Powering an Off-grid City by Using a Photovoltaic-Wind Hybrid System in Algerian Sahara and Kampung LB Johnson, Malaysia

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ABSTRACT – In this work, we would supply a Green city in Algerian Sahara by the renewable energy sources only. An optimal PV/Wind hybrid system is developed, improved and implemented to obtain a reliable grid connection for powering this off grid area. The performance of all systems is driven based on technical, economical, and environmental aspects. The system performance were analyzed and compared with the achievement of similar configuration in Malaysia. The simulation and the optimization design were conducted in HOMER software.

1. INTRODUCTION

The pursuit of clean energy is at the heart of world's aspirations for a better future, as reflected in the Paris Agreement on Climate Change, which was signed by 197 countries. Moving from fossil fuels to renewable sources such as solar and wind is the key to achieving social, economic and environmental development [1]. In several regions in the world that use the fossil fuel as a base to supply the energy needs are established to be a major actor in the lucrative market of renewable energy such as Algeria. In this country most of the energy used is coming from fossil fuels; however, thinking about alternative sources to produce energy by using the natural advantages in this region is highly required. According to GSA (German Space Agency) [2], Algeria has the largest solar energy potential in the Mediterranean see i.e.: $169000\ Twh/year$ for thermal energy and $13.9 Twh/years$ for photovoltaic energy this Algerian potential is equivalent to 10 oilfields. The Algerian desert is exposed to the 3500 sun-hour/year on an average of $8h/day$ during summer the exposition to the sun can reach 12h/day except the extreme south of Algerian Sahara.

Recently, several studies recommended combining renewable energy systems with conventional sources of energy [3]–[5] or only renewable energy to powering a residential city in Algeria[6]. With respect to this, a hybrid system that integrates the photovoltaic system, battery energy storage and wind turbine source was proposed for powering a new residential city in Adrar city, Algerian Sahara and Kampung LB Johnson, Malaysia. The electrical and the economic performance has been analysed and compared. The system design, sizing requirements, technical and environmental aspects were studied. HOMER software was used for simulation and modelling process.

2. METHODOLOGY

Homer software is a computer optimization model developed by the U.S. National Renewable Energy Laboratory (NREL) to assist the design of micro-power systems and to facilitate the comparison of power generation technologies across a wide range of applications [5]. In this study, we use HOMER software to simulate and find the optimum size of the proposal hybrid system. The studied hybrid system consists of wind and solar energy systems components working together connected with a battery bank storage and electrical converter as in Figure 1.

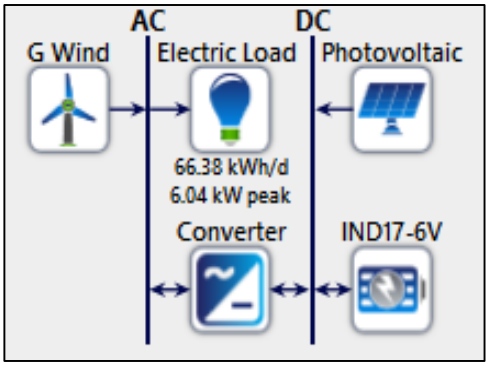

Figure 1: Schematic diagram of hybrid system.

A critical analysis was carried out to design and implement the proposed hybrid system at two locations that are Adrar city, Algeria Sahara and Kampung LB Johnson, (state), Malaysia as case studies. The geographic parameters of the proposed locations are summarized in Ttable 1.

Table 1: geographical data for selected location

Site	Latitude	Longitude	Topographic Situation
Adrar	27°53'N	0° 11' W	Desert
Kampung LB Johnson	2°43.5'N	101°47" E	village

It is assumed that the hourly load profiles for a day in the both locations are as shown in Figure 2. The load rate consumption of the both proposal locations is $66.38\ kWh/day$ with the peak power of $6.04\ kW$.

