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Research Article

Hybrid Wind Solar Energy System Optimization

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ABSTRACT

Wind and also PV systems' ability to provide reliable power is highly climate-dependent. Both systems are very vulnerable without a backup system, like batteries or a conventional engine generator. Whenever two systems are integrated utilising a storage device, the system's dependability rises dramatically. Even in this situation, the battery bank must have enough capacity to power the load over prolonged gloomy and non-windy days. Consequently, the key component of a hybrid power system (HPS) is the appropriate size of system components. This essay reviews current patterns in the use of energy derived from renewable sources. It covers numerous approaches and optimisation standards for the HRES, along with physical modelling of RESs. In the current atmosphere of energy and environmental concerns, HRES is becoming more and more popular. Based on the existing literatures, we give a thorough analysis of the state of optimisation approaches that are especially suitable for the tiny and isolated power system in this study. The current trend in hybrid RES optimisation demonstrates that AI may be able to deliver effective system optimisation without comprehensive long-term meteorological data.

Keywords: *Hybrid energy system; Solar; Wind; optimization; Artificial Intelligence (AI)*

INTRODUCTION

HRESs (Hybrid Reneweble energy system) are utilised in standalone mode for individual homes or in microgrids (MGs) (Zhang et al., 2016). The second method is gaining popularity in remote and island places (Camblong et al., 2016) because it offers a cost -effective option when fuel transportation is expensive and problematic (Chauhan and Saini, 2014). Geographic information system (GIS) study now puts the population of islands at around 740 million people globally (Mannke, 2013).
Standalone HRES, or even MGs, along with RES are a viable and also sustainable alternative (Singh et al., 2016). However, this problem may be circumvented by the deployment of an HRES that integrates several energy sources and a backup generator (Ramli et al., 2016). Additionally, by integrating energy storage systems (ESSs) like battery banks or traditional energy sources like diesel generators, HRESs are able to offer an application with a power supply that is more dependable and affordable (Ramli et al., 2016). The primary issues with these hybrid systems (HSs), however, are their high initial cost, elevated maintenance costs, and various depreciation rates (Ramli et al., 2016). Most research utilised solar along with wind HSs since they work best together (Sinha and Chandel, 2015). The size optimisation methods used by on-grid and also off-grid solar and also wind HSs are taken into consideration by the authors in (Mahesh and Sandhu, 2015). The best size procedure for two HRESs is covered in (Askarzadeh, 2016), along with several of the sizing algorithms' overview (Erdinc and Uzunoglu, 2012). An overview of the application of artificially intelligent algorithms for HRES sizing may be found in (Fadaee and Radzi, 2012). The authors of (Luna-Rubio et al., 2012) concentrated on control and administration of standalone HRES, storage system alternatives, scaling approaches, and integration settings. A survey of multi-objective artificial algorithms taking into account a

few combinations of freestanding HSs is given in (Sinha and Chandel, 2015). The optimum size of various HS combinations tuilised for standalone and also grid-connected utilisation, which includes several artificial and traditional sizing approaches, is covered by the authors in (Nogueira et al., 2014)

LITERATURE REV IEW

Table 1. Optimization results of the system components based on IAEO and other algorithms for PV/WT hybrid system

Reference	Systems studies	Topics Covered	Highlights
Khatod et al., (2010)	Oil/Steam/coal/seam,,hydro, wind, nuclear	Costs, overall, CO2, emissions, fuel use, energy price risk, and minimising outage costs(reliability)	According to the study, a power electric system model called multi-objective generation expansion planning (MGEP) that incorpoarates renewable energy sources (RES)
Gupta et al., (2015)	PV and wind Generator	Reduced emissions, anticipated costs, and societal acceptability	This study uses several multi-criteria decisions Analysis (MDCA) optimisation strategies to size the PV-WT to its optimum.
Khatib et al., (2016)	Costs, environmental effects, imported fuel and fuel price risks	Conventional steam plants, coal-fired plants, combined-cycle plants, gas turbines, wind farms, geothermal plants and hydroelectric plants	A multi-objective generation expansion planning (MGEF) model is suggested in this work.
Louie, (2016)	PV, Wind, Diesel, Biodiesel and Battery bank	Total greenhouse gas emissions (GHG) and COE	The massive sizes of biodiesel-fuelled generators, produce a reversal in the results, resulting in COEs that are too small and CO2-equivalent emissions produced, utilising FC with natural gas as a fuel is not advised

RESEARCH GAP

Optimal size of PV-WT HES and evaluation metrics encompassing economic, along with reliability, and also environmental, and also social considerations are discussed, as are new improvements in single algorithms along with hybrid algorithms, and also software tools utilised for this purpose.

