ISSN: 2037-4445

Analysis of Grid Integrated PV, Fuel Cell Hybrid System

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Abstract
Nowadays, The use of renewable energy sources has recently gained widespread attention. Due to the clean energy they provide, both grid-integrated and stand-alone systems have increased their reliance on renewable sources of electricity. Integrating many sources is necessary because of the intermittent nature of PV, wind, etc. The hybrid system is more effective and reliable. The purpose of this article is to conduct a technical and economic analysis of a hybrid photovoltaic (PV) and fuel cell (FC) system connected to a utility grid. To address the electrical load need of academic block 1, Jntu Jagityal, a grid-tied solar photovoltaic-fuel cell (PV-FC)-based hybrid energy system is presented in this study. The system is developed with, a fuel cell, PV panels, hydrogen storage tank, and electrolyzer . Reliability constraints for grid also considered.
Keywords: hybrid power system, PV, Fuel cell, optimization, Homer

I.Introduction

Pollution from traditional power production and the depletion of fossil fuels make it more important to plan and build a micro grid system that can be connected to the grid or stand alone. HOMER Pro Software is capable of Planning, designing and simulating the model to give optimal solutions with various Renewable energy sources. Constraint-based simulation is performed by this programme, and the best possible outcome is shown in the output window.
In this work, analyzed and discussed the ideal design for satisfying the load requirement in Brest. This battery-free, stand-alone device relies on fuel cells and PV instead[1]. In this work, a method for the optimal design of a hybrid PV-wind system with a battery storage component is provided. This setup is not grid-connected [2]. In this study, a sensitivity analysis and an emission analysis the proposed system is conducted, as well as the technical performance of stand-alone wind, DG, and PV systems is examined[3]. The optimal size of a battery/hydrogen stand-alone hybrid power system is achieved using an ant colony algorithm , that takes into account the least annual system cost and the loss of power system probability[4]. The solar photovoltaic panels, diesel engines, wind turbines, micro-hydro power plant, and battery storage used in this article constitute the hybrid system. The Homer programme is used to get the best possible solution[5]. In this work, a hybrid energy system composed of photovoltaic cells, wind turbines, diesel generators, batteries, and converters is evaluated to get optimal solution to reduce NPC and COE [6]. In this work, the HOMER programme is used to find the best possible combination of renewable energy sources[7].Fuzzy logic is used to determine the optimal values for replacement and capital costs, and using homer-optimal hybrid system is developed [8]. In this study, different combinations of sources with battery have optimized by considering LCOE and NPC [9].

II.System Description

The proposed hybrid power system consists of a grid-connected PV and fuel cell system. This hybrid model is designed and analyzed to meet the load demand of 1839.33kwh/d,232.98 peak load of academic block1, Jntu Jagityal. The latitude for location is $18^0$39. 8’N, longitude is $78^0$54.5’E. The real load profile, solar irradiation, and temperature are considered.

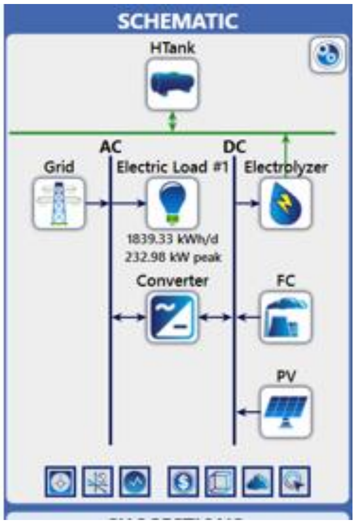

Fig.1. solar photovoltaic/fuel cell hybrid system proposal

Fig.2.Proposed location

A.Load profile: The load demand of academic block1, Jntu Jagityal is1839.33kwh/d,232.98 peak load. Dailyand yearly profile are given in fig 3, fig 4.

