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Research Article

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A Mathematical Design of Off-Grid Hybrid Renewable Energy System Using Optimisatization Techniques

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Abstract This study proposes an autonomous hybrid generation device that blends wind and solar power with a battery storage bank and a diesel generator for back-up use. This study explored how hybrid renewables systems can be improved, dimensioned and run, contributing to low expense. Information of Energy3D and BEopt AutoCAD drawings that were included in all hybrid power device components. In the MATLAB / Simulink, which is fast correctly applied and includes dynamics and supervision controls, we have the device dynamic model and simulations provided here. The proposed control algorithm tracks the system's usable surplus / lacking energy and controls the PV / Wind Turbine and battery bank charging / discharging to hold the system frequency constant. Matlab / Simulink simulation findings demonstrate that the overall hybrid architecture works under different temperature and load conditions.

Keywords Design, Energy, Off-Grid, Optimization and Renewable

Introduction

Around 33 percent of the combined residential and industrial buildings are Global production of greenhouse gases (GHG). The leading sources of electricity production have been historically coal, oil, natural gas, and other fossil fuels. Researchers worldwide are involved in extending the production of green hybrid energy for decades. For a variety of important factors, many people recognize the effect of our dependence on fossil fuels for energy: fossil fuels combustion is a daily source for much of the worlds of anthropogenic greenhouse gas pollution, fossil fuel prices may rise over the next few years and the world's fossil reserves, which are increasingly difficult to detect [1-3]. The carbon dioxide produced by the combustion of fossil fuels influences the atmosphere and induces global warming. These issues now arise and will impact future generations. Carbon dioxide pollution and the waste of electricity production from conventional coal-fired power plants are also an important environmental concern. Homeowners and corporations will produce a lot of their own electricity. Light, wind and water are free, so electricity prices for technology are significantly smaller, with a good effect on the community and a greater availableness. Similar movements are currently under way to encourage the production of sustainable sources of power generation by electricity utilities and likely even to retain a particular share of the renewable energy they produce [4-6]. The location and availability of certain natural resources, which affect site selection, rely on many renewable resources [4-6]. However, less fossil fuel decreases pollution and waste whereas healthier, fresher air and water are enjoyed in culture. There are less oil discharges and chemical incidents that contribute to less polluted land. Renewable technologies are usually positioned further from metropolitan centres, contributing to the development of centres which have been destroyed by conventional factories.

2. Problem Description

The house in Lagos, Nigeria, is a study of offices. Figure 1 shows the view Office building researched. The building has six floors and has 250 people. Construction. On the top of the house is the planned hybrid energy infrastructure.

