Prefeasibility Economic Scrutiny of the on-Grid Hybrid Renewable System for City Electrification

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Abstract. In particular, in developing countries, such as India, renewable sources' contribution to the entire energy mix is increasing rapidly. The comparative cost-effectiveness of off-grid development is that the available local surplus resources can be used at or without equal costs. Renewable energy sources are valuable and sustainable sources as they are produced from fuels, which is inexhaustible. Many forms of renewable energy do not pollute the environment or emit greenhouse gas. The increasing popularity of renewable sources makes them important in the planning of micro grids in the future. This paper focuses on emerging giant India and explores grid integration using intelligent grid technology to produce renewable resources. The integration will be investigated with the simulation using HOMER for the best energy-and emission-based systems. Based on this study, stabilization and sustainable energy supply for the appropriate villages for the optimal hybrid power generation off-grid solution are found in the Levelised Electricity Cost..

Keywords: Sustainable Energy, Hybrid power generation, Levelised Electricity Cost, Micro grid.

NOMENCLATURE

CC	Capital Cost
COE	Cost of Energy (US$/kWh)
EE	Excess Energy
GSR	Global Solar Radiation (kWh/m2/d)
HPS	Hybrid Power System
NPC	Net Present Cost
RF	Renewable Fraction (%)
RC	Replacement Cost
W	Watt
WND	Wind
WS	Wind Speed (m/s)

PV Photovoltaic

HRES Hybrid Renewable Energy System

1 INTRODUCTION

The growth in population, suburbanization and industrial development is causing energy demand to increase every day. The energy consumption rates are high, and the energy supply is insufficient to satisfy the load demand, contributing to energy shortages [1]. The large-centered power generation uses conventional energy sources not only limited and inappropriately dispersed on the crust of the earth. Since fossil fuels like coal, oil and gas have been increasingly depleted; these conventional energy sources have more environmental effects with the rise in the carbon content contributing to global warming. The planet is seeing a transition from the existing centralized generation to the futurethat is more dispersed. Hybrid power systems are linked to the wind, photovoltaic, fuel cell and micro-turbine generators for power generation at the load location and the grid/micro-network connection to decrease fossil fuel dependence [2]. The hybrid system is a better choice for building new, economic, environmental and social grids. This form of renewable energy is called distributed energy source and is known as distributed generation, as shown in Fig 1.

