converter and battery. The optimized system resulted in net present cost (NPC) of $17.15 million, cost of energy (COE) of $0.279/kWh, renewable fraction (RF) of 41.6%, and CO_2 of 2,571,131 kg/year. Whereas, the diesel only system takes NPC of $21.09 million, COE of $0.343/kWh and CO_2 of 5,432,244 kg/year. The diesel only system has higher NPC, COE and CO_2 emission than optimized HRES. The designed and analyzed HRES model might be applicable to any tourist locations and decentralized places in SCSM and around the world having similar climate conditions.

1. Introduction

Renewable global status report shows renewable energy sources contribute 22.8% of global electricity, whereas, the remaining 77.2% comes from fossil fuels and nuclear power plant (Renewables Global Status Report, 2015). According to this report, about 1.1 billion of the world population do not have access to the electricity. However, the people of remote islands in South China Sea, Malaysia where no accessibility to the national electrical grid due to high construction cost of the transmission line, relies on the diesel generators for electricity (Basir Khan, Jidin, Pasupuleti, & Shaaya, 2015). Besides, the tourist sectors in the these islands completely depend on diesel generators for 24 h power supply (Shezan et al., 2015). But the volatile market price of diesel fuel, CO_2 emission and high operation and maintenance cost of diesel plant makes the system environmentally risky and costly (Ashourian et al., 2013; Fadaeenejad, Radzi, AbKadir, & Hizam, 2014). In addition, the diesel price is almost double in the Malaysian islands than on the mainland (Anwari, Rashid, Muhyiddin, & Ali, 2012). Therefore, standalone hybrid renewable energy system (HRES) can play the most important role to supply reliable electricity to the tourist sectors in these islands.

The islands located in South China Sea are full of renewable energy resources. In 2004–2005, eight solar hybrid system (SHS) was established by TNB in five different islands situated in South China Sea. These SHS are operated in Pulau (Pulau means Island in local language) Besar (45 kW), Pulau Pemanggil (50 kW), Pulau Sibu (100 kW), Pulau Aur (50 kW) and Pulau Tinggi (50 kW) (Borhanazad, Mekhilef, Saidur, & Boroumandjazi, 2013). In 2007, Malaysian government in collaboration with TNB implemented a hybrid renewable energy system (HRES) in Perhentian Island, which comprised of 100 kW PV array, two 100 kW wind turbine, one 100 kW diesel generator and a battery bank of 480 kWh, 240 V (DC) (Darus et al., 2009).

Techno-economic viability of off-grid HRES for remote villages and islands has been reported by many authors (Ajayi, Ohijeagbon, Mercy, & Ameh, 2016; Charfi, Atieh, & Chaabene, 2016; Demiroren

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