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The Best Techno-economic Aspects of the Feasibility Study Concerning the Proposed PV-Wind-hydro Hybrid System in Nilphamari, Bangladesh

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Abstract: This paper proposes multiple optimal combinations of renewable and nonrenewable energy systems for Nilphamari, Bangladesh. The Nilphamari relies mainly on on-grid electricity system. Therefore, the optimal combination of hybrid energy systems related to renewable and nonrenewable options is proposed to mitigate grid dependency. This hybrid energy system generates electricity for the consumption loads of the project area in which the natural resource potentials like solar, wind, hydro, and diesel are available. All power sources and resources data are included in the Homer software carefully. Finally, the Homer software is applied for viable techno-economic investigations especially cost of energy (COE) and net present cost (NPC) for the proposed hybrid system in Nilphamari, Bangladesh. The optimization result indicates that $0.224/kWh is the minimal COE. The proposed system has an operating cost of $16,156.16, a COE of $0.241/kWh, an NPC of $2,961,790.00, and a CO_2 output of 3,373 kg per year. The proposed system's legitimacy, as determined by the LCOE and the NPC, was confirmed by optimization analysis. Within a few years of the project's lifetime, the system is estimated to pay for itself completely. The evaluations yielded the best system configurations, hybrid system costs, fuel savings, and CO_2 emission reductions.

Index Terms: Hydro, hybrid, COE, Nilphamari, Homer pro.

1. Introduction

The demand for energy has grown quite quickly in recent years due to the development of cutting-edge technology and improved energy consumption. As of right now, the two main energy sources for producing power on a global scale are nuclear and fossil fuels. Petrol, coal, and natural gas are examples of fossil fuel energy sources. In addition to harming the ecosystem, fossil fuels release a lot of dangerous substances into the atmosphere. The use of environmentally friendly renewable energy sources is the opposite. In comparison to non-renewable energy sources, renewable energy is the best source for producing power [1]. A hybrid energy system is made up of two or more energy sources, such as solar, wind [2], hydro, and diesel energy systems, as well as an energy storage device, controller, and power conditioning unit [3]. The world's fastest-growing method of generating electricity is the hybrid electrification system [4]. In light of environmental protection and electricity consumption, a hybrid electrification system might be the greatest option for producing electricity. Hybrid energy systems can be divided into three categories for electrification: off-grid distribution systems, off-grid based on direct supply, and grid-connected modes. Numerous researchers have optimized the hybrid energy system [5] utilizing economic analysis [6] in terms of various metrics [7] such life cycle cost, NPC, and COE of the system [8]. Fuel savings and a dependable power supply are the main goals of a hybrid electric system. Performance of the system is improved by the alternation between power generating sources and renewable energy sources [9]. Energy system research can proceed in a number of ways, particularly optimization [10,11], which was dependent on simulations [12] and decision-making processes [13,14]. In the area of the electrical power market, the analysis is impossible and profitable [15].

A hybrid energy system combines several methods for generating and storing energy, or it uses two or more different fuels to power a generator. The economic viability of a PV, diesel, and battery hybrid system backed by NPC, COE, and RF was determined by Lanre et al. [16]. The performance of a hybrid PV, wind, diesel, and battery combination supporting hourly measurement was examined by Fazia et al. [17] using the Homer program. Mixed-integer applied arithmetic was developed by Andre et al. [18] to simulate system behavior and provided integrated sizing and scheduling of wind, PV, diesel, and battery-based hybrid systems. Off-grid intermittent renewable energy source (IRES) combining biogas combined heat and power (CHP) and solar power (PV) to generate electricity was the subject of a techno-economic analysis by Castellanos et al. [19] using Homer software, Sen et al. [20] presented a hybrid electric system with renewable resources, including solar photovoltaic (PV), solar thermal power (SHP), wind turbines, and biodiesel generators, and determined the optimum off-grid alternative to the conventional grid. Gonzalez et al. [21] showed the ideal size for grid-connected hybrid PV-wind power systems, taking into account the system's lowest life cycle cost. A continuous power supply was proposed by M. M. Rashid et al. [22] by combining conventional and unconventional energy sources. A grid-connected PV system based on excess electricity, unmet load, NPC, RF, and CO2 emissions % was presented by Ramli et al. [23]. The optimal hybrid power system configuration for a specific geographic area was determined by Kolhe et al. [24] using techno-economic research to identify the sensitivity characteristics, COE, yearly average wind speed, and sun irradiation.

The research-based on the study and analysis of hybrid energy options for electricity production in Rangpur [22]. But, there is no hybrid energy production system in Nilphamari. This analysis helps to choose a hybrid energy option for electricity production and reduce the problem created by the lack of electricity in the region of Nilphamari.

This paper implements a combination of solar, wind, micro-hydro, and diesel system based on actual load profiles for Nilphamari. Therefore, if the suggested system is implemented, long-term electricity production will be possible and reduced grid dependency of Nilphamari.

The remaining of the paper proceeds as follows: Section 2 materials and methods; Section 3 discusses results and discussion, and the last one is research conclusion.

2. Materials and methods

2.1 Simulation setup

This paper discusses the hybrid power system consisting of PV, hydro, wind, diesel generator, reformer, and electrolyzer, as shown in Fig.1. In the proposed system, the diesel generator power plant is incorporated with another energy source, PV, wind, hydro, reformer, and electrolyzer.