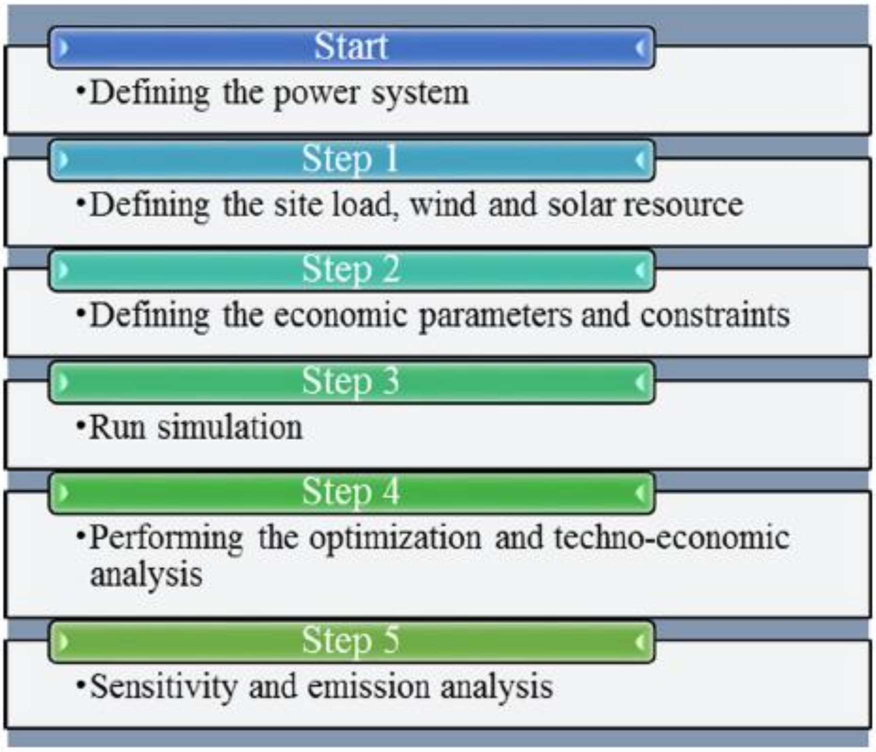

Figure 1: Schematic diagram used in this investigation to examine optimisation of the theoretical HOMER hybrid system [7]

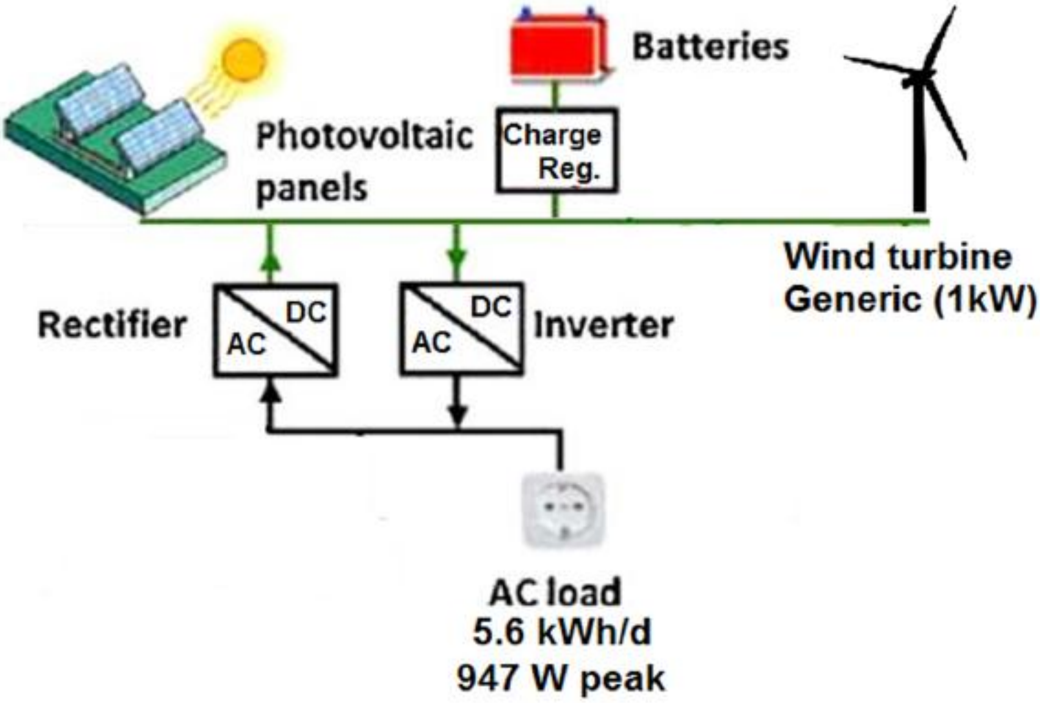

Figure 2: Schematic diagram in the analyzed office building for the planned hybrid power system [8]

Renewable Energy in Power Generation

In every hourly period, the load is called constant on the device. And if this is not optimal, the model would soon be crowded and complicated. In the wintertime, an electricDG2500E small portable 1,5-kW diesel generator is mounted and chosen for a correct model for loading in the remote area depending on the power load to provide. The DG2500E is a small portable diesels generator. The diesel generator motor is disconnected at 1200 rpm and reconstructed for 12,000 hours. This machine incorporates a diesel engine to produce electricity using an electric generator (often an alternator). This is a case in point with the engine generator. A diesel compression allumage engine is mostly designed to work on fuel oil, although some models are ideal for other liquid or natural gas fuels. In overload cases, the secondary role of a stand-by diesel generator is to compensate for a power shortage.

