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"GENERATION OF HYDROGEN ENERGY USING CLEAN ENERGY WITH HOMER PRO"

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Abstract –
In this paper author has study the clean fuel (Hydrogen) generation using clean energy. The author has selected the educational institute of Bhopal as a site. The modeling and simulation is done with the help of HOMER Pro Software. The clean energy used is Solar and wind. The electricity generated from clean energy is used to generate hydrogen fuel. The simulation result shows the Net Present cost, Levelised cost of electricity, operating cost of system. It also give the levelised cost of hydrogen and zero emission of harmful gases. The battery is also provided to meet the excess electricity demand.
Key words— Clean energy, Hydrogen fuel, HOMER Pro.

1 Introduction

The paper gives the study of generation of Hydrogen fuel (H_2) in urban area using clean energy. The suggested system serves the purpose of generating both electricity and hydrogen fuel. [1]
In recent years, there has been an increase in extensive use of clean energy sources due to the increase demand of energy and shortage of fossil fuels. Renewable energy sources are considered clean, accessible, and significantly reduce environmental pollution. The most important sources among these are wind, solar, biomass, and geothermal. Meanwhile, wind and solar energy have gained popularity due to technological advancements and government encouragement.[1]
The alternative and future fuel is Hydrogen. Hydrogen can be used in internal combustion engines or fuel cells, with negligible greenhouse gas emissions and emit water vapor. A HES system design is totally free from emission method to produce hydrogen.[2]
Climate change, an increasingly evident serious issue for much of the population, has been directly contributed to by rising CO2 levels, resulting in the global warming phenomenon, depicting the dramatic increase in CO2 levels over the past 200 years along with the global average temperature. [3]
Hybrid Energy Systems (HESs) is cost effective, efficient and practical method. The HES gives better result due to use of two or more energy sources**.** The outputs **of** HES encompass electricity & H_2 fuel. Hydrogen become substitute to fossil fuels in transport, and also supplies fuel to devices such as fuel cells, which can be use to produce electricity with less emissions and produce heat as a by-product.[1]
The use of clean energy sources to produce H_2 can mitigate environmental problems. A straightforward process for obtaining hydrogen with ninety nine percent purity is electrolysis. In an electrolyzer water breakdown into oxygen and hydrogen gases in the presence of electricity. However, a major issue is to provide electricity to electrolyzer. The issues rise of Carbon dioxide level from use of non-renewable energy. While renewable energy is irregular

and unreliable. From the literature, it is suggested that a hybrid system could serve as a viable solution to these challenges. Hybrid Energy Systems based on clean energy system can play a important role in transitioning from unsustainable development to sustainable development. The study of HESs for energy supply has gained the attention of researchers worldwide. The research is going on both theoretical and experimental to increase efficiency of the system. [2]

System Description

The HRES design provides electricity to electrolyser to generate hydrogen gas. The HRES used consist of 2 clean energy source i.e. Solar and wind**.** Converter is connected for conversion process. The 1kwh Li Ion ASM 1Kwh battery is used.

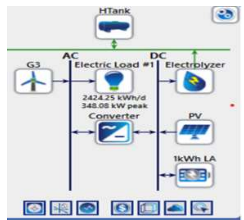


Figure 1 HRES model

Electric Load profile: - It is commercially scaled, with a mean of 2424.2 kWh/day, mean of 101.01 kW, and a peak value of 348.08 kW. The load factor is 0.29.

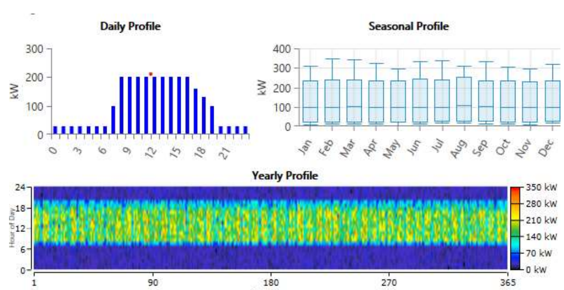


Figure 2 The schematic layout of the introduced load profile, for commercial use.

Electrolyzer: - A generic electrolyzer, commonly utilized for the production of hydrogen gas, is characterized by an efficiency 85% and a life duration fifteen years. AFC, operating in the temperature range of 65–220 °C, belongs to the category of low-temperature fuel cells. It is characterized by high efficiency, ease of control, adaptability for mini or micro scale power plant, suitability for real time procedures, and cost-effectiveness compared to PEM fuel cells. Nevertheless, operational requirements include the necessity for pure oxygen and hydrogen. AFCs stand out as the pioneering fuel cells capable of generating significant power for transportation purposes. [2]

Converter: - This generic system converter i.e. Inverter input has a lifetime 15 years with efficiency 95%, while the rectifier has a relative capacity 100% and efficiency 95%

Solar PV panel Plate:- The sun's light is converted into electrical energy through the use of a solar PV panel. It is a generic flat plate PV with a related capacity of 1 kW, and it belongs to the flat plate panel type. The life time of Generic flat plate is 25 years and derating factor is 80%. The electric bus is DC type.

Hydrogen tank: - A generic hydrogen tank, sized at 100 kg, is characterized by a life period 25 years.

Wind turbine:- It is a generic 3 kW turbine with a capacity 3 kW, characterized by a lifetime of 20 years and a hub height of 17 meter. The conversion of kinetic energy from the wind into electrical energy is accomplished through the use of a wind turbine. The hydrogen produced by the electrolyzer finds utility in various applications, including transportation.

