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Comprehensive Study on Sizing of Hybrid Renewable Energy System using Commercial Software

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Abstract

To fulfil the ever-rising demand for energy, it is imperative to use all available energy sources. Renewable energy sources are clean, abundant, and non-polluting, but their intermittent nature is a drawback. A hybrid energy system, a combination of renewable energies, is employed to solve this issue. In-depth literature reviews of recently released papers in the subject of hybrid renewable energy are presented and analyzed in this work. A review on sizing hybrid system for renewable energy using commercial software is done and presented in this paper.

Keywords: *Commercial Software, Energy, Hybrid Renewable Energy System (HRES), Sizing*

1.0 Introduction

India's prospective energy requirements can be met relatively economically through solar energy[1]. By taking into account environmental considerations, specialized displays, and financial concerns, this assessment may be applied to select the optimum mixed Photovoltaic systems for a smart city[2]. When it comes to providing grid alternatives for supplying power to rural consumers, HRES is one of the most affordable and reliable[3]. High dependability, higher efficiency, modularity, the need for less energy storage capacity, and reduced LCOE compared to systems based on a single energy source are all benefits of HRES[4,5].

In comparison to 2019, the globe's energy consumption falls by 5.9% in 2020 as a result of the corona virus pandemic and complete power blackout. In the first quarter of 2020 compared to the same period in 2019, global economic development resulted in a noteworthy 3.8% decrease in power usage worldwide[6]. The very first quarter of 2020 saw a 1.5% increase in the need for renewable energy[7]. Exxon Mobil's most recent energy report forecast, 25% of the power used globally in 2040 will come from nuclear and renewable sources[8]. The solar energy infrastructure in Algeria is among the best in the world, with 2000 hours of sun energy over the whole nation and 3900 hours across the highlands and Sahara. The worldwide horizontal irradiation of Algeria is 3×10^3 Wh/m^2 in the north. In the south i.e. in Sahara, it is greater than 5×10^3 Wh/m^2. A significant wind resource is also present in Algeria, with wind velocity ranging from four to eight m/s. In fact, it is estimated that the region's wind energy resources will produce 35 TWh annually in the south[9]. Algeria, which is ranked 131st globally, uses 1.5% of the world's electrical production and is the latest nation to use green energy globally[10]. However, the government has created a renewable energy plan for the years 2011 to 2030.

Systems that combine one renewable energy source with a variety of other energy sources fall under the category of Hybrid Renewable Energy Systems (HRES), which includes electrical systems[11]. The choice of the

