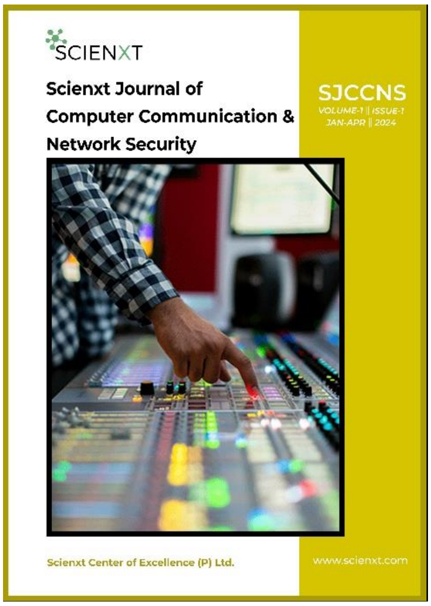

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Review on the working of Hybrid renewable energy systems

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Abstract:

Sustainability-wise, a single criterion is insufficient to establish the best Hybrid Renewable Energy System (HRES). This paper presents a multi-criteria method for low-income HRES selection. The investigation compares energy demand with or without EET (EET). The HRES is optimized using hybrid optimization of various renewable energy (HOMER), or the multi-criteria analysis uses CRITIC and TOPSIS (TOPSIS). PV/GEN/BAT is the best HRES in energy demand scenarios. A 44.6 percent decline in energy demand utilizing EET reduces net current expenses by 51.38 percent, energy prices down 11.90 %, CO_2 emissions at 96.61 percent, and renewable fraction by 193.94 percent. Multi-criteria HRES selection impacts the best acceptable alternative selection and ranking. MCDM may help decision-makers to choose the best HRES.

Keywords:

Energy Efficiency, Hybrid Renewable Energy System, Homer, Topsis, Low-Income Household.

1. Introduction:

Electricity has been acknowledged as a key factor in the growth and development in the city, the suburbs, and the country (Monyei and Adewumi, 2017). This is due to electricity's role as a catalyst, source of employment, and motivator in the production of goods (Akinbulire, Oluseyi and Babatunde, 2014). Businesses, homes, production lines, services, and more rely heavily on constant availability to electricity. One of the Sustainable Development Goals (SDGs) promotes universal, affordable, and sustainable access to energy (Babatunde, Munda and Hamam, 2019). It is anticipated that this would lead to a worldwide decline in poverty while simultaneously raising the level of living for all people. Expanding utility grids to previously unconnected areas or installing distributed power in places that are not grid-viable are common strategies for raising electrification rates. The problem in many developing nations (particularly in sub-Saharan Africa) goes much beyond the extension of the grid and decentralized generation; many regions that already have utility grids and distributed generation still lack access to sufficient and dependable energy. For several people, power outages can last for many days. Weaknesses in electricity production are a major factor in this.

Here, we propose a techno-economic optimization as well as emission analysis of HRESs, using the energy-efficient loads characteristic of low-income dwellings as the study's data source. To further assist in selecting the optimal HRES, we have included a multi-criteria approach. This same Home Energy Resource Optimization (HOMER) technique can be used for the techno-economic optimization of an HRES, while multi-criteria analysis is performed using the Criteria Significance through the use of Intercriteria Link (CRITIC) and Technique for Preference other than Similarity to something like an Ideal Solution (TOPSIS) methodology (Akinyele, Belikov and Levron, 2018). Our research shows that HRESs can cut costs by improving their energy efficiency, which really is good for both their bottom lines and the environment. The usage of multiple selection criteria of HRESs can also change the ranking of HRESs returned by such a single criterion.

1.1. Aim:

This study’s research aim is to enable low-income families make informed decisions about which renewable energy system options are best for their needs.

1.2. Objective:

The goals of this work are multifold:

1) To maximize the generated by a PV array that is wired into the public power grid, and

2) To effectively address the problems previously encountered by energy customers, in particular those in the Global South.
3) Through the use of HOMER, we will model and analyze potential HRES configurations in order to determine the best course of action.

1.3. Research questions:

1) Why are hybrid energy systems becoming so common?
2) Two, what are some strategies for maximizing the impact of your efforts to spread awareness about renewable energy?

2. Literature review:

2.1. Hybrid renewable energy system:

The literature identifies numerous categories of technologies useful in the design and planning for hybrid energy systems. The availability of generation-side fuel sources, a grid connection, a heating network, as well as the proposed application scenario all influence how well they fit the bill. The following technological options are viable under the HRES framework: Miniature wind turbines, micro internal combustion engines (micro-CHP) systems, heat pumps, and thermal chillers are only some of the solar technologies available today.