Simulation Result of suggested Hybrid Energy System

Cost Metrics

Total NPC	**$9,229,178,00**
Levelised COE	**$0.8071**
Operating Cost	**$169,235,30**

Simulation result of cost summary with component

COMPONENT	CAPITAL $	REPLAEMENT	Q & MS ($)	FUEL ($)	SALVAGE ($)	TOTAL($)
Generic 1 kwh lead acid	$118,230,000	$104,448,831	$50,947,343	$ 000	$14,161,462	$259,464,711
Generic 3kw	$203,400,000	$64,845,415	$26,294,569	$ 000	$ 36,544,550	$ 257,995,434
Generic flat plate PV	$ 371,680,325	$000	$ 19,219,610	$ 000	$ 000	$ 390,899,935
System converter	$ 10,828,223	$ 4,594,132	$ 000	$ 000	$864,662	$14,557,693
System	$ 704,138,548	$ 173,888,377	$ 96,461,522	$ 000	$51,570,674	$922,917,773

Simulation result of electrical generation

Generation	**kWh per year**	**Percentage**
Solar flat plate PV	2,453,589	82.5
Generic 3 kW	518,769	17.5
Total	2,972,358	100

Simulation result of electrical utilization

Utilization	**kWh per year**	**percentage**
AC primary Load	884,535	99.7
Electrolyzer Consumption	2,320	0.262
Total	886,855	100

Simulation result of electrical quantity

Quantity	**kWh/yr**	**%**
excess electricity	**2,020,899**	**68.0**
unmet electric load	**317**	**0.0358**
Capacity shortage	**861**	**0.0973**

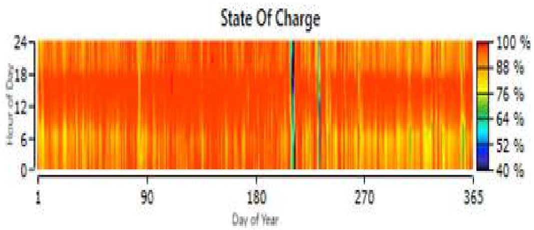
Simulation result of hydrogen production

Levelized COH-14,278$/kg

Production	**kWh/yr**	**%**
Electrolyzer	50.0	100
Reformer	0	0
Total	50.0	100

Simulation result of generic 1 kWh load acid on the basis of quantity-

The batteries are 3941 quantites with string size 100 and also bus voltage is 12.0V. all string are connected in parallel**.**



Simulation result of Solar flat plate PV

The rated capacity of Solar flat plate PV is 1487KW, mean output is 280Kw, Mean output per day is 6722Kwh/day. The capacity factor is 18.8% and the **overall generation is 2,453,589Kwh/year**. The minimum output is zero output and maximum output is 1464Kw, PV penetration is 277% . The levelised cost is 0.123$/kWh and clipped production is zero kwh.

Simulation result of Generic 3KW Wind Turbine

The rated capacity is 339kw, mean output is 59.2kw, capacity factor is 17.5%, **total production is 518,769Kwh/year**. The minimum output is zero Kilo watt, maximum output is 339 kilo watt, wind penetration is 58.6%, hour of operation is 7,006hrs/year and levelized cost is 0.385$/Kwh.

Simulation result of System Converter

Quantity	**Inverter**	**Rectifier**	**Units**
Capacity	361	361	Kilowatts
average output	63.9	2.83	Kilowatts
Max. output	348	256	Kilowatts
Capacity factor	17.7	0.785	%
Hours of operation	6,700	1,212	Hrs/year
Energy out	560,137	24,812	Kwh/year
Energy in	589,618	26,118	Kwh/year
Losses	29,481	1,306	Kwh/year

Simulation result of Generic Electrolyzer

The rated capacity is 100Kw, average input is 0.265kw and maximum input is 100kw, the total input energy is 2320Kwh/year. The capacity factor is 0.265%. the total production is 50 kg/year. The maximum output is 2.15kg/hour and specif consumption is 46.4kwh/kg

Simulation result of Hydrogen tank

The hydrogen storage capacity is 100kg, energy storage capacity is 3,333Kwh, tank autonomy is 33hours, **content at beginning of year 50 kg, content at end of year is 100kg.**

Simulation result of harmful gases emission

The harmful gases emission are Carbon dioxide, carbon monoxides, unburned hydrocarbons, particulate matter, sulphur dioxides and nitrogen oxides are negligible**.**

CONCLUSIONS

The regular consumption of fossil fuel result decrease of natural resources. It also play negative effect on atmosphere and climate. Hence use of clean energy sources becomes essential for the environment. The object of this paper is to generate the hydrogen fuel using the HES configuration. The HES configuration comprises Solar PV, Wind turbine, Electrolyser with battery storage. The HES is standalone system. The purpose of HES configuration is to generate electricity along with hydrogen fuel. The electricity production of proposed set up is 2,972,358 kWh/yr (82.5% by Solar PV and 17.5% by wind turbine). The electrolyser consumption 0.262% and excess electricity generated is 68%. The Levelized Cost of Hydrogen is14,278$/kg. the total production of hydrogen fuel is 50 Kg/year. The emission of harmful gases is negligible.

The net present cost of HES is $9, 229, 178, 00, levelised cost of energy is $0.8071 and operating cost is $169,235,30.

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