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A Systematic Review of Hybrid Renewable Energy Systems About Their Optimization Techniques with Analytic Hierarchy Process

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Abstract-

Hybrid renewable energy systems are the fastest growing power sector worldwide. The drawbacks of most hybrid energies were identified by the previous researchers such as space/sizes and costs of the system. This review article aims to find out the best optimization techniques for HRES by using the Analytic Hierarchy Process (AHP). More than 100 plus papers were taken to-do this review. Among all the top energy journal publications are consider for these reviews such as ELSEVIER - 54.9%, SPRINGER-6.9%, MDPI-5.9%, TAYLOR AND FRANCIS-5%, IEEE ACCESS-13% and others -15%. Thus, the expected result of this review is that the researchers acknowledge their decision-making to choose the best optimization techniques and hybrid renewable energies.

Key words- Hybrid Renewable Energy System (HRES), Optimization, cuckoo search algorithm, Taguchi method, HOMER, Analytic Hierarchy Process, Review and Applications.

1. Introduction

Hybrid Renewable Energy System plays the vital role of electrical energy distribution field. The common research problem of HRES are such as capital cost and size of different renewable energies. These things were optimized by different techniques or algorithms. This review article aims to find out the best optimization techniques by using the Analytic Hierarchy Process

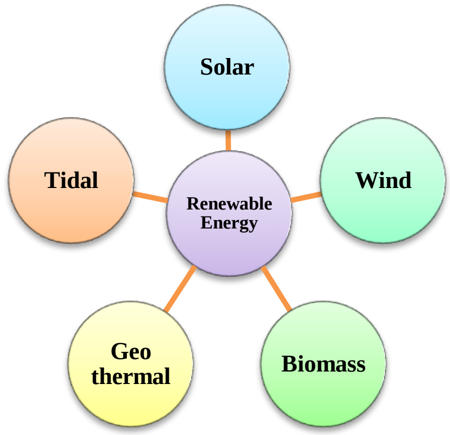


Figure No: 01 Renewable Energies {SOURCE:1}

This optimization techniques reduces the sizing, cost, and increasing the performance by the Khan, M. J. point of view [1].

2.0 DIFFERENT TYPES OF OPTIMIZATION TECHNIQUES

2.1 ARTIFICIAL NEURAL NETWORK (ANN)

It is an algorithm that finding out optimal sizing by harmony search, chaotic search and simulated annealing [2]. It is a learning algorithm. The simulation software has been incorporated by the MATLAB. This technique mostly used in solar and wind hybrid projects. Thus, the author tried to forecast RE but their failed to forecast the natural energy [3]. The Cadenas, E & Rivera, W. (2010) were described the origin of ANN algorithm that it is from the errors of ARIMA algorithm. By Both algorithms are forecasting the wind speed, time serious and errors. The author concludes on this paper that mean error, mean square error and mean absolute error may consider as better or equal result obtained compare with ANN [4]. Physical Hybrid Artificial Neural Network is one of the forecast algorithms based on the ANN Algorithm. By these algorithms to solving the fundamental errors in renewable energy systems [5].

2.2 DYNAMIC VOLTAGE RESTORER

The DVR is the power optimal algorithm. It is used in wind and solar hybrid renewable energies. It is used in a three-phase medium voltage network that improves the power quality and low voltage riding capacity. The authors were successes their concept that PCC (point of common coupling) reduce the LVRT [6]. The load fluctuation withstands and controlled by this DVR algorithm. The voltage is calculated by the load input [7].

2.3 HYDROGEN ENERGY SYSTEM

The HES is a mechanism. It made by three RE sources and its used in any weather condition. It consists of Program Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA) systems [8]. The main applications of HES in hybrid renewable energy system such as increase the efficiency and minimize the cost [9]. Compare to Grid independent hybrid renewable energy systems the HES is less economical [10]. The De Battista, H., Mantz, R. J., & Garelli, F. Were obtained that the HES combined with wind energy has optimal more output taken by this combination [11].

2.4 GEOSPATIAL APPROACH

The geospatial approach more suitable for tropical country like India. The main concept of geospatial approach such as

- Minimize the cost of power
- Minimize the capital and
- Optimal sizing [12].