The HRES frequently makes use of sensible and latent storage, battery electric storages, thermal decomposition building systems, and electric cars for flexible electric storage to aid in energy management. Depending on the intended use and required power output, the HRES's above-mentioned parts can be arranged in a variety of configurations. Electricity from sources such as photovoltaic panels could be used to supplement the heat pump's required supply. However, the combustion-based micro-CHP may back up the variable solar energy generation and kick on the thermal chillers during the cooling period.

Various HRES layouts have been the subject of research (Bhandari et al., 2015). Detailed the results of an evaluation of the HRES's photoelectric (PE), biomass Stirling engine, and battery system's performance. Energy efficiency, environmental impact, and financial viability were all considered in their comparison of the HRES as well as the PV/diesel motor hybrid model. According to their findings, the HRES outperformed all of the other research subjects across the board (Diemuodeke et al., 2019). Researched a new solar-aided CCHP system that included PVT collectors, a reversible heat pump, and adsorption chillers. The purpose of this study was to construct the system, run a dynamic simulation of it, and analyse its impact on energy consumption, environmental impact, and bottom line.

2.2. Homer pro simulation model:

The suggested hybrid energy system's components have been sized and costed optimally with the help of HOMER pro software. An acronym for "hybrid optimization method for electrical renewable," HOMER was created by the National Renewable Energy (NREL) in the United States (Sau and Patoding, 2017). With HOMER pro, you can model grid-connected then-off systems that produce electricity from a wide range of renewable energy sources, including photovoltaic (PV) panels, wind generators, biomass-based electric generators, micro-turbines, hydrogen fuel, batteries, hydrogen storage, as well as auxiliary generators of varying fuel types and load sizes (Sau and Patoding, 2017).

The simulation model, created with the help of the HOMER pro program, includes a photovoltaic (PV) system, a wind energy conversion system, a diesel generator, and a battery. Fig. 3 shows the conceptual framework for this model of a hybrid energy system.

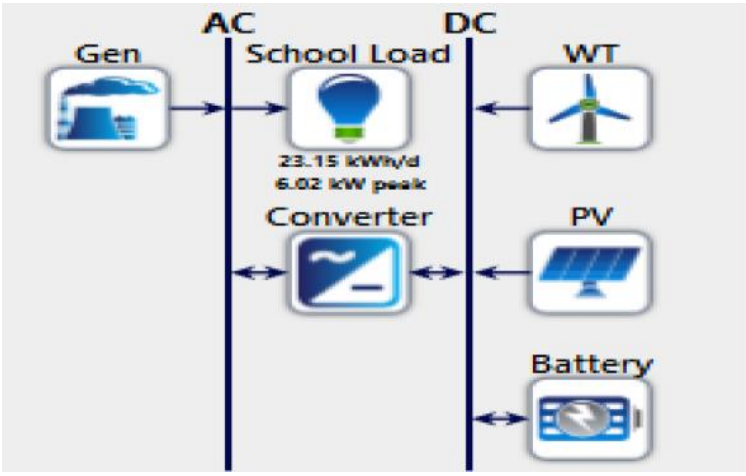

Figure. 1: HOMER simulation model of hybrid energy system

3. Methodology:

3.1. Data collection:

System modeling as well as energy efficiency techniques was used to analyze data from secondary sources such as newspapers and the Internet (EETs)

The research procedure used in this study consists of three distinct steps. The first step is to assess the energy requirement, energy resource, and technical and cost information of the components. HOMER is a program that can model, simulate, and conduct sensitivity analysis on an energy system, and it relies heavily on the information presented here (renewable and conventional).

