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Techno-economic Analysis for Remote Area Electrification of Awbeh village in Afghanistan using HOMER Pro

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Abstract— **This research finds an economical expediency of grid connected renewable energy system for the remote area applications in the Awbeh village located in 90 km East of Herat city in North-West of Afghanistan. The research has carried out by looking at the capacities of solar and wind energy, as well as gathering data from a variety of sources. Hybrid Optimization Model for Electric Renewable (HOMER-Pro) software has been used to analyze the data and evaluate the economic feasibility of the proposed hybrid power system. For comparison, on-grid and off-grid models have been designed and optimized. In addition, for each model, a sensitivity analysis has been executed to evaluate the impact of changes in grid energy costs on the total cost According to the simulation findings, the suggested on-grid hybrid power system is reasonably acceptable and cost competitive for the Awbeh village.**

Keywords— ***on/off-Grid; Homer-Pro; hybrid power system.***

I. INTRODUCTION

Renewable energy sources offer a viable answer to global warming and rising fuel prices. As a result, interest in renewable energy sources, particularly photovoltaic and wind energy [1], [2], is expanding. Due to their potential benefits, hybrid power systems incorporating renewable energy are becoming increasingly popular [3]. Despite the benefits of wind and solar, due to its intermittent nature, a solar or wind generator in a stand-alone system cannot provide demand on a continuous basis [4].. Because load demands are not constant and change over time, changes in solar or wind energy generation do not correspond to the time distribution of consumer demand [5]. As a result, increased battery storage or other equipment is needed to keep the load powered up. A combination PV/Wind/Battery system has been found to be a reliable source of electricity [6], [7], [8]. A stand-alone device, however, is prohibitively expensive due to the high cost of battery energy storage [9]. As a result, it's critical to develop a viable solution to this issue. On the other hand, an on-grid hybrid power system with proper planning necessitates storage with lower capacity, lowering costs. As a result, the major objective of this study is to determine the economic viability of a grid-connected hybrid power system to fulfil the load requirements of Awbeh hamlet.

A. *Study Location*

Awbeh is a village in Herat Province, Afghanistan, and the administrative headquarters of the Awbeh/Obe Village. It is located in the Hari River valley, northeast of Herat, at 34.3697°N 63.1764°E and 1277 m altitude.

II. SYSTEM DESCRIPTION

A standalone system, on the other hand, is prohibitively expensive due to the high cost of battery energy storage [9]. As a result, it's critical to discover a workable solution to this issue. A well-planned on-grid hybrid power system, but at the other hand, necessitates lower-capacity storage, which reduces costs. As a result, the study's major goal is to establish the economic viability of an on-grid hybrid power system to meet Awbeh village's load demand.

A. *Load Profile*

Irrigation pumps dominate the area under consideration during peak demand. The planned area's typical energy consumption, which is 645.73 kWh/d, was factored into the load profile in this article. The average daily load profile is depicted in Figure 1, with peak demand occurring between 18:00 and 21:00 h, setting the system's size. In this scenario, the peak load is 93.81 kW. 645.94 kWh/d is believed to be the yearly average.

Fig.2 Monthly average load of the region.

Fig.1. Load-profile (daily)

Fig. 2. Load of entire an-year (Average-monthly).

Fig. 3. Wind-Speed of entire an-year (Average-monthly)

B. Solar Radiation and Wind Speed

NASA's surface meteorology and solar energy database released data on wind speed and sun radiation. Figure 3 shows wind speed data taken at 50 metres above sea level for the area of Awbeh-Herat [10]. As indicated in the graph, the wind speed ranges from 4.74 to 7.1 m/s. The wind speed is at its highest in June. Monthly average solar radiation data is depicted in Figure 4. According to HOMER-PRO software, the latitude and longitude of Khulna village are 34.25° N and 63.25° E, respectively. On an annual basis, solar radiation is expected to be 5.31 kWh/m2/day [10].