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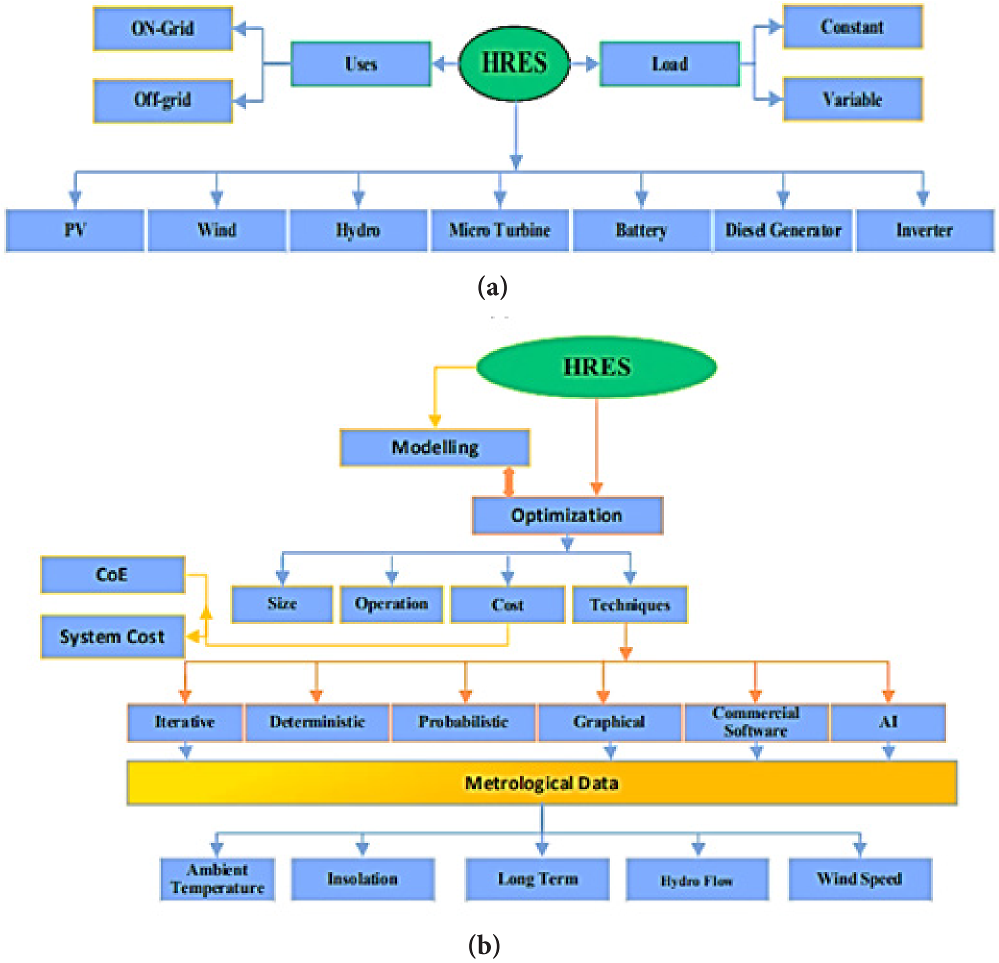

Figure 1. **(a)** A HRES system formation **(b)** Optimization methodology in HRES[36].

different device parts for the mixed energy plant is based on a number of size parameters, it has been demonstrated. Several commercial programmes are also utilized because of the size and optimization. Examples of these software include RETScreen, HOMER, iHOGA, and INSEL[12]. Working with numerical formulae that outline the mathematical models for how the various HRES components should function is a necessary part of HRES simulation in practice. As a result, the behaviour of the system may be demonstrated, which can help with project decision-making[13].

The variables that make up a pertinent HRES optimization process are shown in Figure 1. Regardless of how difficult, a designing, analyzation, ability to comprehend, and making plans of an project related to mixed system requires a elaborate theory based pre-feasibility assessment and a research of the veracity of its outcomes using special intent simulation tool and pertinent circumstances used as case studies[14]. Therefore, efficient RES usage and exact project design are strongly tied to a thorough HRES study[15].

One optimal size approach is needed in order to exploit renewable energy sources effectively and economically. The optimal scaling technique may help achieve the least price while permitting the mixed system to execute at its most consistent and cost-effective standards by fully utilising the photovoltaics, wind turbine, and battery bank. You may be capable of achieving the finest potential compromise between reliability and affordability financial objectives are set and evaluate the total result of the system

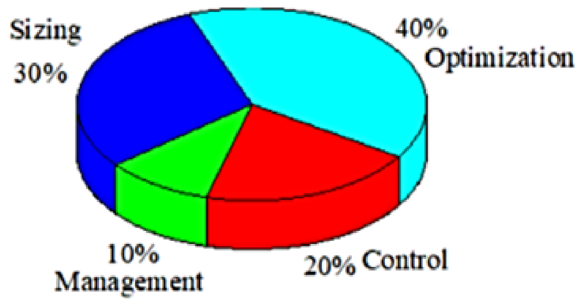

Figure 2. The number of articles for mixed system from 1992-2022 depending on different arrangements.

over the years[16]. According to different settings, Figure 2 shows the no. of papers for mixed system from 1992 to 2022.