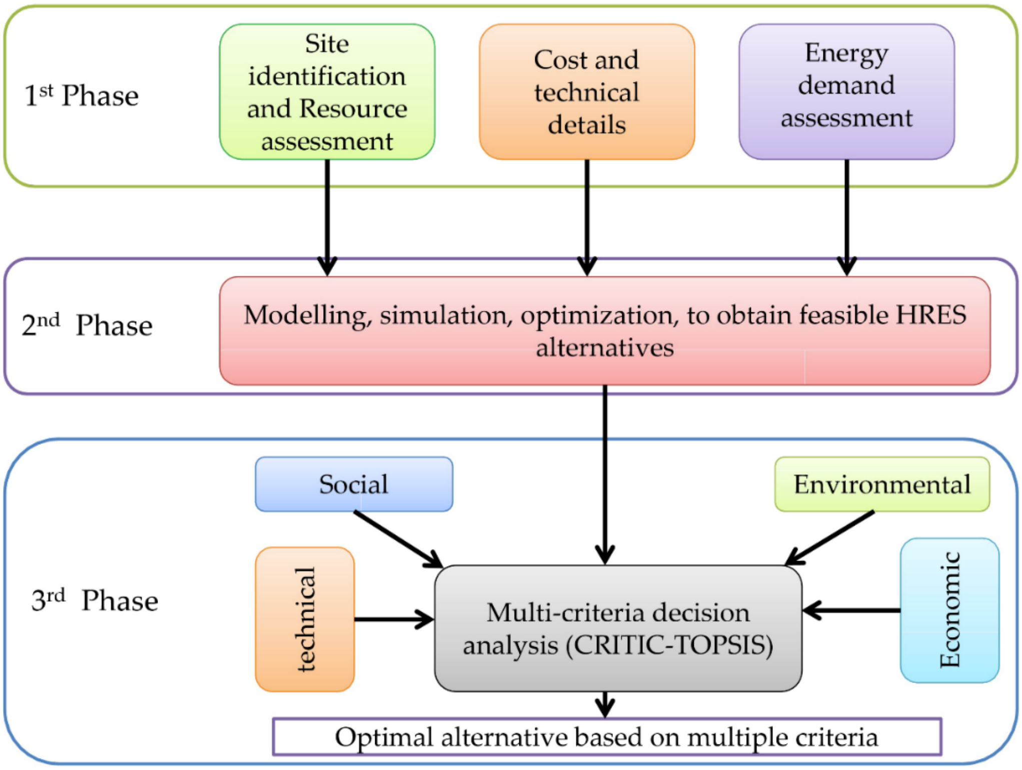

Figure. 2: optimal based alternative on multiple criteria

In the second step, we use HOMER to run simulations and find the best HRES options. Overall net present cost is now used for selecting and ranking HRES (TNPC). In the last phase, the HRES options are ranked using a cross decision-making (MCDM) approach (economic, technical, environmental, social as well as policy). The best option, determined by a number of factors, is depicted in Fig. 2.

3.2. Site description and resources assessment:

Specifically, in Akoka, Lagos state, Nigeria (6.5270° N, 3.3918° E), a low-income housing complex is planned, and the HRES will serve as the heating, ventilation, and air conditioning system. As the commercial center of Nigeria, Lagos consumes a lot of energy. The chosen location has a high potential for harvesting renewable energy sources like wind and solar.

The area under consideration, like the majority of Nigeria, has a daily average of fewer than 8 hours of uninterrupted electricity. On top of that, people live in a constant state of darkness because of utility grid failure, vandalism, poor maintenance, and natural forces (rain, storm etc.).

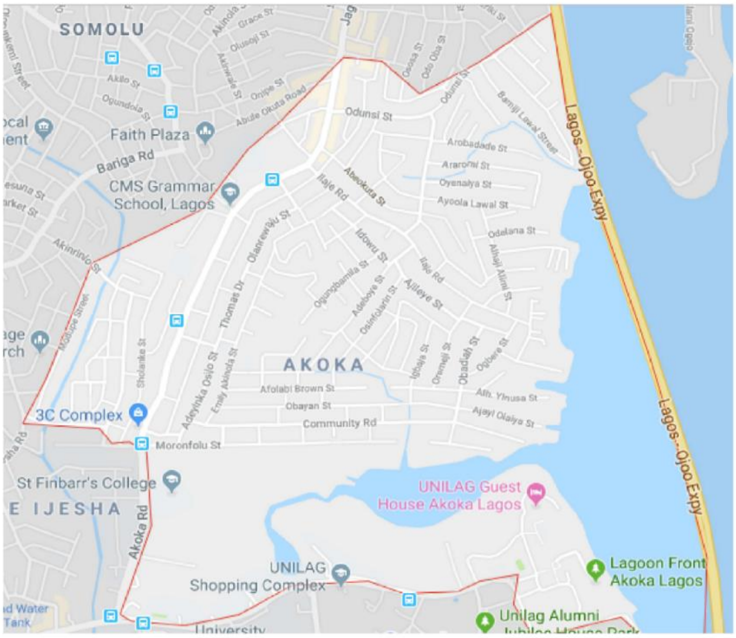

Figure. 3: Map of the Study Area

Many locals rely on gasoline or diesel-powered generators that they keep in their homes to meet their basic electricity demands. Captive-generating sets are not efficient or sustainable. The map of the Research Area is shown in Fig. 3.