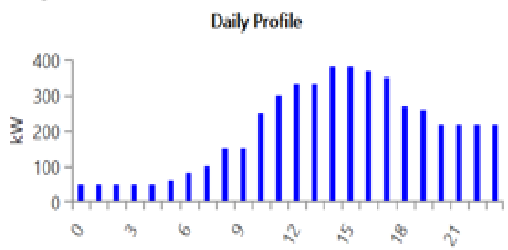

Fig.3.daily prorfile

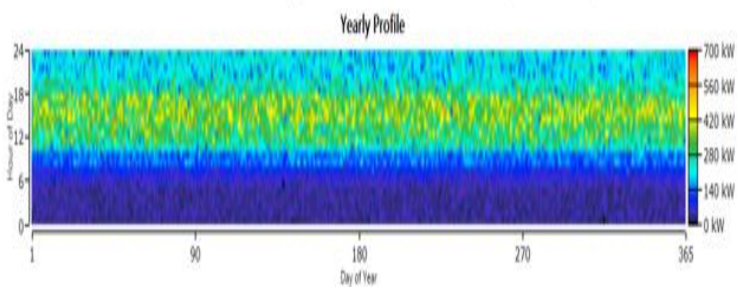

Fig.4.yearly profile

B.PV Generator Data And Solar Resource

Solar radiation data of the selected site is obtained from NASA Atmospheric Data Center. Replacement cost, Capital cost, and O&M cost of Generic flat plate PV are 2500$,2500$, and 10$ respectively. MPPT Tracking is not considered.

C.Converter

The initial cost is $300, the cost to replace it is $300, and the cost to operate and maintain it is $0. 15 years of lifespan, or 95% efficiency.

D. electrolyzer, fuel cell, and hydrogen tank

The electrolyzer has a 15-year lifespan, costs $1400 to purchase, $1,000 to replace, and $20 per year to operate.

ISSN: 2037-4445

Capital cost, Replacement cost, and O&M cost of the fuel cell are 3000$,2500$, and 100$, fuel–stored hydrogen, fuel curve slope -0.0300 kg/hr/kW, fuel curve intercept-0.280 kg/hr.
Replacement cost, Capital cost and O&M cost of the hydrogen tank are 2500$,3000$, and 20$.
E.Grid
In the Proposed hybrid system when power is not supplied by PV,FC it is purchased from the grid.The load is fed by PV during day light and excess power used for production of hydrogen through electrolyzer to generate power from FC or sold back to the grid. Figure 5 displays a monthly grid schedule rate from 00:00 to 23:00, where the rows represent the hours of the day. The price accounted for both off-peak and on-peak hours. The buy-back prices are $0.05 per kWh, $0.1 per kWh, and $1.0 per kWh. Reliability constraints for grid considered as mean outage frequency (1/yr) is 20,mean repair time is 2 hrs, repair time variability is 20%.

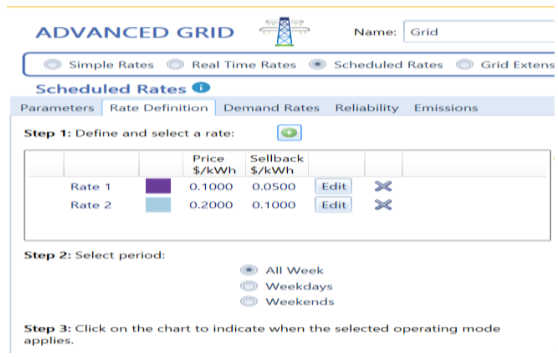

Fig .5.grid schedule rate

III. Optimization results

In HOMER the proposed system is simulated by considering different sizes of different components. Homer gives an optimal combination of the components to reduce the net present cost and the Levelized cost of energy. For the proposed grid-tied PV, FC system optimal solution is a generic flat plate PV 400kW, system converter 440kw, fuel cell 100kW, electrolyzer 300kW, hydrogen tank 100kg, grid with a total net present cost of 7,138,198$,Levelized COE -$0.798,operating cost $434,6569.9