2.5 HOMER SOFTWARE

The HOMER stands for Hybrid Optimization Model for Electric Renewable. This software gives the optimal size and minimizes the economical of capital in HRES. It also minimizes the total net present cost [13]. Fulzele, J. B., & Dutt, S. states that the HOMER is best suitable for solar and wind in hybrid renewable energy system. The inverter and PV generator with battery is very expensive [14]. The HRES is very best optimization technique has HOMER for optimal size, capital, emission and technical [15]. On optimization the main factors are consider every condition such as annual electricity demand, reliability, net present cost, employments and the environmental factors [16]. This software also used for simulation [17]

2.6 HOMER PRO

The HOMER PRO is an advanced version of HOMER software. The basic simulation only on HOMER software but HOMER PRO included the deep simulation. The HOMER pro analysis is consisting of costing, optimization, sizing, and control strategy [18].

The MESCA stands Modified Electric System Cascade Analysis. Compare to MESCA the HOMER PRO software gives the best output [19]. The unit costs of energy (UCOE) outputs are basically comparing with the HOMER PRO software

[20]. HOMER PRO software is the primary model and simulation tool in HRES [21].

2.7 Monte Carlo Simulation

It gives the approximately solution for the quantitative problems [22]. Montfort et.al was explored the authors estimate the solar and wind plant installation in the large scale installation [23]. It is best for optimization of off-grid hybrid system [24]. Monte-Carlo-simulation has the fast calculation to find the losses of load [25].

2.8 Adaptive Sine Cosine Algorithm (ASCA)

The population-based optimization algorithm is ASCA. It has trigonometric functions of Sine and Cosine. In prominent region the parameter affected as its drawback [26]. It is an efficient to determine the optimal parameters of PID controller [27]. This algorithm is also used for structural damage detection. It also tackles the test problem [28]. In construction sites the ASCA improves the performance of accuracy, diversity, convergence and distribution [29]. In power distribution network reconfiguration (PDNR) problems are also solved by ASCA. The random variable used in ASCA such as r_1,r_2,r_3 and r_4 [30].

2.9 Genetic Algorithm (GA)

GA is the estimated process for multi objective problems in HRES [31]. Non-dominated Sorting Genetic (NSG) Algorithm is designed to turbines. It decreases the total cost and increase the performance [32]. It is the superior algorithm in HRES and it also optimal the size [33]. Compare to particle swarm optimization (PSO) algorithm the genetic algorithm gives the better result [34]. The genetic algorithm generally used for two purposes in HRES. The primary function has reduced the formulated objective function and load served depend upon reliability [35].

2.10 PSO

The PSO algorithm has the best suitable to solar and wind hybrid systems. The PI controllers are mainly based the PSO algorithm [36]. It is a biological inspired direct search method and find the optimal energy management solution [37]. The PSO algorithm technique has minimize the cost of energy and gives the best result for optimal the size [38]. The Fuzzy Logic Controller is also related to the PSO Algorithm. The PSO optimizes membership sequence of Fuzzy Logic Algorithm [39]. The PSO has mainly find out the objective functions of HRES [40].

2.11 Numerical Algorithm

The numerical algorithm is an analysis and optimal size in HRES. The selection is based on the nature and genetic of renewable source [41]. The classical numerical simulation solver and the quantized state system both are family of numerical algorithm [42]. The numerical method is more suitable for solar, wind, hydro turbines and wind turbines [43].

2.12 Maximum Power Point Tracking (MPPT)

The Maximum Power Point Tracking algorithm gives the increasing optimal output voltage in HRES. This algorithm also used for tracking purpose in HRES [44]. In wind energy the maximum speed has ensured by the MPPT algorithm [45]. The MPPT enhance the efficiency of the hybrid renewable energy system. It is most suitable for solar and wind [46]. The MPPT used in solar and wind system as simultaneously for energy harvesting [47]. The MPPT optimizes the exact duty cycle of DC converter based on current and voltage parameters [48].

2.13 DPSO

Dynamic particle swarm optimization has optimization algorithm that includes simulation module and sampling average techniques [49]. The main objective of Dynamic particular swarm optimization is to minimize the net present total cost [50]. The DPSO has also utilized to give solution the dynamic optimal power flow problems [51].

2.14 Greedy Particle Swarm And BBO Algorithm (GPSBBO)

The biography-based optimization (BBO) has the multi-objective optimization. The PSO combined with their exploration of biography-based optimization is known as Greedy Particle Swarm and Biography Based Optimization [52]. The Greedy Particle Swarm & Biography Based Optimization gives the both advantage of PSO and BBO [53]. It is best suitable for hybrid renewable energies of wind and solar [54]. The cost of installation and output voltage cost are decreased. The performance and design of hybrid system has been improved [55].

2.15 Stochastic Load Profile Model

The challenge of hybrid renewable system is energy supply and demand [56]. It is suitable for hydro power stations and diesel generation. The stochastic load profile model is a two stage mathematical model.

