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Comparative analysis of PV, DG and PV, Fuel cell hybrid systems

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Abstract: The utilization of renewable energy sources has faced difficulties with power insecurity and low efficiency because of their intermittent nature. Fuel cells (FCs) have recently gained popularity as a potential option for backup power generation in remote microgrids due to their low maintenance requirements and extended lifecycle. The operational methods and system sizing affect efficiency. An analysis of the hybrid between a solar photovoltaic system with storage batteries and a diesel generator set and a solar photovoltaic system with storage batteries and a fuel cell system is done in this study. Carbon emissions are significantly reduced when employing fuel cells, as shown by a comparison of two situations but net current cost is higher due to the additional electrolyser hydrogen tank component.

Keywords: hybrid power system, PV, DG, Fuel cell, optimization, Emission analysis, Homer

I.Introduction:

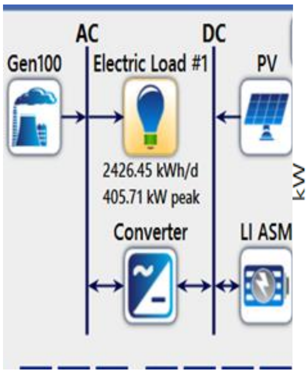
Today, solar energy generation is one of the most promising renewable energy generation technologies and can be used to meet a significant share of the world's energy needs. However, the PV system would not provide power at night, In other words, environmental factors like temperature and irradiance have a significant impact on the amount of power that can be generated by a solar array. A PV system can be used with various alternative power sources to solve this issue. The past decade have seen significant advancements in the field of system integration of PV with other energy sources.[1-8] The integration of PV with diesel generators is one example. But the problem with diesel backup is that these generators can't always react quickly enough to the constantly varying PV output.[9-10] The fuel cell (FC) may be suggested as an alternative for this system as a quick and dependable backup. The fuel cell is a desirable option for use in the hybrid operation with the photovoltaic system due to its lower healing rate, fuel flexibility, high reliability, and quick response rate. Another benefit of using fuel cells over diesel generators is that they require less fossil fuel since they are more efficient than diesel engines and experience less power loss because they may be installed at or close to the load center. A significant area in the literature has also been found for the use of PEMFC systems as backup in hybrid applications to reduce carbon emissions. [11-15]

II.System Description

In this study, a comparison is made between a solar photovoltaic system with storage batteries and a fuel cell system, as well as a solar photovoltaic system with storage batteries and a diesel generator system.

Case i) photovoltaic system with storage batteries and a diesel generator system

The load demand of academic block2, Jntu Jagityal is 2426 kwh/d, 405.71 kw peak load and 101.1kw average load. System model and Seasonal profile are given in fig 1 , fig 2



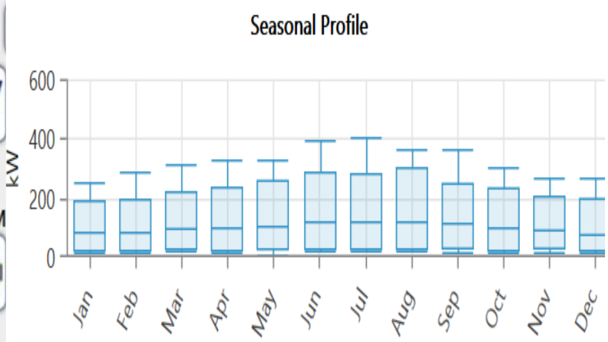


fig.1.PV,DG and battery system fig.2.seasonal load profile

Solar PV : NASA's Atmospheric Data Center provides the site's solar radiation data. Generic flat plate PV has replacement, capital, and operation and maintenance costs of $2500, $2500, and $10, respectively. MPPT Tracking is not taken into account. Life time 25 years

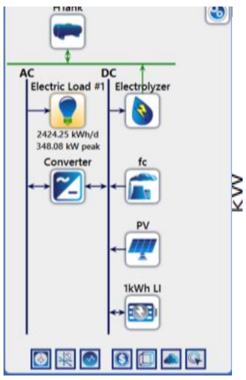
Converter: It costs $300 to purchase, $300 to replace, and $0.01 to operate and maintain. It has a 15-year lifespan and a 95% efficiency rate.