OBJECTIVES

1. To determine the utmost cost-effective and environmentally friendly method of utilising a REHS.
2. To create optimization algorithm to find the optimal combination of solar panels along with wind turbines.
3. The objective goal is to find a solution that has the lowest possible net present value (NPV)

METHODOLOGY

PV-WT HES requirements and assessment parameters

When predicted data is utilised instead of data from previous years, the accuracy of the optimisation outcomes increases (Hocaoglu et al., 2009). Additionally, by raising the beginning and operating cost values, the solar and wind speed peaks have an impact on the size optimisation outcomes (Azimi et al., 2016). In order to get predicted data, estimate and forecasting methods are used, which increases the accuracy of the size optimisation algorithm outcomes. The impact of projected and historical data on the outcomes of optimisation was examined by Gupta et al. (2015). The research discovered that the outcomes of optimisation are enhanced by the weather prediction data. Artificial neutral networks (ANN) were used by Sinha and Chandel (2015) to forecast solar and also wind data, and they discovered that the predicted data utilising ANN are rather near to the observed and estimated data. A PV module and WT were modelled utilising ANFIS, which produced datasets for solar radiation, along with wind speed, and also temperature. Also, the neuro-fuzzy model is trained utilising data that are produced by the weather. Nogueira et al. (2014) utilising a statistical model per the Khatod et al. (2010) probability density function (pdf). In order to construct a HES to feed a communications base station, the ARENA modelling programme to forecast the wind speed, along with solar radiation, and also electricity demand distributions at the facility. Per Weibull distribution and locally gathered meteorological data, Zhao and Yuan (2015) got one year's worth of hourly wind speed data utilising HOMER, and they also obtained one year's worth of hourly sun radiation data on a horizontal plane utilising the solar radiation law. In order to anticipate solar radiations, Azimi et al. (2016) created a hybrid forecasting technique that combines TSA, a cutting-edge cluster selection algorithm, and MLPNN.

Based on historical hourly data for solar irradiation, along with wind speed, and also temperature, Chen (2016) calculated the WT and PV power production. In order to predict the power doubts and related balancing and also reserve power needs of hybrid PV-WT systems owing to solar irradiation and also wind speed uncertainty.

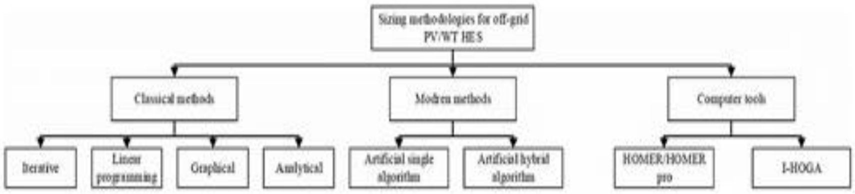

Fig 1. Recent size optimization methodologies for standalone PV-WT THES

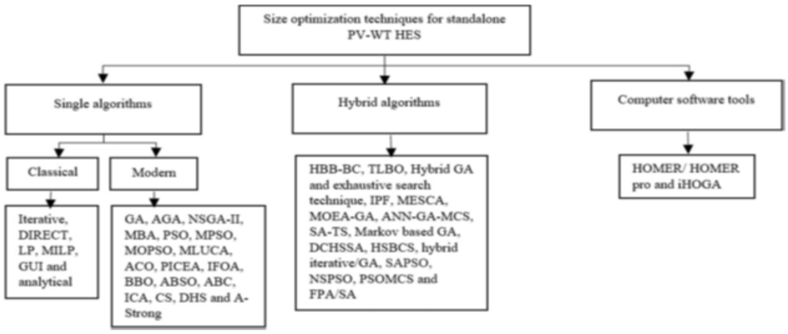

Fig 2. Overview of the size optimization techniques discussed in this paper

The primary aim of this investigation is to develop the ideal design for the suggested HS and to confirm its correctness. IAEO method is used in this work. The first AEO's performance is enhanced by the IAEO. Production, consumption, and decomposition are the three stages of the AEO's performance, however the IAEO is suggested to enhance AEO's performance in the consumption phase (Hatata et al., 2018), have been replaced by the sine-cosine approach. Whereas, the sine-cosine function generates several solutions and varies either outwards or in the direction of the ideal solution. This is one way to represent the improved equation:

$$r_1 = 2 - It \times (\frac{2}{MaxIt}) \quad (1)$$

$$r_3 = (2 \times pi) \times rand\,(0,1) \quad (2)$$

where MaxIt is the maximum number of iterations and It is the current iteration. and (0, 1) are two random numbers r_1 $and r_3$, respectively (Fathy, 2016).

$$x_i(t+1) = \begin{Bmatrix} x_i(t) + r_1 \times \sin(r_3) \times C \times \left(x_i(t) - x_1(t)\right) r_4 < 0.5 \; i \in [2, \dots, n] \\ x_i(t) + r_1 \times \cos(r_3) \times C \times \left(x_i(t) - x_1(t)\right) r_4 > 0.5 \; i \in [2, \dots, n] \end{Bmatrix} \quad (3)$$

$$\left\{ x_i(t+1) = \begin{Bmatrix} x_i(t) + r_1 \times \sin(r_3) \times C \times \left(x_i(t) - x_j(t)\right) r_4 < 0.5 \; i \in [3, \dots, n] \\ x_i(t) + r_1 \times \cos(r_3) \times C \times \left(x_i(t) - x_j(t)\right) r_4 > 0.5 \; i \in [3, \dots, n] \\ j = randi([2i - 1]) \end{Bmatrix} \right\} \quad (4)$$

$$\left\{ x_i(t+1) = \right.$$

$$\begin{Bmatrix} x_i(t) + r_1 \times \sin(r_3) \times C \times \left(r_2(x_i(t) - x_j(t)\right) + (1 - r_2)(x_i(t) - x_j(t))), r_4 < 0.5 \; i \in [3, \dots, n] \\ x_i(t) + r_1 \times \cos(r_3) \times C \times \left(r_2(x_i(t) - x_j(t)\right) + (1 - r_2)(x_i(t) - x_j(t))), r_4 > 0.5 \; i \in [3, \dots, n] \\ j = randi([2i - 1]) \end{Bmatrix}$$

(5)

RESULTS AND DISCUSSIONS

Results Before Optimization of Algorithm

Given the lack of fuel supplies and great cost of grid expansion for islands along with isolated rural regions, the adoption of HRESs offers a dependable and affordable solution. Based on site requirements, RES are chosen for a particular place. This analysis demonstrates that the PV-WT-DGBS system, which offers dependability and continuous power supply and is followed by PV-WT-BS since it is an extremely environmentally beneficial combination having zero emissions, is the most ideal HES for islands and isolated places as shown in fig 3.