2.0 Sizing Approaches of HRES

A critical step in calculating the units' capacity is the mixed system's sizing. The system may be small or large without the correct calibration of size[17].

The two basic kinds of sizing treatments are shown in Figure 3.

3.0 Sizing of HRES Utilizing Commercial Software

iHOGA, HOMER, RET Screen, INSEL, ReOpt, SAM, and WISDEM are just a few examples of the commercial applications for scaling hybrid systems that operate on Windows and employ Visual C++ as their programming language[18]. Baneshi *et al.* sized a mixed system in Iran, using the HOMER. This system includes a Solar Photovoltaics, Diesel Generator, and Wind Turbine as well as batteries are used as the storage solution. The prime aim of is to create a mixed system model that is affordable and emits little Carbon dioxide. The most economically significant discovery is an overall levelling price of 9.3 to 12.6 cents per kWh, with 43.9 % of that cost originating from world production and renewables, as reported by Baneshi[19]. For a small Malaysian community, Fadaeenejad *et al.* created a hybrid model using the iHOGA tool that consists of two Renewable Energy System (Wind Turbine and Solar Photovoltaics) and two typical units (Diesel-Generator and batteries). The Hybrid2 tools were created by the RERL at the University of Massachusetts with assistance from NREL. In Chicago, Mills *et al.* utilise this technique to estimate the scale of a hybrid PV/wind/FC complex. The fuel cell alternative's modelling[21] indicates that there is enough RE to manage the peak demand. Strategic plan and evaluating energy infrastructure using the "RETScreen" method considers system from a range of angles, including technical-based, economic, environmental, and efficiency of power, ones[22]. P. Kumar *et al.* simulated model DG, SPV, WT, and a mixed battery bank using a model - based tool from Canada to assess systems from a range of viewpoints, taking into account monetary, technological, environmental, and efficiency of power. Results show that the mixed system's dependency on green energy has resulted in a 99 percentage reduction in CO_2 emissions[23]. Each scaling tool's entry and outlet features are provided in Table 1 as follows:

Modeling thermal systems is a common use of the programme "TRNSYS"[24]. Using this technology, Kumar *et al.* create and model PV and thermic hybrid systems, and their study shows that these systems perform better than SPV systems both technologically and economically[25].

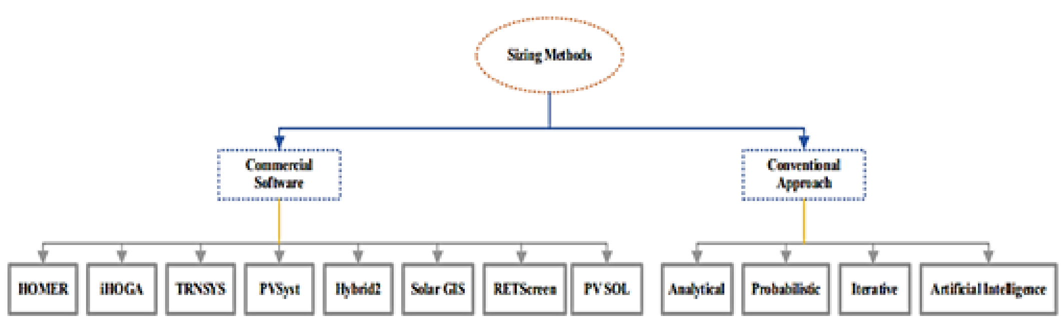

Figure 3. Methodologies of sizing.

