Chapter 7
Optimal Sizing of Hybrid Wind and Solar Renewable Energy System: A Case Study of Ethiopia

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ABSTRACT

If properly designed and utilized, earth has rich potential of clean energy in satisfying the energy demand of the world. In this chapter, nature-inspired methodology was employed to optimize hybrids of renewable energy system in the case of Jeldu district of Ethiopia. The main goal of the researchers here is to minimize the total annual cost of the system, which can be designed by using appropriate numbers of components based on the pre-designed constraints to satisfy the load demand. MATLAB code was designed for the proposed methodology, and the results were discussed. It was seen from the result that the proposed approach has solved the optimum sizing of defined problem with high convergence. The results show that energy demand of the village can be optimally satisfied by the use of wind and solar hybrid system. Moreover, the application of this chapter is important for countries like Ethiopia to increase access to electricity.

INTRODUCTION

A lot of efforts have been made in the direction of improvement in order to curb the issue of climate change and global warming through cutting an inevitable production of CO2 which produce harmful emissions from the power generating schemes. Now days, based on the increment of population and

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energy demand all over the world, different decentralized power production schemes have been raised. Till now, world is using fossil fuels as a central source of energy (Marc Anthony Mannah, 2017, Kharchenko, V., & Vasant, P., 2018, 2020, 2020). These conventional energy sources are subject to depletion and have multi directional effects, like the issue of environmental pollution, diminution of its sources and continuous increase in oil prices (Thomas, J. J., Karagoz, P., Ahamed, B. B., & Vasant, P., 2020). As a result, the global population without access to electricity was about 840 million in 2017 (Guardian Agencies Report, 2019). Since many efforts have been made in all developing countries of the world to achieve millennium development goal of 2030, the global electrification rate reached 89% in 2017 from 83% in 2010, which means still about 840 million people out of 7.7 billion current world population leaving without access (UNSD, WB, WHO, 2019).

This large number of populations which accounts about 10.9% of the total world population without power access needs global effort to bring the solution. Among this, significant number was the population settled in the rural areas of the world. In most cases, the citizens reside in the rural area of the world lives in scattered manner in very difficult geographical location to extend electricity from national grid by the help of government. Instead the government designs different off grid power generating mechanisms to satisfy the basic need of that society. These off-grid mechanism may include the use of diesel generator which may not affordable for most the society living developing countries (Bhandari, B. et al. 2016). All these challenges have pushed the world attention for the development and utilization of alternative renewable energy sources (Geleta & Manshahia, 2020; Luna, Trejo, Vargas, & Os-Moreno, 2012; Rubio, Perea, Vazquez, Os-Moreno., 2012; Vasant, Kose, & Watada, 2017). Encouraging the off-grid power generating mechanisms are most advantageous in terms economic aspects, sustainability of the power, reliability and environmental protections for the nations living far from national grids. As explained above, in addition to shortage of power there was unfair distribution among urban and rural settlers in all countries, especially sub-Saharan African countries and South Eastern Asia. The rural area of these regions uses kerosene for lighting, wood and animal dugs for cooking. Due to less communication and technologies, the life standard of these countries is still under expected in 21st century. Serves giving sectors like schools, health centers and Agri-processing centers are need electricity in order to properly functioning.

Here we employ nature inspired algorithm to optimize hybrids of wind and solar which may applicable at any remote areas of the world and relatively easier and cheaper to implement. This paper is presenting a case study of Kabi village of Jeldu district, Ethiopia to find the optimal size of hybrids of wind and solar renewable energy system. The main concern is to determine the numbers of wind turbine, solar system and batteries, so that the desired load can be satisfied with minimum possible annual cost.

BACKGROUND

The rural area of sub-Saharan African countries and South Eastern Asia uses kerosene for lighting, wood and animal dugs for cooking. Due to less communication and technologies, the life standard of these societies is still under expected in 21st century. Serves giving sectors like schools, health centers and Agri-processing centers are need electricity in order for proper functioning.

Sub-Saharan African countries, which hosts more than 950 million people, is the most electricity-poor region in the world. More than 600 million people lack access to electricity. This access, a smaller number of the region was less due to the only country South Africa has high coverage of electricity. Ethiopia, is