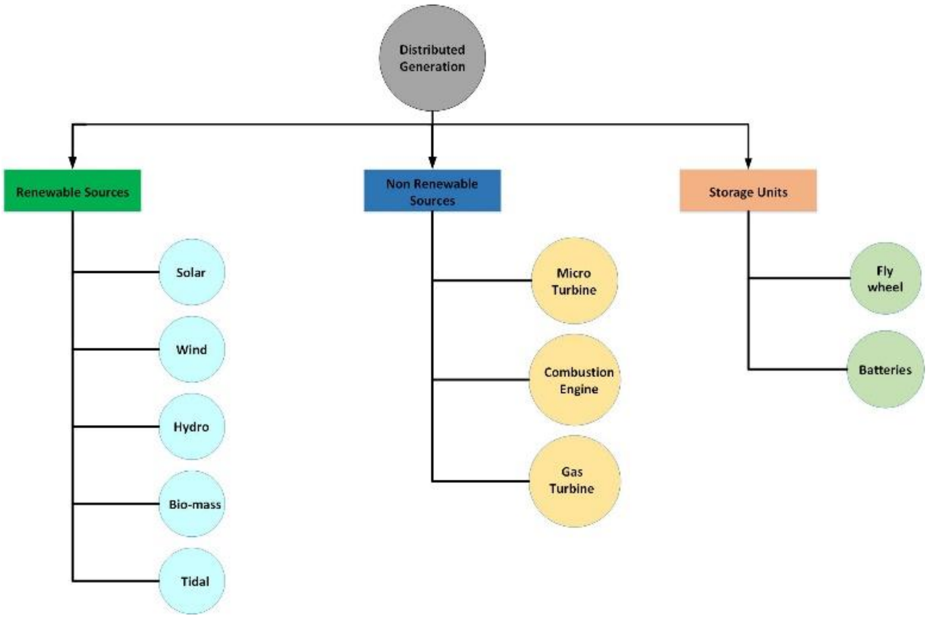


Fig. 1. Map of Distributed Generation

Today, hybrid systems and their implementations are being studied extensively. The literature has studied various configurations. A review of rural electrification literature also shows that renewable energy is one of the most productive options for rural areas far from the electricity grid. Good quality and stable electricity have also proved possible for different use in these remote areas.
Numerous studies have subsequently been carried out to evaluate HRES's feasibility with various computer programs and algorithm. Each sizing approach has its features and potential for sizing the hybrid energy system and can be made to choose from according to the type of application and user requirement. The methods of optimisation were studied by Erdiinc and Uzunoglu [3]. Branker et al. [4] performed a study to compare energy costs levelling (LCOE) of solar photovoltaic systems and held that photovoltaic energy met grid parity in certain particular areas. Depending on (COE) as well as Carbon emissions criteria, the analysis of tropical climate in Shaahidand El-Amin [5] revealed that, over two other scenarios involving an independent diesel system and a stand-alone photovoltaic system, the hybrid photovoltaic-pump-drum-power scenario was economically successful. Barsoum et al. [6] have performed the independent solar and biomass device studies separately. Due to its high performance and lower energy costs, this study suggested a biomass energy system in rural areas (LCOE). An 80 K.W. solar PV-grid link system was conducted by Adramola [7] in Nigeria with the use of HOMER and noticed that the grid solar P.V. system linked to the P.V. system could be economically feasible.
This paper is structured as follows; the next section contains the objectives of the work. Section 3 contains the methodology used. Section 4 tells us about the resource assessment. Section 5 tells us about the selection of components, Section 6 tells us about the results and discussion, and section 7 deals with the conclusion.

2 OBJECTIVE OF THE WORK

This work aims to incorporate renewables into the Jaisalmer national grid, so that load dumping in the rural and urban areas is avoided or eliminated, according to the case study. In addition to promote socio-economic growth and development. More ever Energy percentage of the participants agreeing to the interruption of power supplies, the national utilities grid for rural areas is low. After all, the increasing cost of maintenance and reliability in relation to the generation of fossil fuels are part of the current systems' unsustainability. For social economic and environmental sustainability access to a balance between energy demand. The goal of the work is stated as follows:

- Discover the use of renewable energy in a city in India
- To suggest a field renewable energy source for a city.
- To use HOMER for load demand.
- To use HOMER for the evaluation of power outputs of numerous renewable energy sources.

3 METHODOLOGY

The most appropriate site for our study is recognized as a city in Rajasthan named Jaisalmer. This study mainly aims to give a minimum total net present cost and cost of energy based on the hybrid system for delivering electrical power to meet the load demands of the proposed study area.

3.1 HOMER SOFTWARE DESCRIPTION

HOMER software is an effective method to design and schedule HRES such that the techno-economic analysis is used to evaluate the optimum size of its components [8]. Many tools are modelled in HOMER, including Wind Turbine, Photovoltaic arrays, fuel cells, biomass, converters, electrolyser, and hydrogen tank. Figure 2 displays the HOMER's usual HRES configuration. It needs input data for HOMER simulation as well as a detailed system to demonstrate how HOMER defines the optimal size of HRES equipment..

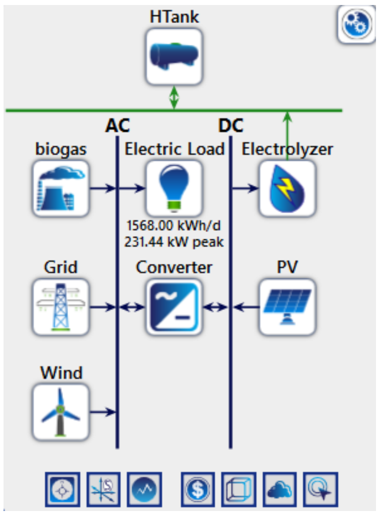


Fig. 2. HRES Configration

3.2 Load Profile

The energy necessity in the city is evaluated via major survey outcomes. The loads comprise of local, municipal, commercial enterprises [9]. The domestic load includes lighting, fans, television, mobile charging point, water pump for drinking water, etc. Community load includes streetlights in the village, fans in the community hall and computer for college. The community daily load demand is estimated at 1568.00 kWh / day with a peak load of 231.44 KW. Figure.3 shows the Daily load Profile of the location and Figure.4 shows the seasonal profile..