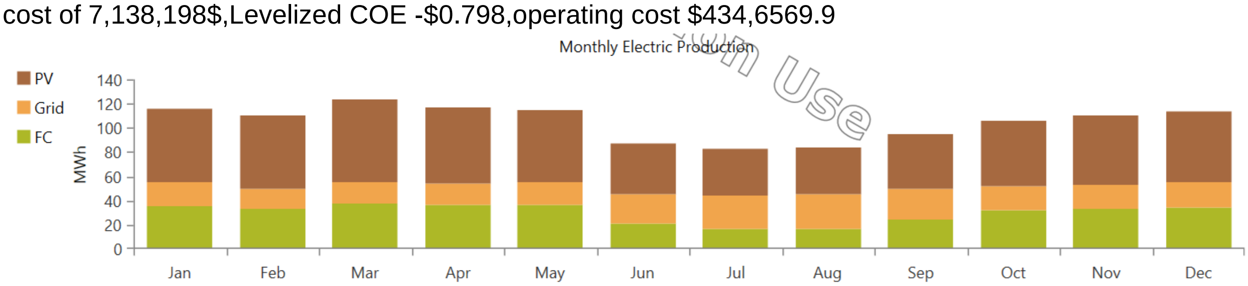

Fig.6.Monthly electric production

Table 1. Electricity generated by the system every year

Production	kWh/yr	%
Generic flat plate PV	646429	51.4
Fuel cell	354932	28.2
Grid purchases	256582	20.4
Total	1257943	100

Electrical energy production from PV is 51.4%, fuel cell is 28.2%, and Grid purchases is 20.4%.

ISSN: 2037-4445

Output of fuel cell :fuel consumption is 11679 kg,fuel energy input is 382297 kWh/yr,Mean electrical efficiency is 91.2%

Table .2.Output of fuel cell

Quantity	Value	units
Fuel consumption	11679	kg
Specific fuel consumption	0.0329	Kg/kWh
Fuel energy input	382297	kWh/yr
Mean electrical effficiency	91.2	%

From the results Energy purchsed from grid and energy sold to the grid month wise as shown below

Table .3.Energy purchsed from grid and energy sold to the grid month wise

Month	Energy purchased(kWh)	Energy sold(kWh)	Net Energy purchased(kwh)	Peak load(kw)	Energy charge	Demand charge
january	19921	1432	18489	132	$1988.52	$1058.48
february	16662	5162	11500	134	$1280.46	$1616.01
march	18478	5834	12644	146	$1381.60	$1596.86
April	17676	4364	13312	139	$1412.84	$1851.25
May	18301	1315	16986	146	$1788.91	$1667.19
June	24199	7	24192	185	$2814.72	$2956.81
July	27749	35	27713	167	$3328.35	$2859.27
August	28941	167	28774	177	$3577.20	$3176.19
Sempteber	24842	277	24565	175	$2807.46	$2921.84
October	20022	469	19552	139	$2162.58	$2387.94
November	19189	1106	18092	165	$1955.54	$2820.03
December	20593	794	19800	147	$2133.62	$2497.76
Annual	256582	20963	235619	185	$26631.80	$27409.63

IV. Emissions.

Using renewable resources to make electricity is good for the environment because it cuts down on greenhouse gas emissions. The results of the PV and FC systems emission analysis are summarized in Table 4

Table 4. summary of emission analysis

Quantity	value	units
Carbon dioxide	25332	Kg/yr
Carbon monoxide	208	Kg/yr
Unburned hydrocarbons	8.41	Kg/yr
Particulate matter	0.832	Kg/yr
Sulfur dioxide	703	Kg/yr
Nitrogen oxides	360	Kg/yr

V. Conclusion

This study describes the planning, design, and analysis of a grid-integrated solar PV/fuel cell hybrid system that can power a single administrative building at JNTUHCEJ with all the electricity it needs. Hybrid solar photovoltaic (PV) and fuel cell power systems connected to the grid. PV generates 51.4%, fuel cells generate 28.2%, and grid purchases account for 20.4% with levelized cost of energy $0.798 per megawatt-hour. One of the greatest strategies and effective methods to improve the penetration of renewable energy in the energy mix at a reasonable cost, decrease the dependency on fossil fuels, and lessen the environmental consequences is the integration of renewable power systems with the utility grid. (greenhouse gas emissions reductions).

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