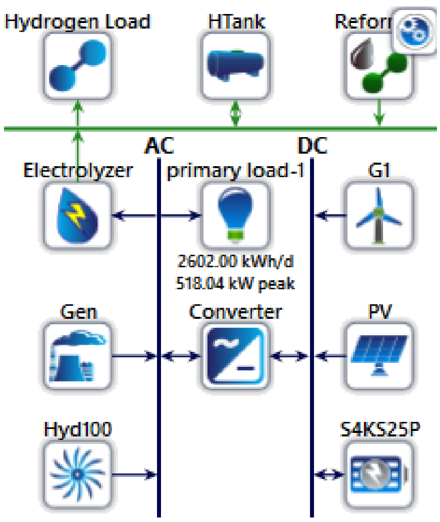


Fig.1. The schematic diagram of the hybrid energy system, Nilphamari.

2.2 Site location

The Nilphamari locate at latitude 25^0 $56.2^/$ N and longitude 88^0 $50.4^/$ E. The location of the project area is shown in Fig.2 [25]. Bangladesh map is the combination of green and red color. The green and red color regions indicate the boundary of Bangladesh and the red color region especially for the Nilphamari location in Fig.2.

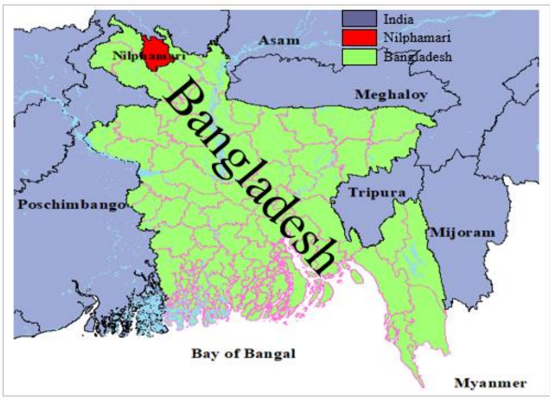


Fig.2. Location of Nilphamari, Bangladesh.

2.3 Consumption

Consumption represents the amount of energy that has been consumed over a specific time (kWh) by the load. This paper shows two consumptions; electric consumption and other is hydrogen consumption.

2.3.1 Electric Consumption

The term "electricity consumption" refers to how many kWh the load has used up in a given amount of time. The pace at which electrical energy is consumed for a required output rating was referred to as the electricity demand (kW). The proposed system requires 2602kWh/day and has a peak of 518 kW load [26]. Fig.3 shows the electrical production; of PV, hydro, wind, and diesel generators. The hydro-generator produces the maximum and the wind turbine produces minimum electricity. In the proposed system, the following generation sources serve the electrical load. The monthly load profile for electric consumption is shown in Fig.4. The maximum monthly average load is 398.37 kW in August and the minimum is 266.73kW in January.

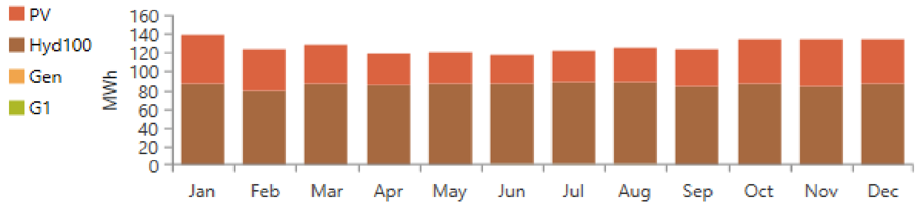


Fig.3. The electrical production of the hybrid system

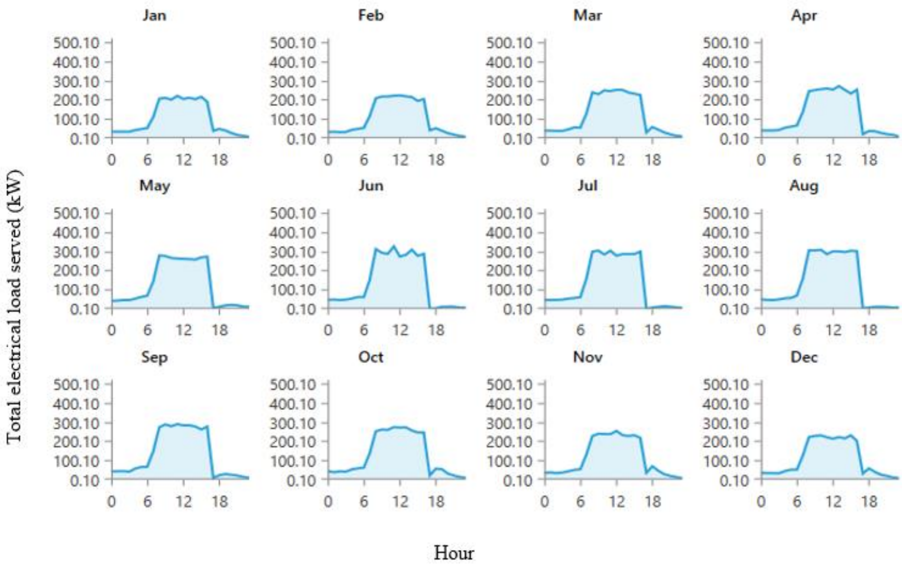


Fig.4. Monthly load profile for electric consumption, Nilphamari.