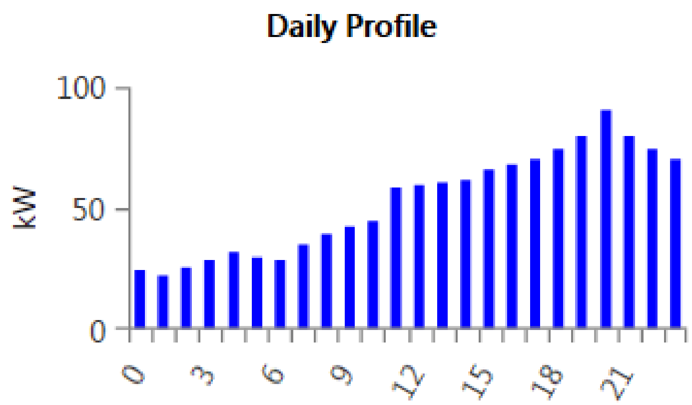


Fig 3:- Daily Load Profile

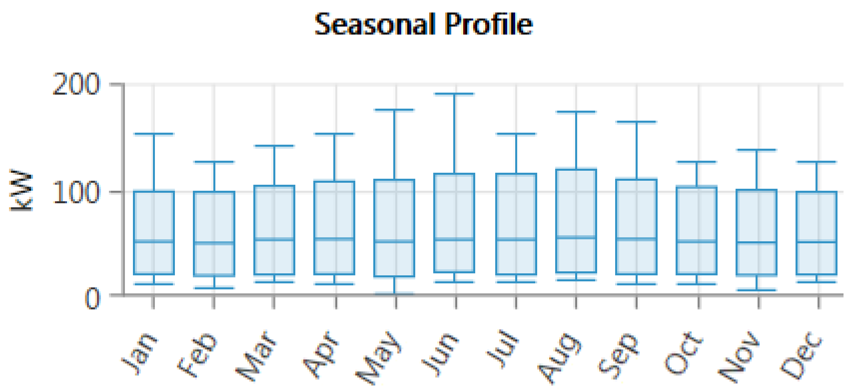


Fig 4:- Seasonal Load Profile

4 RESOURCE ASSESMENT

We have considered solar, wind, biomass resources in this simulation

4.1 Solar

Solar energy is a renewable free source of energy that is sustainable and very inexhaustible, unlike fossil fuels that are finite. It is also a non-polluting source of energy, and it does not emit any greenhouse gases when producing electricity. The data used in Figure 5 is obtained from the NASA Surface Meteorology and Solar Energy website [10]. It can be inferred from the table that the annual average of radiance is 5.80 kWh/m2/day.

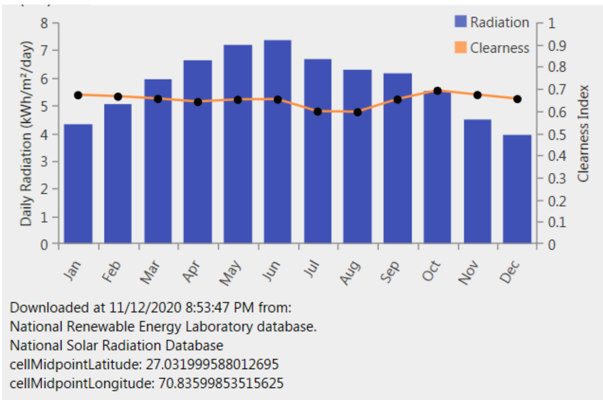


Fig 5:- Annual average of radiance

4.2 WIND

In this study area, Wind energy resources are taken from the NASA website [10]. The annual average wind speed is 5.37 m/s, which can produce a good result throughout the year. July has the highest average monthly wind speed. The detailed data is given in Fig. 6.

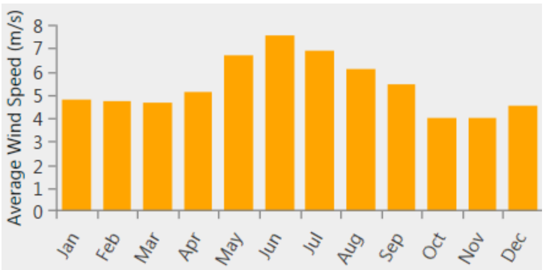


Fig 6:- Annual Wind Speed

4.3 BIOMASS GENERATOR

The assumed biomass resource at Jaisalmer has been presented in Fig 7 [9]. The average available biomass is 0.96 tons per day.