3.3. System modelling:

It is via the use of Hybrid Optimization for Multiple Electric Renewable Sources that the suggested HRES may be simulated and optimized (HOMER). Off-grid and on-grid energy systems were modeled, simulated, optimized, and subjected to sensitivity analysis with the help of the HOMER program. A yearly energy balancing calculation is carried out by HOMER It takes a simulation time of one hour to adequately represent an energy system (8760 h). It evaluates the system's output against the hourly energy requirements (both thermal and electrical). It does calculations on energy exchange between the components of the system to obtain an overall energy balance. This evaluation is performed for various potential energy system configurations.

3.4. Technology for efficient use of energy (EETs):

Demand-side management includes energy conservation. The purpose of these strategies is to reduce the overall amount of energy required to carry out a task or make a product. Consequently, these aids future generations in making the most of existing and projected energy sources. If both kW_{NDSM} and kW_{DSM} are greater than 1, then the DSM action is beneficial. The higher the value, the more advantageous the DSM action.

$$DSMQI = \frac{kW_{NDSM}}{kW_{DSM}}$$

$$EET = \begin{cases} beneficial & \text{if } DSMQI > 1 \\ not\ beneficial & Otherwise \end{cases}$$

$$DSMAI = \frac{COE_{NDSM}}{COE_{DSM}}$$

Below are designated the DSM energy demand (kW_{NDSM}), the DSM energy demand (kW_{DSM}), the DSM energy cost (COE_{NDSM}), and the DSM energy cost (COE_{DSM}).

4. Findings and discussion:

TNPC, COE, as well as CAC were 0.316 kWh/year, $2900, for 14,230. Both with gas generator now this system running 3931 hours a year, we might hit 33% renewable. The gasoline generator emits 2479 kg of CO_2 annually. Second-best HRES: PV/WD/BAT with $18,568 TNPC and 52% RF. Other HRES include PV/TNPC BATs with 100% RF, WD/GEN/TNPC BATs with 25% RF, and PV/WD/TNPC BATs with $22,350 RF. Cost-effectiveness-wise, this ideal system (PV/GEN/BAT) surpassed the typical gasoline generator most homeowners use. One HRES estimated payback, annual value, as well as present value reasonably well (DPB). PV/GEN/BAT is really the only economically beneficial HRES that can displace a gasoline generator when linked loads remain inefficient.

PV-generator-battery systems with a smaller generator and bigger PV capacity are best for EET-powered apartments. 6 batteries, 0.4-kW generator, 2-kW PV. TNPC is $6919 and COE is $0.28/kWh, for a $5807 initial investment (including retrofits to equipment). This HRES has a 97% RF because the gasoline generator barely runs 367 hrs each year and creates 83.2 kgs CO_2. The EET produces PV/BAT with only a TNPC worth $7738 or a 100% RF, PV/WD/GEN/BAT with the a TNPC of $11,087 as well as a 95% RF, PV/WD/GEN/BAT with just a TNPC of $11,766 as well as a 100% RF, PV/GEN with just a TNPC of $11,778 or a 39% RF, and PV/GEN with one Discounted PV/GEN/ PV/GEN/BAT HRES's current value, annual value, ROI, as well as total ROI were higher than alternatives (IRR). These factors increase the economic feasibility of a PV/GEN/BAT HRES.

EET results in a 100.24 percent rise in starting capital, a 51.38 decrease in TNPC, an 11.9 percent drop of COE, a 96.61 reduce business on Emissions of co2, as well as a 193.94 percent growth in renewable fraction as compared to the same optimal HRES procedure return without EET. The DSMQI score of 1.81 and the DSMAI score of 1.19 are both encouraging, suggesting that the EET approach employed is both technically feasible and beneficial. Even in the absence of EET, most ideal systems still have yearly load loss rates that are rather low (less than 3 hours). If EET is adopted, the ideal system would be down for maintenance roughly three times a year. These are the most likely HRES values. The results showed that the HRES used to deliver that load had higher dependability when EET was not used. Since the diesel generator provides more capacity to sustain the entire system when EET is not used, this is the case.

5. Conclusion:

Total net current price is the only factor when choosing HRES. One criterion may not guarantee sustainability and informed decision-making. This study analyzed the viability of HRES adaptation for one typical low-income home using multiple criteria. It also examined how energy-saving methods affect the optimal system for a low-income family. This research examined how a low-income home's electricity needs could be met using gasoline; wind, as well as solar in different configurations. Using the HOMER program, efficiency regulations, a MCDM tool (TOPSIS), plus relevant literature, simulation, optimal size, including deciding on the best HRES for low-income families were accomplished. The HRES uses a genuine low-income home's daily electricity use pattern. System capacity, current battery levels, combination electricity generation, renewable components, and system dependability are analyzed.

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