2.3.2 Hydrogen Consumption

Hydrogen consumption represents the amount of hydrogen energy that has been consumed over a specific time (kWh) by the load. The proposed system requires 11 kg/day of hydrogen and has a peak of 2.393 kg/hr [27]. The following generation sources serve the hydrogen load of the system. The hydrogen production of the proposed system is shown in Fig.5. The reformer and electrolyzer are used to generate the hydrogen. The monthly load profile for hydrogen consumption is shown in Fig.6. The average monthly maximum load is 1.60 kg/hr in August, and the minimum load is 0.37 kg/hr in January.

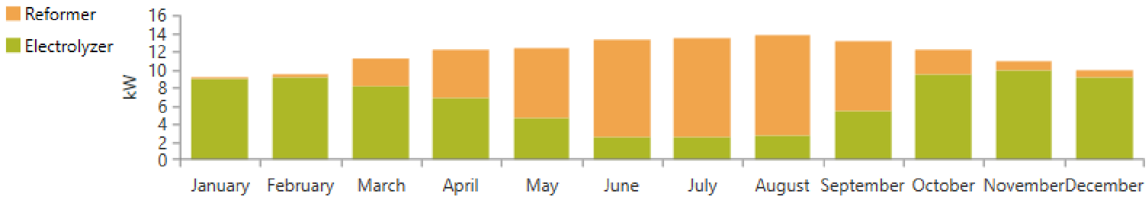


Fig.5. Hydrogen production.

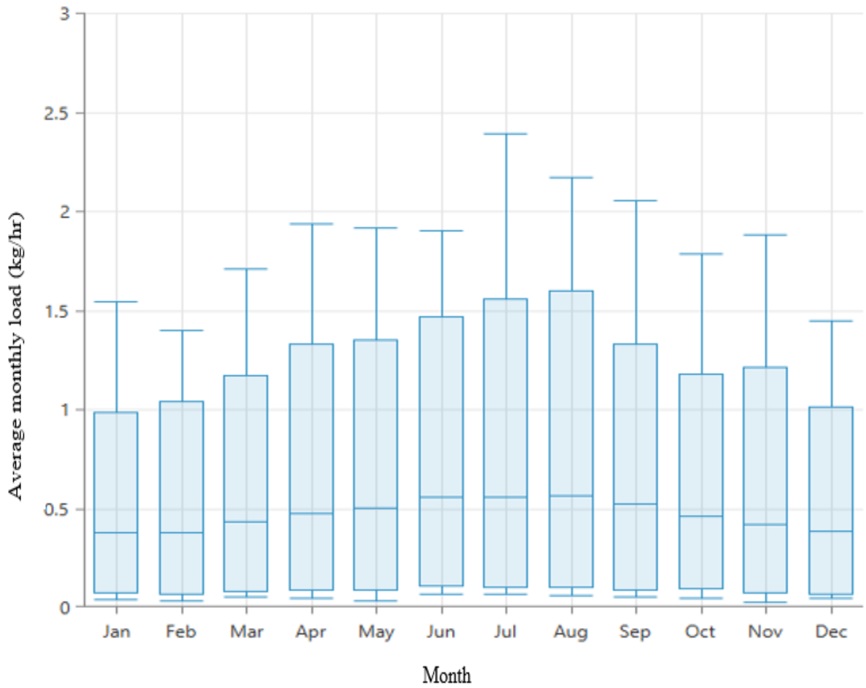


Fig.6. Monthly load for hydrogen consumption.

2.4 Renewable energy resources

Renewable energy resources are such as solar energy, wind energy, hydro energy, biomass, biogas energy, etc. Through the project area solar, wind, and hydro energy resources are used for optimization.

2.4.1 Solar resource

Based on the location of the project area, the annual average daily solar radiation of the area is 5.85 $\mathrm{kWh/m^2/day}$ [28]. Fig.7 shows the monthly average daily solar radiation and clearness index. According to Fig.7, in October, solar radiation is maximum i.e., 6.080 $\mathrm{kWh/m^2/day}$ whereas, in May, solar radiation is minimum i.e., 5.680$\mathrm{kWh/m^2/day}$.

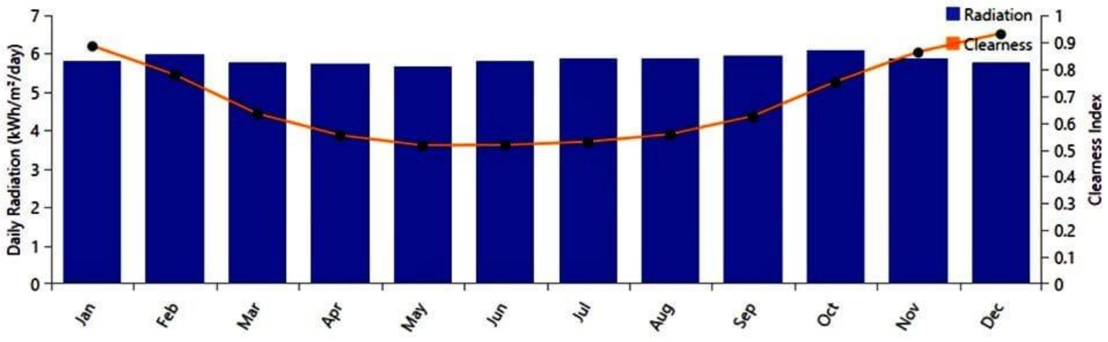


Fig.7. Solar resource

2.4.2 Hydro Resource

According to the statistics (January 2016 – December 2020) of the Bangladesh Water Development Board (BWDB) [29], Rangpur in Bangladesh. The annual average stream flow for the river of Teesta is 899,752.35 L/s. The maximum stream flow in July is 2,512,522.00 L/s and the minimum stream flow in February is 63,277.170 L/s, as shown in Fig.8.