Such as inter-annual variability and uncertainty [57]. The stochastic load profile also used to minimize the net present cost and loss of load probability [58]. The wind speed and solar radiation of total annual cost, uncertain in electric demands are calculated by stochastic load profile model [59]. The JADE and CPLEX validate algorithm are used in stochastic load profile model. Both algorithms are popular intelligent optimization algorithm [60]. The stochastic approach represents the terms of technical, social criteria and economical [61]. The cost coefficient and energy demand minimize the total cost. The total cost includes electrical cost, thermal cost and the revenue from exporting power [62].

The stochastic model also is to determine the power supply reliability configuration [63]. It deals with the power supply and demand fluctuation [64]. The best values are determined for grid connected hybrid renewable energy [65].

2.16 CUCKOO SEARCH ALGORITHM

The cuckoo search optimization algorithm is the techno-economical simulation algorithm [66]. It minimizes the cost and optimal size of hybrid renewable energy system [67]. The size optimal is higher than compare to GA and PSO [68]. It solved the design problems in hybrid renewable energy system. It is similar to Genetic Algorithm and PSO algorithm. The cuckoo search algorithm is also solved the convex and non convex fossil fuel problems [69]. The cuckoo search algorithm is also used to forecast the power supply management [70]. The cuckoo search algorithm's advanced version is hybrid mimetic cuckoo search algorithm. It is used for forecasting for loading, predicts the result, efficiency and error rate [71]. Similarly, the next version is grey wolf optimizer and cuckoo search. It balances the exploitation and exploration in hybrid systems [72].

The cuckoo search algorithm is also handling the non-linear variation components of renewal energy system [73]. The third type of cuckoo search algorithm is biography based heterogeneous cuckoo search algorithm (BHCS). It is used for four parameters estimate problems. Such as two PV panel module, single diode model, double diode model and photovoltaic model [74]. The fuzzy logic controller is based on the cuckoo search algorithm. It is used to find out the power rate of batteries, solar and diesel generator [75]. By using the cuckoo search algorithm, that the multi objective optimization is possible [76]. The cuckoo search algorithm fourth type is Hybrid Nelder-Mead and cuckoo search algorithm (HNMCS). It is used to determine the generator output [77]. The total investment cost is minimized by micro-grid cuckoo search algorithm. The total investment cost includes such as investment, capital, maintenance and operations [78]. The cuckoo search results are comparing to genetic algorithm for better optimization [79]. In hydro power station, the multi objective cuckoo search algorithm (MOCS) has used. It gives the better result compare to another algorithm [80]. The environmental pollution is measured by hybrid the cuckoo search algorithm and ANN algorithm [81]. In quantum optimization, the advanced version of quantum chaotic cuckoo search algorithm (QCCS) has used to solve the cluster problems [82]. The cuckoo search algorithm is combined with the optimal operation of multi reservoir system for obtaining the maximize energy production rate [83]. In 2009, the Cuckoo search algorithm is developed by Deb and Yang [84]. In solar system, the maximum power point tracking based up on the cuckoo search algorithm for estimating low power losses [85].

2.17 TAGUCHI METHOD

It is used to estimate the steady state electrical distribution in solar and wind hybrid system [86]. The orthogonal experiments are done by the taguchi method. This method affects the load resistance and tilt angle in hybrid projects [87]. At a time, there are nine experiments conducted in taguchi method by standard orthogonal array [88]. The unit commitment problems are solved by the hybrid taguchi ant colony system [89]. Taguchi method is achieved the cooling mode operations using L_9 3^4 orthogonal arrays [90]. The design combinations and noise level are calculated by using taguchi method [91]. In multisource power system model are optimized by the hybrid taguchi genetic algorithm [92]. The phase angle, line flow, other metrics, means and standard deviation of power generation problems are estimate by the taguchi method [93]. The optimum design procedures in the cascaded control of PCS unit are solved by taguchi method [94]. The key design, net power output and efficiency of solar geo thermal system are optimized by the taguchi method [95]. The taguchi algorithm with the orthogonal array plays the vital role in optimizing the fast charge of lithium ion battery [96]. The power systems of optimum number and placement location are optimized by the taguchi binary bat algorithm [97]. The taguchi combined genetic algorithm is used to minimize the maximum overshoot, settle time, raise time and steady state error [98]. By using taguchi method the solar assisted ground source heat pump system has optimized the heat exchanger length and solar collector area [99]. The hybrid nano particle such as Al_2O_3, TiO_2 and MoS_2 are optimizing the transformer dielectric strength by using taguchi L16 orthogonal array method. It is reacting with 16 different composition of volume percentage [100]. The taguchi method is mainly used for noise ratio analysis in power generation system [101]. The extension taguchi method is a optimization allocation of equipment capacity in hybrid renewable energy system [102]