Generic 1 KWH Li-ion battery: It costs $3500 to purchase, $3500 to replace. maximum capacity:276Ah.nominal voltage 3.7v.minimum State of charge 20%

Generic 100kw fixed capacity generator set: It costs $40000 to purchase, $40000 to replace, and $2 to operate and maintain.

Case ii) photovoltaic system with storage batteries and a fuel cell system

The load demand is 2424.25 kwh/d,348.08 kw peak load and 101.01kw average load. System model and daily load profile are given in fig 3 , fig 4



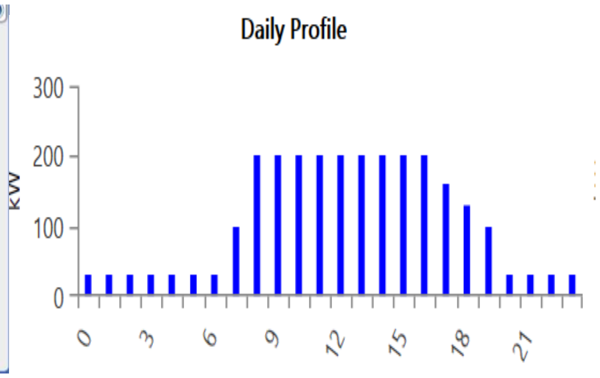


fig.3.PV,FC and battery system fig.4.Daily load profile

Solar PV : NASA's Atmospheric Data Center provides the site's solar radiation data. Generic flat plate PV has replacement, capital, and operation and maintenance costs of $2500, $2500, and $10, respectively. MPPT Tracking is not taken into account. Life time 25 years

Converter: It costs $300 to purchase, $300 to replace, and $0.01 to operate and maintain. It has a 15-year lifespan and a 95% efficiency rate.

Generic 1 KWH Li-ion battery: It costs $3500 to purchase, $3500 to replace. Maximum capacity: 276Ah.nominal voltage 3.7V. minimum State of charge 20%

Fuel cell: It costs $1400 to purchase, $1000 to replace, and $20 to operate and maintain

Converter: It costs $1400 to purchase, $1000 to replace, and $20 to operate and maintain

III.Optimization results:

In HOMER, the suggested system is simulated by taking into account various component sizes. Homer suggests the ideal arrangement of the elements to lower the levelized cost of energy and the net present cost.

Case i) For the proposed PV, DG, battery system optimal solution is a generic flat plate PV 1790kW, system converter 323kw, 2274 Generic 1 KWH Li-ion battery with a total net present cost of $6.50M ,Levelized COE $0.568,operating cost $72,114,Renewable fraction is 97.1%

When This optimized solution compared with base case of generic flat plate PV 2131kW, system converter 968 kw, 7544 Generic 1 KWH Li-ion battery produces a total net present cost of $10.8M ,Levelized COE $0.947,operating cost $169897,Renewable fraction is 100%

Case ii) For the proposed PV, FC, battery system optimal solution is a generic flat plate PV 2196kW, system converter 381kw,1011 Generic 1 KWH Li-ion battery , Fuel cell 100kw,

Electrolyzer 200kw ,hydrogen tank 100 kg with a total net present cost of $8.49M ,Levelized COE $0.743,operating cost $147730.

Emission Analysis: emission analysis of two cases is displayed in the table 1

TABLE 1: emission analysis

Quantity	Values for PV+DG+battery system	Values for PV+FC+battery system	units
Carbon dioxide	19,696	-165	Kg/yr
Carbon monoxide	134	105	Kg/yr
Unburned hydrocarbons	5.42	4.24	Kg/yr
Particular matter	0.536	0.419	Kg/yr
Sulphur dioxide	48.2	0	Kg/yr
Nitrogen oxides	10.7	8.38	Kg/yr

Conclusion: The planning, design, and comparative analysis of a solar PV,DG,Battery hybrid system and a solar PV,FC,Battery hybrid system and that can provide all the electricity required for academic building 1 at JNTUHCEJ are covered in this paper. In second case the carbon emissions are reduced considerably but net present cost is more because of more number of components.

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