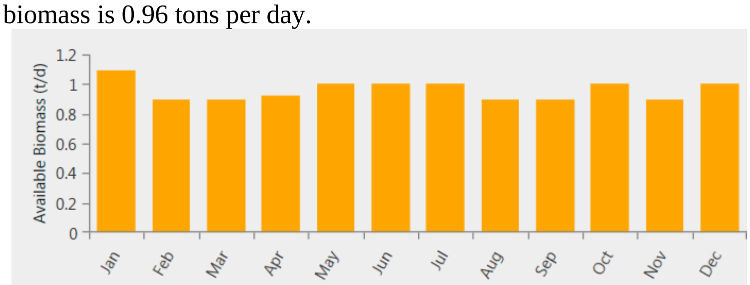


Figure 7:- Annual average Biomass

5 COMPONENT SELECTION

The components used for the modelling of the system in HOMER were P.V. panels, wind turbines, battery, converter, fuel cell-electrolyser-hydrogen tank system, grid and a biogas-fuelled generator displayed in Table 1.

Table 1. A complete description of components

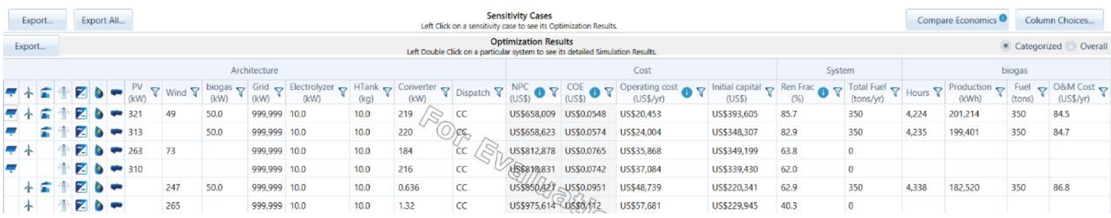
Component	Capital (US$/year)	Replacement (US$/year)	O&M (US$/year)	Lifetime (Years)
PV	830	604	10	25
WT	800	300	20	20
BG	500	280	0.050	15,000 Hours
CT	300	300	3	15
Electrolyzer	1100	825	10	15
Hydrogen Tank	655	524	0.21	25

Grid Specifications

The sell back price of the Grid is 0.050 (US$/kWh), and the power price is 0.140 (US$/kWh)

6 OPTIMIZATION RESULTS

The simulation is performed using the HOMER Pro software, developed by the U.S. National Renewable Energy Laboratory. Fig.8. is the comprehensive result of cost optimization that is organized in the increasing order. As for this study, the result is on line 1 with 321 kW of P.V., 49 kW of Wind Turbine, 50 kW of Bio generator, 999,999 kW of Grid, 10 kW of Electrolyzer, 10 kW of Hydrogen tank and 219 kW of the converter are selected.



Architecture								Cost				System		biogas			
PV (kW)	Wind	biogas (kW)	Grid (kW)	Electrolyzer (kW)	HTank (kg)	Converter (kW)	Dispatch	NPC (US$)	COE (US$)	Operating cost (US$/yr)	Initial capital (US$)	Ren Frac (%)	Total Fuel (tons/yr)	Hours	Production (kWh)	Fuel (tons)	O&M Cost (US$/yr)
321	49	50.0	999,999	10.0	10.0	219	CC	US$658,009	US$0.0548	US$20,453	US$393,605	85.7	350	4,224	201,214	350	84.5
313		50.0	999,999	10.0	10.0	220	CC	US$658,623	US$0.0574	US$24,004	US$348,307	82.9	350	4,235	199,401	350	84.7
263	73		999,999	10.0	10.0	184	CC	US$812,878	US$0.0765	US$35,868	US$349,199	63.8	0				
310			999,999	10.0	10.0	216	CC	US$818,831	US$0.0742	US$37,084	US$339,430	62.0	0				
	247	50.0	999,999	10.0	10.0	0.636	CC	US$850,421	US$0.0951	US$48,739	US$220,341	62.9	350	4,338	182,520	350	86.8
	265		999,999	10.0	10.0	1.32	CC	US$975,614	US$0.112	US$57,681	US$229,945	40.3	0				

Figure 8: Cost optimization of the system

Fig.9.and Table 2 shows the complete cash stream for this system. The total Net Present Cost and Levelised Cost of Energy for this model are calculated at $ 658,009.00 and $ 0.0548 kWh, respectively. Operating cost for this system is at $ 20,452/yr.