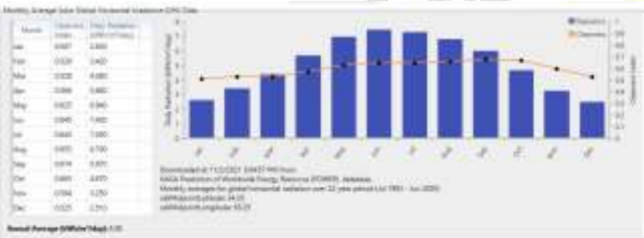


Fig. 4. Clearness index & solar radiation (monthly-average)

III. METHODOLOGY

A. HOMER-Pro Software

HOMER-PRO software was created by the National Renewable Energy Laboratory (NREL) in the United States (USA) [10]. It's commonly utilized in hybrid power system design and analysis. Electrical load, solar radiation, and wind speed statistics, as well as component descriptions and pricing, are provided as input data to HOMER-PRO in this publication.

B. Cost Analysis Procedure by HOMER-PRO [10, 11, 12]

1) Net present cost (NPC): NPC refers to the system's installation and running expenses over its lifetime, as calculated by [12].

$$NPC = TAC/CRF\ (i, Rpr_j)$$

TAC, CRF, I and Rrpj stand for total annual cost ($), The capital recovery factor, the percentage interest rate, and the project life time in years are all respectively calculated.

C. Total annual cost: It is the total annual cost of all power system equipment, including capital, operating, and maintenance expenditures. It also covers the cost of replacement and fuel [12].

i. *Capital recovery factor:* It is a ratio which is used to find the present value of a series of equal annual cash flows [12]

$$CRF = \frac{i * (1+i)^n}{(1+i)^{n-1}}$$

ii. where n denotes the number of years and i is the annual

real interest rate. *Annual real interest rate:* It is a function of the nominal interest rate shown as [12]

$$i = \frac{i' - F}{1 + F}$$

The real interest rate, nominal interest rate, and annual inflation rate are represented by i, i' and F, respectively.

iii. *Cost of energy (COE):* This is the average cost per kWh of usable electricity generated by the system. [12] This is how the coefficient of equivalence (COE) is calculated:

$$COE = \frac{TAC}{L_{prim,AC} + L_{prim,DC}}$$

where, $L_{prim,AC}$ and $L_{prim,DC}$ The AC primary load and the DC primary load are, respectively.

SIMULATION MODEL

To do simulation, the components are selected from HOMER-Pro. The grid-connected battery and on-grid power are depicted in Figure 5. The identical design is shown in Figure 6 but without the grid connection.

To estimate system performance under various conditions, HOMER-Pro simulates the supplied two arrangements at the same area and load based on various expenses such as the projected cost of installation, cost of operation and maintenance, cost of replacement, interest, and cost of energy.

The grid-connected hybrid system's primary components are a wind turbine, solar panels, a battery, and a converter. In economic analysis, the figures below are utilized.

A. Photovoltaic-Array:

Name: Generic Flat Plate-PV It has a lifespan of roughly 25 years and a 13 percent efficiency. PV arrays are expected to have an initial installation cost of $3000 per kW and There are no operating or maintenance charges.

B. Wind-Turbine:

Three Northern Power NPS100C-21100 kW wind turbines were employed to conduct this research [10]. The hub is 23 meters high, 30 meters tall, 37 meters tall, and the rotor is 30.1 meters long, with a 20-year lifespan. The capital, operating, and maintenance expenses are calculated to be $32,000 and $300, respectively, according to the equations.