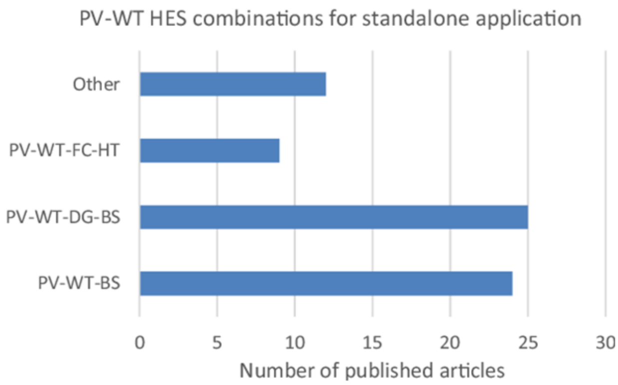

Fig 3. PV-WT HES combinations for standalone application since 2012-2016

The load profile statistics are often unavailable since isolated and rural locations are where standalone HESs are employed the majority of the time. Additionally, the correctness of the load profile has a significant impact on the outcomes of size optimisation. Therefore, additional study is needed to create and also build more precise forecasts for the load profile in the subject of load profile estimate and forecasting. The size optimisation options are influenced by the sun radiation and wind speed peaks. Because hourly data cover the troughs and also peaks of solar irradiation along with wind speed, utilising hourly yearly solar and also wind data is advised rather than utilising daily or even monthly data. According to the research that have been evaluated, HS components' manufacturing costs are the primary cause of the high starting costs of HES, and these prices must be significantly reduced in order to lower the initial system cost. Also, this reduction will shorten the payback period and boost return on investment, both of which will ultimately raise the human development index and societal acceptability. Owing to the enormous potential of PV, along with wind, and also battery systems inside off-grid utilisations, advancements in battery life and also power converter efficiency may lead to an increase in the usage of this trio owing to their zero-emission advantages. The optimisation outcomes are shown to be majorly affected by the height of WT and also its swept area. These restrictions in the optimisation issue should be taken into account in this situation.

Results of Proposed Optimization Algorithm

The tools used in the optimisation programme, which provide the fitness function's optimum value in all scenarios, are emphasised. The IAEO method's convergence curves suggested in this study are compared directly with those produced from the standard AEO algorithm, along with other well-recognised algorithms such as PSO, along with SSA, and also GWO. Figure 4 displays the convergence curves associated with various techniques. The graphic demonstrates that the IAEO algorithm consistently outperforms competing algorithms across all suggested configurations, as seen by the higher fitness function values achieved.

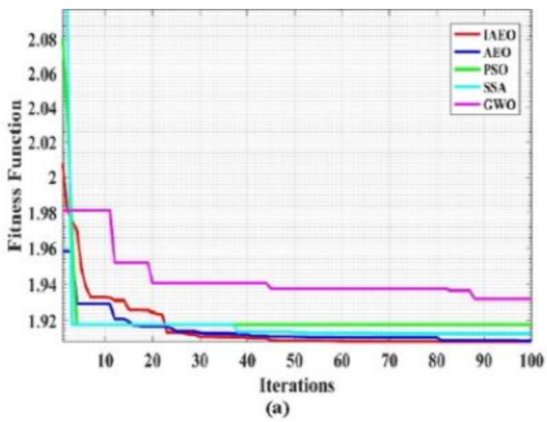

Fig 4. Convergence curves for PV/WT optimization algorithms.

Table 2. Fitness function and solution

		IAEO	AEO	PSO	SSA	GWO
Best fitness function		1.9084	1.90896	1.918023	1.912848	1.931887
Best Solutions (units)	PV	260.0132	260.0182	260	2,60,000	2,60,000
	Wind (units)	60.0152	60.0111	60	600000	600000
	Electrolyzer (kW)	710.0505	712.0299	710	724.7619	7100000
	Hydrogen tank (kg)	129.0353	130.861	200	157.4691	158.1626
	Fuel cell (kW)	200.0237	200.1415	200	200000	23.8356
	DC/AC coverter (kW)	400.2782	401.0518	400	400.9362	424.9118
Computation (s)		110.853	165.913	45.835	631.817	116.177
COE (S/kWh)		0.41243	0.41304	0.422926	0.417422	0.437675
NPC(S)		9.957.537	9972230	10210924	1,00,78,019	1,05,67,013
LPSP		2.9194x10-18	1.8961×10-18	9.781×10-19	1.203×10-18	4.364×10-19
D_load		1.3153	1.3153	1.31506	1.31506	1.31506
D_gs		35.771	35.7706	35.7659	35.7659	35.7659
STD		56.835	56.8344	56.8255	56.8255	56.8255

CONCLUSION

This study provides a thorough analysis and also critical comparison of the most current size optimisation techniques for freestanding HESs based on solar and also wind energy. A thorough analysis of the optimisation of HPSs utilising renewable sources is provided. The strengths of various optimisation techniques and optimisation design standards are discussed. T Based on the analysis, it is concluded that utilising projected data for the solar, wind, and load profiles in the optimisation issue leads to better size optimisation outcomes than those obtained when utilising historical data. In order to size freestanding solar and wind systems, artificial approaches have received more attention than traditional methods.

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