Review of Related Work

Renewables are often blamed for being unpredictable or sporadic from sources such as wind and solar power. The International Energy Agency notes that this applies only to some renewables, particularly photovoltaics from wind and solars, and their value depends on a number of elements, such as renewable energy penetration [2]. Solar energy does not cause any toxic pollution during service, unlike fossil-fuel technology. The efficient and emission free source of electricity in homes and offices may be a tiny solar electric or photovols (PV) device [3]. PV technology produces energy using direct and distributed sunlight [4]. The most influential of the Sun is Africa which is sometimes referred to as the "Sun Continent" as it gets several more hours of clear sunlight throughout a year. The sun resource in Libya is extensive for domestic solar power [5]. As a location governed by blue sky and through deserts with long hours of sunlight. Saharan or northeastern Africa, however, is especially well established for its sunshine world records [5]. In 1839, the concept of solar cells began. When light was shined on an elektrode in an electrolyte solution Edmund Becquerel discovered the photovoltaic effect. The photovoltaic cell is now commonly used and recognized as the fastest-growing technology

System Description and Specifications

PV modules and array production.

For the PV modules the nominal power level was set at 1.8 kWp, which is appropriate. To supply the toilet room with the greatest demand. There are independent subarrays in the PV modules (MA45 modules). There are 16 modules each in each sub-array. The PV module form is one Silver with a maximum performance of 45 W, polycrystalline. Each module has a region of 0.45 m^2

46.2 cm 97.7 cm measurements. The panels are fixed to the south and installed Tilt angle face 45. The PV module has a nominal working temperature of 45 ºC and the system's nominal performance is estimated at 11.5%. The picture of the Figure 3PV device on the building's rooftop.

Table 1: Specifications for wind generator in proposed hybrid energy system

Description	Specification
Wind generator's type	Generic 1 kW
Rotor diameter	3m
Blades	3-carbon fiber composite
Start-up wind speed	3 m/s
Rated power	1000 W DC at (12.5 m/s)
Voltage	48 V_{DC}
Over speed protection	Electronic torque control
Capital cost	$980
Replacement cost	$300
Operating and maintenance cost	$30
Lifetime	20 yr
Wind turbine sizes considered (kW)	0, 1.0

$$P_w = \sum_{i=1}^{N_B} \frac{1}{2} (\mathrm{U}_{i+1} - U_i)(\mathrm{P}(\mathrm{U}_{i+1})\,\mathrm{P}_W\left(U_{i+1}\right) + P(\mathrm{U}_i)P_w\left(U_i\right), \tag{1}$$

Using Eq. (1) for the average wind machine power, it is possible to calculate the annual energy captured from wind turbine.

$$E_w = P_w \times N \times \Delta t, \tag{2}$$

where N is the number of measurement periods, Dt.

If PR is the rated power of the turbine and CF is the capacity factor, the energy generated (EI) by the turbine

$$E_I = 8760 \times P_R \times CF, \tag{3}$$

Capacity factor, which is measure of electrical energy generated per kW of installed capacity (kW h/kW) per year, would primarily depend on the wind speed distribution and the design of the wind turbine.

Storage batteries

The battery bank's size depends on the storage quantity required;Rate of discharge and the minimum battery temperature used.

The storage device

The following criteria should be fulfilled by the battery: to withstand different loading and discharge Cycles can work at defined limits at a low rate of self-discharge. The following equation defines the power

$$BC = 2 \times f \times W / V_{batt}, \tag{4}$$

When the energy of the battery is BC, f is the reserve component, W is the regular power and Vbatt areIs the DC voltage of the device. The battery bank has technological and economic information (Table 2). The nominal voltage of storage batteries were 12V with a power of 200 A hPicked to simulate. There are 2 plum acid battery batteries in each battery string4.8kWh of power sequence and manufactures. To determine energy efficiency, numerous Battery string numbers can be checked. The battery's versatility is defined by and the design for zero-maintenance. The battery lifespan is 10 years.