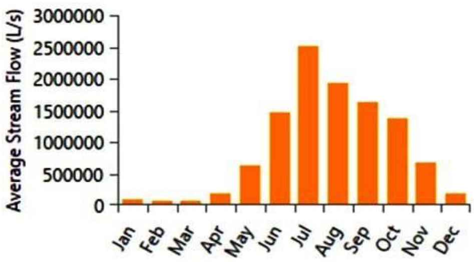


Fig.8. Hydro resource.

2.4.3 Wind Resource

For this assessment, the project area's wind resource is taken into consideration. Homer describes the wind speed using the site's latitude information obtained from NASA (national aeronautics and space administration, USA) via the internet. [30]. The annual average wind speed data is 3.91 m/s. The maximum wind speed data in June is 4.980 m/s and the minimum wind speed data in December is 2.800 m/s, as illustrated in Fig.9.

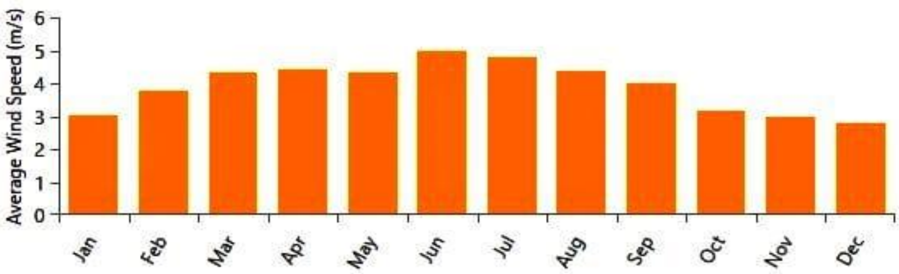


Fig.9. Wind Resource.

2.5 Power sources

This project uses different combined power sources such as PV, wind, hydro, diesel generator, electrolyzer, and reformer to get efficient power to fulfill the consumption load.

2.5.1 PV system

The name "photovoltaic" is taken from the Greek words "photo," which means light, and "voltaic," which means voltage. Photovoltaic systems use sunlight to generate electricity. To determine the clearness index for the PV system, Homer employs the standard global horizontal radiation. The entire amount of radiation that hits the surface of the globe is known as global horizontal radiation. But the amount of radiation impacting the PV array's surface determines how much power it can produce. Homer must therefore determine the amount of radiation that has been incident on the PV array's surface. In this project, the Peimar Inc. PV module is used. Table 1 shows the PV output. In Table 1, the rated capacity of PV is 254 kW, the annual production is 486,337 kWh/yr and LCOE is 0.268 $/kWh. Fig.10 demonstrates

PV power output at different months per hour of the day. In Fig.10, the black color represents the zero output and the yellow color represents the maximum output which is 261 kW.

Table 1. PV output.

Parameters	Quantity
Rated Capacity	254 kW
Specific Yield	1,913 kWh/kW
PV Penetration	51.2 %
Total Production	486,337 kW
LCOE	0.268 $/kWh

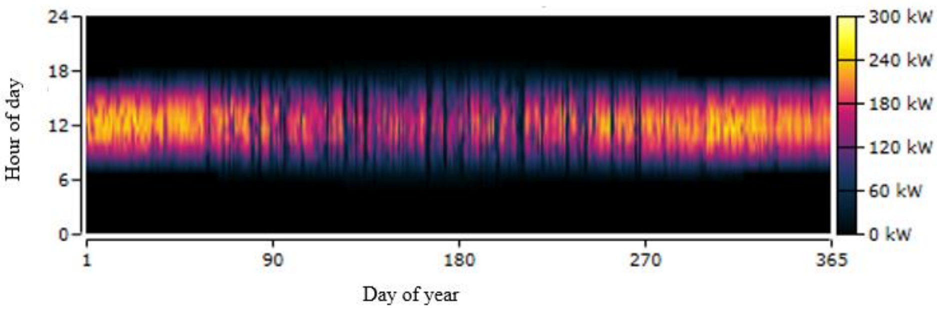


Fig.10. PV power output at different months per hour of the day.

2.5.2 Wind Turbine

A wind turbine is an energy-generating machine that is propelled by the wind's kinetic energy. Table 2 displays the output of wind turbines. From Table 2, the wind turbine's total electrical production is 1,304 kWh/yr, rated capacity is 2.00 kW. Fig.11 demonstrates wind turbine output at different months per hour of the day. According to Fig.11, the black color represents the zero output and the red color represents the maximum output of 2.0 kW.

Table 2. Wind turbine output.