Table 1. Sizing tool's input and output[18-23]

INPUT	**HOMER**	**PV SOL**	**RETScreen**	**TRNSYS**	**PVSyst**	**Solar GIS**	**iHOGA**	**Hybrid2**
Load Demand	√							√
Resources Data	√	√	√	√	√	√	√	√
Component Data	√	√				√	√	√
Constraints	√	√			√		√	
Controlling a System	√		√					
Data on Emissions	√		√				√	
Data on the Economy	√				√		√	
Financial Information	√	√						√
Databases for Projects			√		√			
Database of Products			√					
Models taken from Own Collection	√			√				
OUTPUT	HOMER	PV SOL	RETScreen	TRNSYS	PVSyst	Solar GIS	iHOGA	Hybrid2
Optimizing the Size	√		√		√		√	√
Technical Evaluation	√		√	√			√	√
Financial Assessment	√	√	√		√	√	√	√
Environmental Analysis	√		√			√		
Optimization with Many Objectives	√						√	
Emissions from a Life Cycle	√		√				√	

Analytical Probability	√		√				√	
Risk Assessment and Sensitivity Analysis	√		√	√		√		
Thermoelectric and Thermal Energy System Dynamic Modelling Behaviour	√			√	√			

Table 2 shows the characteristics and constraints of each tool as shown by the comparison. Choosing the finest software in terms of system usage and size optimization is the most crucial consideration. This allows iHOGA to size any structure, RET Screen-Software & HOMER-Software to size/scale any structure/system using a straightforward optimization equation, and Photovoltaic with a 10 kiloWatt limit. While TRNSYS-Software & PV Syst-Software will not scale/size all generators without optimization since Hybrid2-Software has approved hybrid

Table 2. Several scaling techniques (professional tools) have evolved in combined systems[18-23]

Commercial Software	Advantages	Limitations
HOMER	1. Compile the results data into an efficiency graph. 2. Easy to understand.	1. Uses linear equations of first order 2. Time series data cannot be loaded 3. Getting started will require a lot of information 4. The user is unable to select pertinent system components based on intuition.
PV SOL	1. Create and estimate a PV power system in a short amount of time. 2. The graphics are very accurate.	1. A complicated calculation is not feasible. 2. A circuit schematic may occasionally be displayed inaccurately.
RETScreen	1. The largest meteorological database. 2. Excel-based software.	1. Less data are entered 2. Time series data cannot be loaded.
TRNSYS	1. Adaptability of the simulator 2. The graphics are quite precise.	1. Certain generators, like hydropower, cannot be simulated. 2. No optimization options are available

PVSyst	1. Rapid PV power system design and estimation 2. Flexibility of the simulator	1. Simulation is time-consuming 2. No single-line diagram is present. 3. There is no way to optimize it.
SolarGIS	1. Simulations WHICH are simple to use and finish quickly 2. Comprehensive weather database with a map	1. A feasibility study is not possible because there aren't enough technical considerations. 2. You'll require internet access to run the simulation.
iHOGA	1. Short simulation step time 2. To complete the goal, which may be mono or multi-objective, genetic algorithms are applied.	1. Insufficient sensitivity and probability analyses 2. Daily load restriction (10 kWh) 3. Simulating a single setup at a time is recommended.
Hybrid2	1. A variety of potential electrical load possibilities 2. More specific options for dispatching 3. It requires a higher level of system configuration experience and more extensive in terms of optimization variables.	1. Simulations ought to last for a long time. 2. Although the project was successfully finished, some simulation problems were found. 3. Simulating a single setup at a time is recommended.

technology, Solar GIS has very few system characteristics and requires the web. SOL has not authorised a created sizing method. According to the findings of this test, the optimum software suite for sizing HRES is made up of RET Screen and HOMER.

4.0 Conclusion

Use of all available energy sources is essential to meet the expanding demand for energy. The intermittent nature of renewable energy sources is a disadvantage even if they are clean, plentiful, and non-polluting. To address this problem, a hybrid energy system that combines renewable energies is used. This study presents and analyses in-depth literature evaluations of recently published studies on the topic of hybrid renewable energy. This research performs and presents an evaluation on the sizing of a HRES using commercial software.

The results of this research indicate that HOMER-Software and RETScreen-Software make form the ideal software package for scaling/sizing HRES.

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