Table 2: Technical and economic specification for the battery bank

Description	**Specification**
Battery's model	Type banner SBV 12-200
Nominal voltage	12 V
Nominal capacity	200 A h
Round trip efficiency	70%
Minimum state of charge-state of charge (SOC)	30%
Nominal energy capacity of each battery (V A h/1000)	2.4 kW h
Capital cost	$447
Replacement cost	$447
life expectancy	10 yr
Number of batteries considered	16-Mar

This findings checked different numbers of batteries. Originally 4,8kW h of the 24V battery bank.

Loading in deep-cycle batteries locked, valve operated (2 to 2).The following equations are often used to calculate the number of batteries needed

$$C_{Ah} = \frac{E_c}{\eta_B\left(DOD\right)V_B} = \frac{n_{day}\left(E_{load}\right)}{\eta_B\left(DOD\right)V_B}, \tag{5}$$

$$n_{battery} = \frac{C_{Ah}}{C_{Single}}, \tag{6}$$

$$n_{string} = \frac{48}{V_B}, \tag{7}$$

where n day is considered as the number of autonomous days powered solely by the battery storage bank; E load is the daily energy consumption (5.6 kW h); Ec¼n day_Eload is defined as the summary of energy demand for the continuous number of autonomous days; gB is the overall battery and inverter efficiency; VB is the battery rated voltage; DOD is the allowable depth of discharge; C single is the storage capacity of a single battery; n battery is the total number of batteries and n string is the string number.

Results and Discussion

The goal of the method of optimization is to specify the optimum value of each decision variable such as the AC – DC inverter number of batteries and scale. In the course of optimisation, HOMER simulates a variety of various structures and discards unfeasible device configurations. And, and, Code ranks and introduces the feasible method on the basis of the overall NPC. The best machine configuration for the lowest overall NPC. Proposed graphical scheme. Figure 3 displays the autonomous hybrid energy device. HOMER has assigned preference to 200 viable hybrid energy systems in the current study. The most excellent Efficient and cost-friendly device choices centered on multiple typical regular loads Requirement between 5.6 and 20 kW h / day and the original design requirement (interest rate Table 3 reveals 12 percent, wind speed: 4.56 m / s, world solar radiation: 4.9 kW h/m^2 day). It is obvious that rising demand is causing PV strength, amount of batteries, overall costs and excess. The power fraction is steadily increasing both of them. In comparison, the complete NPC of hybrid optimal systems. It is between 21 132 and 24 732 dollars; 45 275 to 49 775 dollars; and 108 096 to 112 496 dollars on cargo; Requirements 5.6 kW / d, 10 kW / d and 20 kW / d respectively.

Table 3: Technical and economic specification for the inverter

Description	**Specification**
Inverter's type	Sunny Boy model 2500
Pnominal	2200 W_P
Maximum input voltage (V_{DC}, max)	600 V
PV-Voltage Maximum power point tracking (V_{pv})	250-600 V
Maximum input current	11.2 A
Pmax	2500 W
Peak inverter efficiency	93%-94.4%
AC Input frequency	49.8-50.2 Hz
V_{AC}	198-251 V
Capital cost	$1,368
Replacement cost	$1,368
Lifetime	20 yr
Power inverter sizes considered (kW)	0-20 in steps of 5

Table 4: The most efficient hybrid renewable energy systems under different average daily load from 5.6 to 20 kW h/day

Req.	**Load**	**Regression Value**	**constant**	**Corre. Coeff**	**Solar**	**Test**	**Train**	**Power Factor**	**Prediction**
5.6	3	1	16	1	18247	386	21132	1.384	53.1
5.6	4	1	12	1	20280	326	22718	1.488	63.5
5.6	4	0	16	1	20767	373	23553	1.543	57.1
5.6	3	1	16	5	21847	386	24732	1.62	53.1
10	9	0	16	5	41867	456	45275	1.661	66.3
10	9	1	16	5	42847	486	46479	1.705	68.8
10	10	0	16	5	45367	473	48900	1.794	69.8
10	9	0	16	10	46347	456	49775	1.826	66.3
20	26	1	16	5	102347	770	108096	1.984	77.7
20	27	0	16	5	104867	756	110517	2.028	77.8
20	27	1	16	5	105847	786	111721	2.049	78.5
20	26	1	16	10	106847	770	112596	2.066	77.7

Optimized solar–wind–battery hybrid systems varies from 1.384 to 2.066 $/kW h, while the Optimal PV-only systems have a COE ranged from 1.543 to 2.028 $/kW h.