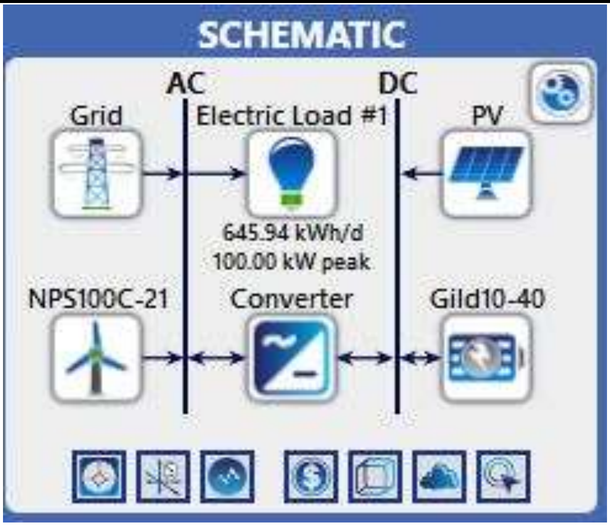


Fig. 5. ON-GRID

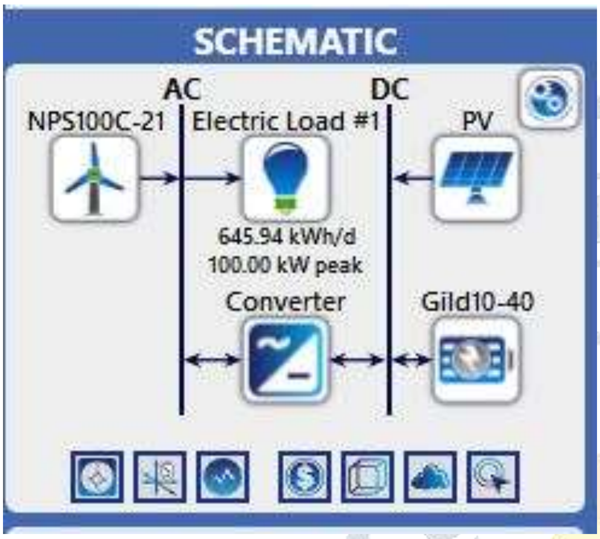


Fig. 6. OFF-GRID

C. Converter:

Generic produces a system converter. Its efficiency is over 90%, and its lifespan is around 20 years. In this study, the capital cost of a 1 kW converter is $300. The cost of replacing is $300, however the cost of operation and maintenance is almost zero.

D. Battery Storage:

This battery is called CELLCUBE®FB10-40 by Gildemeister, it has a 40 kWh capacity and an 876000 kWh life duration. That has an efficiency rating around 64%. A battery is only utilized in grid-connected devices to preserve supply continuity in the event of a grid fault.

E. Grid:

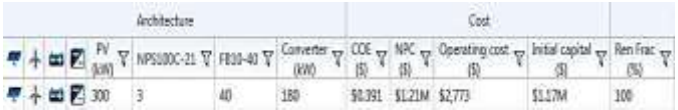
The grid is utilised as a backup power component or additional power absorbency in an on-grid power architecture. When renewable energy systems cannot satisfy load demand, the grid supplies power, and when there is excess power available, the grid consumes it.

Due of the abundance of renewable energy sources in the Awbeh neighborhood, the hybrid power system is designed to use wind and PV energy. The off-grid mode is supported by a battery energy storage system.

V. OPTIMIZATION RESULTS

Optimization results of a hybrid power system with and off-grid connection are shown in figures 7 and 8, respectively. The minimal COE obtained from the result for grid linked systems is $0.0995, as shown in Fig. 7. In this scenario, renewable energy contributes 73 percent of total energy. In the suggested grid connected approach, an optimal number of renewable energy sources is activated and supplies electricity to the load. Figure 8 illustrates that for the same demand, an off-grid power system costs more ($0.391) than a grid-connected system ($0.0995). The cost of designing NPCs for on-grid and off-grid environments is $535,661 and $1.21 million, respectively. The overall annual production of the suggested hybrid model is 436,186 kWh/yr, but the load consumption is 238,967 kWh/yr, as shown in Fig. 9. The remaining production is sold to the electrical grid. Figure 10 shows the suggested approach's monthly average electricity generation from various units.

Fig. 7. Simulation is used to find optimal design (ON-GRID).



Architecture				Cost					
PV (kW)	NPS100C-21	FB10-40	Converter (kW)	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)
300	3	40	180	$0.391	$1.21M	$2,773	$1.17M	100

Fig. 8. Simulation results of off grid power system (Solar/Wind Energy & Battery).