Parameters	Quantity
Wind Turbine Total Production	1,304 kWh/yr
Wind Turbine Lifetime	25.0 years
Rated Capacity	2.00 kW
Hours of Operation	5,864 hrs/yr

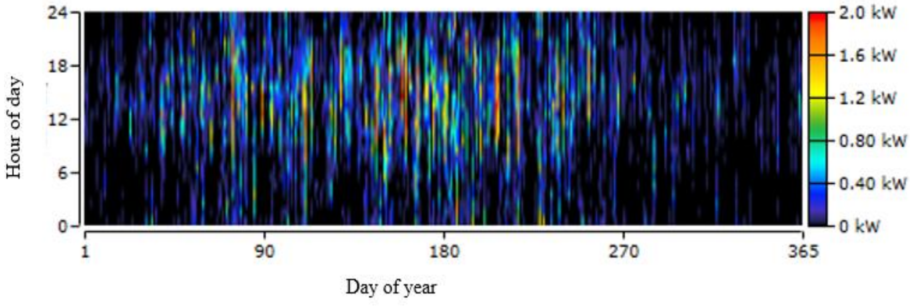


Fig.11. Wind turbine output at different months per hour of the day.

2.5.3 Diesel generator

A generator is a device that transforms mechanical energy into electrical energy. Power output from the diesel generator system output is shown in Table 3. According to Table 3, the rated capacity is 570 kW using diesel as fuel, electric production is 4,231 kWh/yr, fuel consumption is 1,289 L, fixed generation cost is 58.0 $/hr, generator fuel price is 1.00 $/L, electrical production is 4,231 kWh/yr, marginal generation cost is 0.248 $/kWh. Fig.12 shows diesel generator output at different months per hour of the day. In Fig.12, the black color represents the zero output and the red color represent the maximum output in kW. The maximum diesel generator output is 192 kW and the minimum output is 142 kW.

Table 3. Generator output.

Parameters	Quantity
Capacity	570 kW
Operational Life	517 yr
Fuel Consumption	1,289 L
Hours of Operation	29.0 hrs/yr
Fixed Generation Cost	58.0 $/hr
Generator Fuel	Diesel
Generator Fuel Price	1.00 $/L
Electrical Production	4,231 kWh/yr
Marginal Generation Cost	0.248 $/kWh

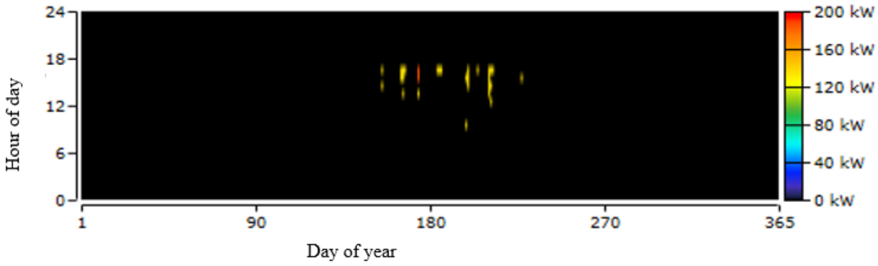


Fig.12. Diesel generator output at different months per hour of the day.

2.5.4 Hydropower

Hydropower, also referred to as water power, generates electricity using falling or swiftly moving water. This project uses hydropower to produce electricity in the Teesta of Nilphamari. Hydropower output is shown in Table 4. Table 4 demonstrates rated capacity 92.0 kW, operation hours 8,760 hrs/yr, levelized cost 0.00378 $/kWh, capacity factor 128%, total production 1,027,199 kWh/yr, maximum output 117 kW, hydro penetration 108%. Fig.13 shows hydropower output at different months per hour of the day. In Fig.13, the black color represents the lowest output and the red color represents the maximum output in kW. The maximum hydro output and the minimum output are 117 kW.

Table 4. Hydropower output.

Parameters	Quantity
Rated Capacity	92.0 kW
Operation Hours	8,760 hrs/yr
Levelized Cost	0.00378 $/kWh
Capacity Factor	128 %
Total Production	1,027,199 kWh/yr
Maximum Output	117 kW
Hydro Penetration	108 %

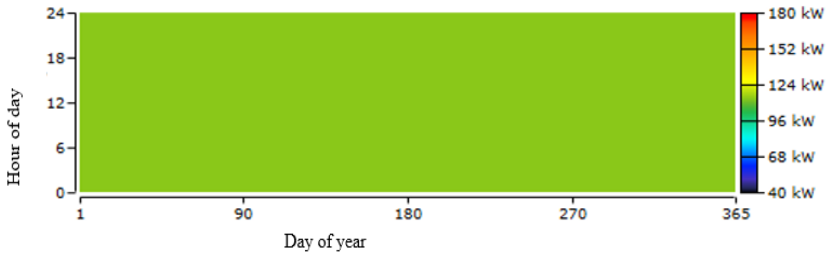


Fig.13. Hydropower output at different months per hour of the day.

2.5.5 Electrolyzer

The electrolyzer is a device that uses electricity to chemically separate the molecules of hydrogen and oxygen in order to produce hydrogen. [31]. In this project, the electrolyzer is used to generate hydrogen. The generic electrolyzer output is shown in Table 5. According to Table 5 the electrolyzer rated capacity is 100 kW, the total annual production is 2,422 kg/yr, hours of operation is 6,148 hr/yr, operating expenses are 1,000 $/yr, the capacity factor is 12.8%, and total production is 2,422 kg/yr. Electrolyzer output at different months per hour of day the shown in Fig.14 in which the black color represents the zero output, and the red color represents the maximum output in kW. The maximum electrolyzer output is 2.15 kg/hr, and the minimum output is 0 kg/hr.