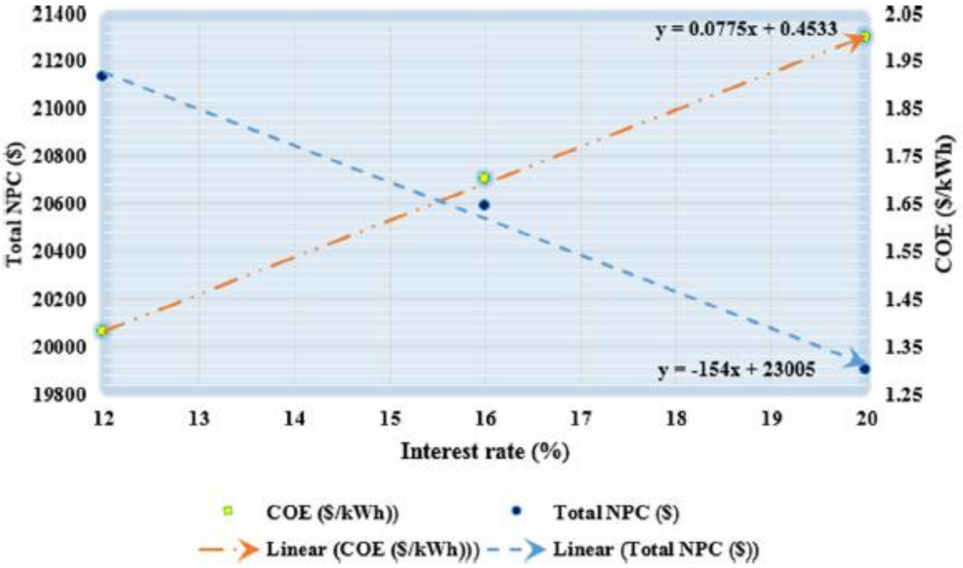

Figure 3: Impact of increasing real interest rate on the NPC and the COE of the hybrid energy system

Just 24 percent reduces COE. Contrary to COE, the net device costs are inverse. True interest rate linked to, because Eqs tells. The actual interest rate is (1) and (2) Increases the expense of the real value received over the duration of the project would be reduced.

Conclusion

The use of off-grid green energy systems in office buildings is one of the strongest uses of clean energy technologies. The hybrid energy systems are built in which excessive power can be transformed and retained to overcome the intermittence of renewable energy sources, such as sun and wind. These sources would have greater device stability, together with energy storage, which would be ideal for standalone applications. The HOMER model has been used to analyze the optimum architectural possibilities and techno-economic feasibility of the building's built hybrid renovable energy system. It has been noticed that when the suggested link architectures are Mixed Coupled Hybrid power systems (HPS), the highest performance of energy usage can be obtained. Various methods of sizing based on the availability of the atmosphere and solar irradiation were checked in the classification. A new energy programming algorithm is proposed and tested for the hybrid PV / battery bank / diesel generator device. Optimum ON / OFF periods for the diesel generator are measured on the basis of optimum battery dod values that fulfill the energy load specifications during the day. As a consequence, gasoline usage and CO2 pollution are lowered. The DG's timetable is focused on the short-term forecast for PV output power which occurs with the automotive regressive model every two minutes. The dod benefit of the battery bank is controlled to provide energy to the load throughout the day when PV power production is inadequate. It also decreases the running period of the diesel generator. The findings obtained illustrate an effective algorithm for energy management that indicates minimal DG running period and steady energy usage.

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