Component	Capital (US$)	Replacement (US$)	O&M (US$)	Fuel (US$)	Salvage (US$)	Total (US$)
Biogas 50KW	US$5,000.00	US$8,763.02	US$1,092.12	US$154,428.28	-US$597.94	US$168,685.49
Generic Electrolyzer	US$11,000.00	US$3,500.26	US$1,292.75	US$0.00	-US$658.78	US$15,134.23
Generic flat plate PV	US$266,110.57	US$0.00	US$41,447.58	US$0.00	US$0.00	US$307,558.15
Grid	US$0.00	US$0.00	US$9,280.59	US$0.00	US$0.00	US$9,280.59
Hydrogen Tank	US$6,550.00	US$0.00	US$0.00	US$0.00	US$0.00	US$6,550.00
System Converter	US$65,743.96	US$27,893.44	US$8,499.06	US$0.00	-US$5,249.83	US$96,886.64
Wind 1 kW	US$39,200.00	US$4,686.47	US$12,668.97	US$0.00	-US$2,641.13	US$53,914.31
System	US$393,604.54	US$44,843.19	US$74,281.06	US$154,428.28	-US$9,147.67	US$658,009.40

Figure 9: Overall Cash Stream of the System

Table 2: Overall Costing on the System

Total Net Present Cost	$ 658,009
Levelised Cost of Energy	$ 0.05481/kWh
Operating Cost	$ 20,452.87

Fig.10. and Fig.11. Shows the load consumption of the simulated system. The annual P.V. module production is at 594,494 kWh/yr; Generic Wind Turbine is at 50,141 kWh/yr, a Grid purchase is at 132,396 kWh/yr, and Biogas Generator is at 201,214 kWh/yr, and the total production is up to 978,245 kWh/yr.

Production	kWh/yr	%
Generic flat plate PV	594,494	60.8
Biogas 50KW	201,214	20.6
Wind 1 kW	50,141	5.13
Grid Purchases	132,396	13.5
Total	978,245	100

Fig 10: Overall Production by the components

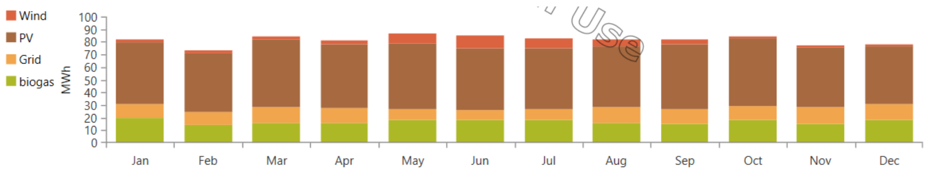


Fig 11: Monthly Production of the system

Fig.12. Shows the A.C. and D.C. load consumption of the system, which is at 572,320 kWh/yr and 0 kWh/yr respectively. Grid sales are at 35,350 kWh/yr. A.C. load consumes most of the energy produced in a year. Fig.13. Shows the additional electrical power generated. The unmet electric load and capacity shortage is the sum of the energy wasted that is not utilised by any of the loads in the system. Fig.14. shows the emissions produced by the system

Consumption	kWh/yr	%
AC Primary Load	572,320	61.6
DC Primary Load	0	0
Deferrable Load	0	0
Grid Sales	356,350	38.4
Total	929,088	100

Figure 12: Overall Load Consumption by the system

Quantity	kWh/yr	%
Excess Electricity	20,462	2.09
Unmet Electric Load	0	0
Capacity Shortage	0	0

Figure 13: Excess Electricity Generated

Quantity	Value	Units
Carbon Dioxide	23,054	kg/yr
Carbon Monoxide	177	kg/yr
Unburned Hydrocarbons	6.46	kg/yr
Particulate Matter	10.6	kg/yr
Sulfur Dioxide	56.5	kg/yr
Nitrogen Oxides	200	kg/yr

Figure 14. Emissions produced by the system

7 CONCLUSION AND FUTURE SCOPE

Because of the large use of non-renewable energy resources, Globe currently faces several environmental problems. In comparison, at a startling pace, fossil-fueled resources deteriorate dramatically. It is now a key time to increase the use of non-conventional sources to preserve non-renewable sources and protect the environment from their harmful effects. Combining more than two accessible non-conventional energy sources will fulfil urban requirements..

ACKNOWLEDGEMENT

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