Table 5. Electrolyzer output

Parameters	Quantity
Rated Capacity	100 kW
Total Input Energy	112,413 kWh/yr
Hours of Operation	6,148 hr/yr
Operating Expenses	1,000 $/yr
Capacity Factor	12.8 %
Total Production	2,422 kg/yr
Specific Consumption	46.4 kWh/kg
Mean Output	0.277 kg/hr

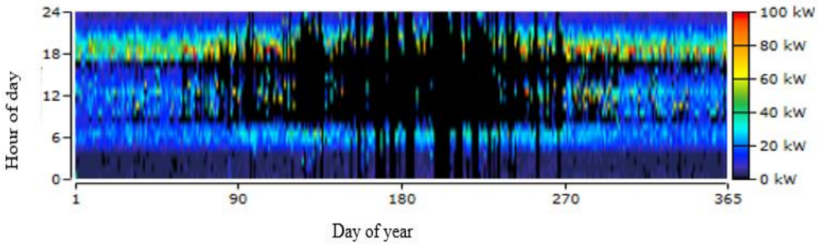


Fig.14. Electrolyzer output at different months per hour of the day.

2.5.6 Reformer

The reformer is a device that separates pure hydrogen from hydrocarbons and supplies it to fuel cells. [32]. In this project, the reformer is used to generate hydrogen from diesel fuels. The generic reformer output is shown in Table 6. Table 6 shows the reformer rated capacity 3.00 kg/hr, hours of operation 3,317 hr/yr, capacity factor 0.0709%, total production 1,863 kg/yr, and maximum output 2.39 kg/hr. Fig.15 reformer output at different months of hour of the day. In Fig.15, the black color represents the zero output and the red color represent the maximum output in kW. The maximum reformer output is 2.39 kg/hr and the minimum output is 0 kg/hr.

Table 6. Reformer output

Parameters	Quantity
Rated Capacity	3.00 kg/hr
Hours of Operation	3,317 hr/yr
Capacity Factor	0.0709 %
Total Production	1,863 kg/yr

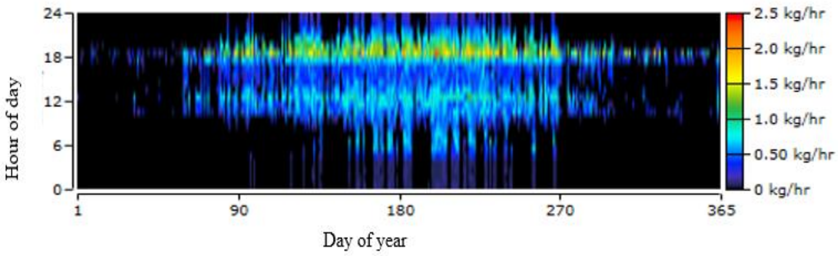


Fig.15. Reformer output at different months of hour of the day.

2.5.7 Hydrogen Tank

A hydrogen tank is such type of tank that is used for the storage purpose of hydrogen in the form of liquid which is used in this project. Table 7 shows the hydrogen tank output of the proposed hybrid system.

Table 7. Hydrogen tank output

Parameters	Quantity
Hydrogen Storage Capacity	1.00 kg
Content at Beginning of Year	0.100 kg
Tank Autonomy	0.307 hr
Energy Storage Capacity	33.3 kWh
Content at End of Year	1.00 kg

Table 7 shows the hydrogen tank output of the proposed hybrid system. The hydrogen storage capacity is 1.00 kg, content at beginning of the year is 0.100 kg, tank autonomy is 0.307 hr, energy storage capacity is 33.3 kWh, and content at end of the year is 1.00 kg. Fig.16 demonstrates hydrogen tank output at different months per hour of the day. In Fig.16, the black color represents the zero output and the red color represents the maximum output in kW. The maximum average storage is 1.00kg and the minimum average is 0.60 kg.

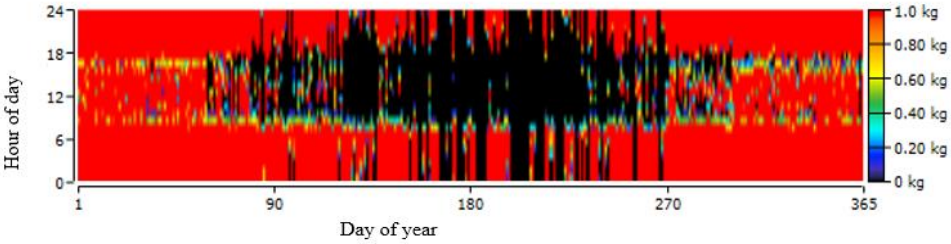


Fig.16. Hydrogen tank output at different months per hour of the day.

2.6 Storages

A battery or storage device uses an electrochemical oxidation-reduction mechanism to convert the chemical energy held in its active components directly into electric energy. This project uses the Surrette 4 KS 25P storage system. The Surrette 4 KS 25P battery, which is designed exclusively for solar and other renewable energy applications, is a solid option for medium- and large-sized charge storage. [33]. Table 8 shows the storage output. Table 8 expresses the rated capacity as 3,305 kWh.