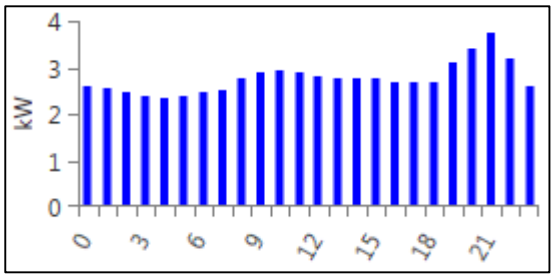

Figure 2: Hourly load profile.

3. RESULT AND DISCUSSION

The proposed hybrid system is designed to serve the residential load demand at all times without any excess energy with the best possible sizes under the lowest possible costs. Figure 3 shows the monthly power production of PV/ wind. Table 2: summarize the optimisation results of the both locations

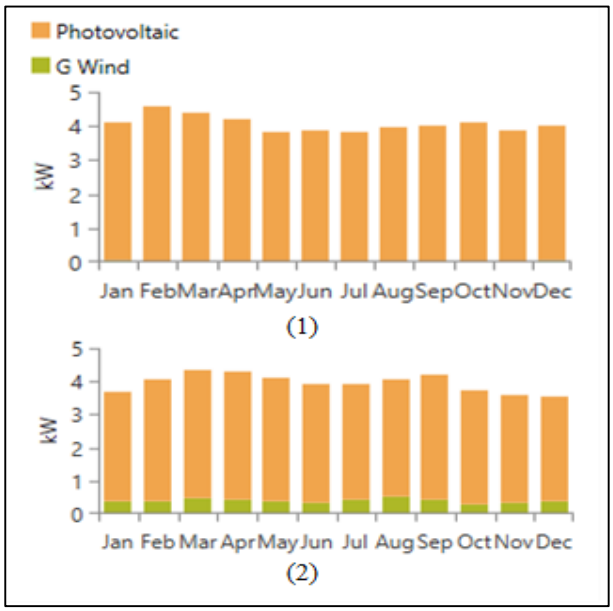

Figure 3: Monthly power penetration of Photovoltaic/wind (1) Kampung LB Johnson, Malaysia; (2) Adrar city, Algeria.

Table 2: Optimisation results of the both locations

Parameter	Adrar City	Kampung LB
PV rated value	16.8 kW	22.3kW
PV production	31.073 kWh/yr	35.410 kWh/yr
Wind rated value	3 kW	3 kW
Wind production	3.501 kWh/yr	0.094 kWh/yr
Load Consumption	24.229 kWh/yr	24.212 kWh/yr
Hybrid system production	34.574 kWh/yr	25.504 kWh/yr
IND17 -6V Number	29 batteries	35 batteries
Autonomy	62 hr	74.8 hr
NPC	$122.773	$147.966
COE	0.392 $/kWh	0.473 $/kWh

In the site of Algerian desert, we find lower PV rated value compared to Malaysia site, for the reason that it's a higher solar and wind resources. As a result, the optimal net present cost (NPC) and the cost of energy (COE) of optimized hybrid system in Adrar city are lower than in Malaysia

4. CONCLUSION

In this study, a hybrid system containing two renewable energies, solar and wind was proposed. This system could be as an effective solution for off-grid electricity to supply a new city in Algerian Sahara. The system performances in Adrara city are analysed and compared to the similar design in a Kampung LB Johnson, Malaysia. The operating outdoor condition and the large PV rate recommend the PV system to share 89.9 % of energy from the global amount of energy produced by the hybrid system while the wind turbine share just 10.01 % from the total energy in Algerien Sahara. Compared to Kampung LB Johnson 99.7% and only 0.264% from the total energy are coming from the PV and the wind turbine respectively. The optimal net present cost (NPC) and the cost of energy (COE) of optimized hybrid system in Adrar city are lower by $25.193 and 0.081 $/kWh$ compared to Malaysia. In addition, the hybrid system is as clean and renewable energy that mean not air pollution and CO2 emission.

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