Fig. 9. Consumption state & Production

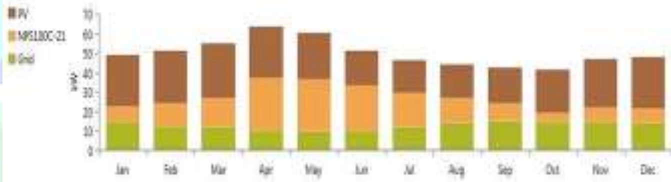


Fig. 10.In above model illustrates, the monthly average electricity production.

VI. CONCLUSION

This research compares without grid hybrid power model to a grid-connected hybrid power system in Awbeh village, Herat, Afghanistan. The optimization result reveals that for the same consumer load, the on-grid hybrid system is more reliable and less expensive than the classic hybrid system. The simulation results also show that the suggested model's Net Present Cost is lower than the off-grid alternative. Despite the fact that an off-grid hybrid system uses 100% renewable energy, it requires a large battery to store electricity. On the other hand, surplus power generation from off grid systems is wasted. In typical operating conditions, an on grid hybrid system does not require an additional battery bank, and excess power generated by renewable energy is fed into the grid. Since a result, it was determined that the suggested on-grid (grid linked) The most suitable and cost-effective choice is a hybrid power system, which offers a number of advantages.

REFERENCES

[1] http://www.bpdb.gov.bd/bpdb/index.php

[2] U. Sureshkumar, P. S. Manoharan, and A.P.S. Ramalakshmi, "Economic cost analysis of hybrid renewable energy system using

HOMER," International Conference on Advances in Engineering, Science And Management, pp. 94-99, March 30-31, 2012.

[3] Ahmad Rohani, Kazem Mazlumi, and Hossein Kord, "Modeling of a hybrid power system for economic analysis and environmental impact in HOMER," 18th Iranian conference on Electrical Engineering (ICEE), , pp. 819-823, 11-13 May 2010.

[4] W. D. Kellogg, M. H. Nehrir, V. Gerez, and G. V. Venkataramanan, "Generation unit sizing and cost analysis for stand-alone

wind,photovoltaic and hybrid wind/pv systems," IEEE Trans. on Energy Conversion, vol. 13, pp.70-75, 1998.

[5] F. Giraud, and Z. M. Salameh, "Steady-state performance of a grid connected rooftop hybrid wind-photovoltaic power system with battery storage," IEEE Trans. on Energy Conversion, vol. 16, no.1, pp. 1-7, 2001.

[6] R. Ramakumar, I. Abouzahr, and K. Ashenayi, "A knowledge-based approach to the design of integrated renewable energy systems," IEEE Trans. on Energy Conversion, , vol. 7, no.4, pp.648-659, 1992

[7] R. Chedid, H. Akiki, and S. Rahman, "A Decision Support Technique for the Design of Hybrid Solar-Wind Power Systems," IEEE Trans. on Energy Conversion, vol. 13, no.l, pp.76-83, 1998.

[8] W. O. Kellogg, M. H. Nehrir, G. Venkataramanan and V. Gerez, "Generation unit sizing and cost analysis for stand-alone wind, photovoltaic, and hybrid wind pv systems," IEEE Trans. on Energy Conversion, vol. 3, no.l, pp.70-75, 1998.

[9] B. E. Turkay and A. Y. Telli, "Economic analysis of standalone and grid connected hybrid energy systems," International Conference on Electrical and Electronics Engineering, pp.l-34-1-39, 5-8 Nov., 2009.

[10] www.nrel.gov/HOMER

[11] Getting Started Guide for HOMER Version 3.3.1;⟨https://www.HOMERenergy. com⟩.

[12] H. Rezzouk and A. Mellit, "Feasibility study and sensitivity analysis of a stand-alone photovoltaic–diesel–battery hybrid energy system in the north of Algeria," Renewable and Sustainable Energy Reviews, vol. 43, pp. 1134–1150, 2015.