Table 8. Storage output.

Parameters	Quantity
Rated Capacity	3,305 kWh
Annual Throughput	158,052 kWh/yr
Autonomy	18.3 hr
Expected Life	20.0 yr
Losses	35,341 kWh/yr

The annual throughput is 158,052 kWh/yr, autonomy is 18.3 hr, expected life is 20.0 yr, and losses are 35,341 kWh/yr. Fig.17 shows storage output at different months per hour of the day. In Fig.17, the black color represents the lowest output and the red color represents the maximum output in a percentage. The maximum average storage is 99.98% in January and the minimum average storage is 90.15% in August.

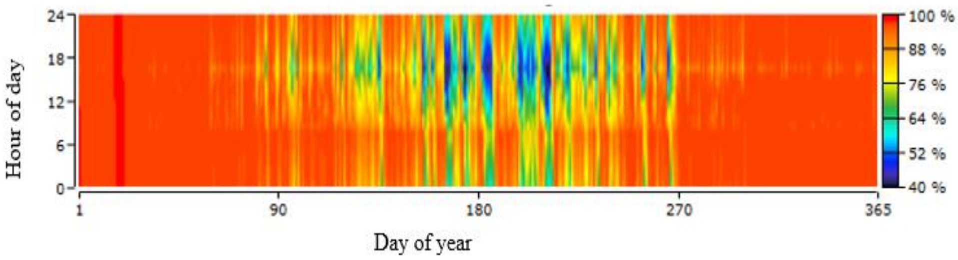


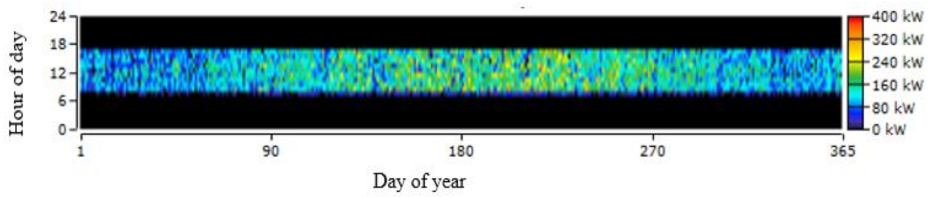
Fig.17. Storage output at different months per hour of the day

2.7 Converter

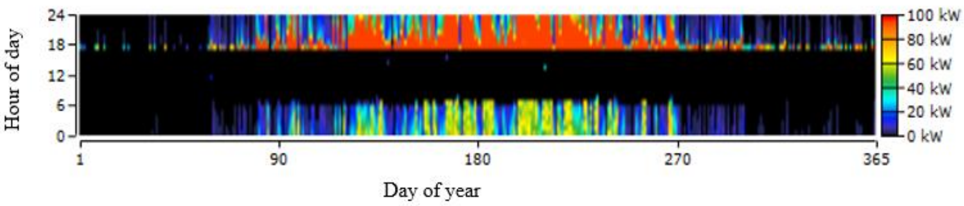
This project uses a system converter, which includes an inverter that converts DC power to AC power and a rectifier that converts AC power to DC power. Table 9 shows the converter output. Table 9 shows the system converter capacity 433 kW, mean output 52.1 kW, capacity factor 12.0%, hours of operation 3,521 hrs/yr, energy output 456,244 kWh/yr, energy losses 50,694 kWh/yr. Fig.18 shows storage output at different months per hour of the day (a) Inverter output and (b) Rectifier output. In Fig.18, the black color represents the zero output and the red color represent the maximum output in kW. The maximum average output of the inverter and rectifier is 381 kW and 99 kW respectively, and the minimum average output of the inverter and rectifier is 0 kW.

Table 9. Converter output.

Quantity	inverter	rectifier	unit
Capacity	433	433	kW
Mean Output	52.1	16.6	kW
Minimum Output	0	0	kW
Maximum Output	381	99.6	kW
Capacity Factor	12.0	3.84	%
Hours of Operation	3,521	4,778	hrs/yr
Energy Out	456,244	145,606	kWh/yr
Energy In	506,938	171,302	kWh/yr
Losses	50,694	25,695	kWh/yr



(a) Inverter output



(b) Rectifier output

Fig.18. Converter output at different months per any hour of the day (a) Inverter output (b) Rectifier output

3. Result and Discussion

Based on the component combinations provided as input data, Homer simulates every potential system configuration, tossing out impractical configurations that can't be implemented given the recommended load, the available resources, and the established limitations. According to the total net present cost, some feasible combinations are presented in ascending order, as shown in Fig.19. The optimization outputs are presented in a categorical format. Fig.19 illustrates all possible system configurations according to cost efficiency for a particular set of sensitivity variables. Four parameters are considered to find an optimal system; COE, RF, NPC, and CO_2 emissions. The optimization result shows that the minimum COE is $0.224/kWh. In the proposed system the COE is $0.241/kWh, NPC is 2,961,790.00, operating cost $16,156.16 and CO_2 3,373 kg/yr. Fig.19 displays the most cost-effective configurations from each possible combination; PV, wind, hydro, electrolyzer, and reformer in which one possible configuration is selected for the proposed project.

Architecture											
PV (kW)	G1	Gen (kW)	S4KS25P	Hyd100 (kW)	Electrolyzer (kW)	Reformer (kW)	HTank (kg)	Converter (kW)	Dispatch	NPC ($)	COE ($)
224		570	574	92.0		3.00		426	LF	$2.74M	$0.224
257			674	92.0		3.00		391	CC	$2.78M	$0.227
254	2	570	438	92.0		3.00		433	LF	$2.85M	$0.232
233		570	535	92.0	100	3.00	1.00	380	LF	$2.87M	$0.234
257			674	92.0	100	3.00	1.00	391	CC	$2.89M	$0.236
224		570	574	92.0	100	3.00		426	LF	$2.96M	$0.241
254	2	570	438	92.0	100	3.00	1.00	433	LF	$2.96M	$0.241
257			674	92.0	100	3.00		391	CC	$3.00M	$0.244
254	2	570	438	92.0	100	3.00		433	LF	$3.07M	$0.250
407	27		449	92.0		3.00		397	CC	$3.79M	$0.309
407	27		449	92.0	100	3.00	1.00	397	CC	$3.85M	$0.313
407	27		449	92.0	100	3.00		397	CC	$4.00M	$0.326

Fig.19. Optimization results in a categorized form.

3.1 Sensitivity parameters

Diesel cost is regarded as a sensitivity parameter. The COE is successively $0.224, $0.226, and $0.228 based on the three distinct diesel price levels of $0.90/L, $1.00/L, and $1.08/L. The renewable proportion for the three sensitivity parameters is 99.6%. For all models, these sensitivity variables are investigated.

3.2 Compare Economics

Homer calculates the actual discount rate (in percent), which is needed to convert between one-time and recurring costs. This process is known as economics. The economics of the project are shown in Table 10 that indicates the present worth is $37,181, the annual worth is 2,876 $/yr, the return on investment is 86.1%, the internal rate of return is 10.3% and simple payback is 24.20 yr.

Table 10. Economic of the project.

Metrics	value
Present worth ($)	$37,181
Annual worth ($/yr)	$2,876
Return on investment (%)	86.1
Internal rate of return (%)	10.3
Simple payback (yr)	24.20

3.3 Emissions

In this hybrid system, several gases are emitted; carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, etc. The emission of the hybrid system is shown in Table 11 in which the emission of various gases; carbon dioxide 3,373 kg/yr, carbon monoxide 21.3 kg/yr, unburned hydrocarbons 0.928 kg/yr, particulate matter 0.129 kg/yr, sulfur dioxide 8.26 kg/yr, nitrogen oxides 20.0 kg/yr. All over the emissions are comparatively less per year.

Table 11. The emission of the project.

Parameters	value
Carbon Dioxide	3,373 kg/yr
Carbon Monoxide	21.3 kg/yr
Unburned Hydrocarbons	0.928 kg/yr
Particulate Matter	0.129 kg/yr
Sulfur Dioxide	8.26 kg/yr
Nitrogen Oxides	20.0 kg/yr

Table 11 shows the emission of various gases; carbon dioxide 3,373 kg/yr, carbon monoxide 21.3 kg/yr, unburned hydrocarbons 0.928 kg/yr, particulate matter 0.129 kg/yr, sulfur dioxide 8.26 kg/yr, nitrogen oxides 20.0 kg/yr. All over the emissions are comparatively less per year.

3.4 Renewable Penetration

The term "penetration" refers to the proportion of power produced by a certain resource. [34]. Renewable penetration can refer to the percentage of the total electricity generated relative to the total electricity consumed.

Table 12. Renewable penetration shows with (a) capacity-based metrics (b) energy-based metrics and (c) peak values.

Capacity based metrics	**value**
Nominal renewable capacity divided by total nominal capacity	38.9%
Usable renewable capacity divided by total capacity	34.2%

(a)

Energy-based metrics	**value**
Total renewable production divided by load	153%
Total renewable production divided by generation	99.7%
One minus total nonrenewable production divided by the load	99.6%

(b)

Peak values	**value**
Renewable output divided by load (HOMER standard)	126,669%
Renewable output divided by total generation	100%
One minus nonrenewable output divided by the total load	100%

(c)

Table 12 shows the renewable penetration with (a) capacity-based metrics, (b) energy-based metrics, and (c) Peak values of the project. For the capacity-based metrics, nominal renewable capacity divided by total nominal capacity is 38.9%, and usable renewable capacity divided by total capacity is 34.2%. For the energy-based metrics, total renewable production divided by load is 153%, and total renewable production divided by generation is 99.7%. For the peak values, renewable output divided by load (Homer standard) is 126,669%, and renewable output divided by total generation is 100%.

4. Conclusion

Homer software is used to present optimal configurations and sensitivity analyses for the models under consideration. The ideal system size for the suggested hybrid system is as follows: 254 kW of solar power, 92 kW of hydropower, 570 kW of diesel power, 438 batteries, 433 kW of converter power, 3 kW of reformer power, and 100 electrolyzers. The construction is deemed to be more palatable when the environment's primary determining factor is taken into account because it emits the least CO_2 (3373 kg/yr). As a result, it can be advised that the project area prioritize environmental issues as a workable solution.

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