3.0 OPTIMIZATION TECHNIQUES AND APPLICATIONS

The following tables explored the different optimization techniques and its applications

OPTIMIZATION TECHNIQUES	APPLICATIONS
Artificial Neural Network (ANN) & Dynamic Voltage Restorer (DVR)	Optimal power[3].
Hydrogen Energy System	Technical And Economic[8]
Geospatial approach	Minimize size[12].
Hybrid Optimization Model for Electric Renewable (HOMER)SOFTWARE	Optimal Cost/economical[14]
HOMER PRO	Optimal economical[19].
Monte Carlo Simulation	Electrical and thermal test[24]
Adaptive Sine Cosine Algorithm (ASCA)	Current And Voltage Errors[29]
Genetic Algorithm (GA)	Optimal the Loss of Power Supply Probability (LPSP) and the Levelized Cost Of Electricity

	(LCOE)[33].
HOMER Pro & Power Management Strategy (PMS)	Optimal economical & Power-Quality Valuation [21]
Particle Swarm Optimization (PSO)	Optimal economical [39]
Numerical Algorithm	Minimize Economical[41]
Division Algorithm (DA)	Minimize size [1]
Stochastic Load Profile Model	Power Loss Minimize[57]
Maximum Power Point Tracking (MPPT)	Control system is efficient and capable to maintain the power transfer [47]
Dynamic Particle Swarm Optimization(DPSO)& Traditional solver (TS)	Levelized cost of energy (LCOE) [51]
Accurate Iterative Methodology	Optimal size [52]
Classical algorithm	Optimize Size [1]
Greedy Particle Swarm And BBO Algorithm (GPSBBO)	Improve The Performance Of Optimization Design [55]
Numerical Model	Mathematical Error Finding [1]
Cuckoo Search Algorithm	Optimal Size And Economic [67]
Taguchi method	Electricity problems [88]

TABLE NO: 01 OPTIMIZATION TECHNIQUES AND ITS APPLICATION

3.1 OPTIMIZATION TECHNIQUES AND HYBRID TYPE

The following table explored the different optimization techniques and hybrid renewable energies.

OPTIMIZATION TECHNIQUES IN HRES	SUITABLE HYBRID TYPE
Artificial Neural Network (ANN) replace Dynamic Voltage Restorer (DVR)	Solar / wind [5]
Hydrogen Energy System	Photovoltaic (PV)/Wind Turbine/ Fuel Cell/Batteries [11]
Study paper- geospatial approach	Rice Husk / Solar Energy[12]
HOMER SOFTWARE	Wind / PV [16]
Motion analysis	Floating Offshore Wind Turbines (FOWT), Wave Energy Converters (WEC) [1]
loss of power supply probability (LPSP) and the net present cost (NPC)	Solar /wind [1]
MONTE CARLO SIMULATION	Solar / wind [24]
Adaptive Sine Cosine Algorithm (ASCA)	Solar / wind [28]
Hybrid Optimization Model for Electric Renewable (HOMER)	Solar /Wind/Bio Mass [21]
Genetic Algorithm (GA)	Solar / wind [33]

HOMER Pro & Power Management Strategy (PMS)	Solar / wind [20]
Particle Swarm Optimization (PSO)	Solar/ Wind [39]
Numerical Algorithm	Solar/gas turbine [42].
Division Algorithm (DA)	Solar/wind [1]
Stochastic Load Profile Model	Bio mass / Photovoltaic (solar) [57]
Maximum Power Point Tracking (MPPT)	Solar / wind [45]
Dynamic Particle Swarm Optimization (DPSO) & Traditional solver (TS)	Solar PV, Wind Power, Diesel Generator And Battery Storage [51]
Accurate Iterative Methodology	Solar/wind [1]
Classical algorithm	Solar/wind [1]
Greedy Particle Swarm And BBO Algorithm (GPSBBO)	Solar/Wind [53]
Numerical Model	Solar/ wind [42]
Cuckoo Search Algorithm	Solar/wind/diesel/battery[77]
Taguchi Method	Solar / wind/geo thermal.[88].

TABLE NO: 02 OPTIMIZATION TECHNIQUES AND HYBRID ENERGY SYSTEM

4.0Methodology

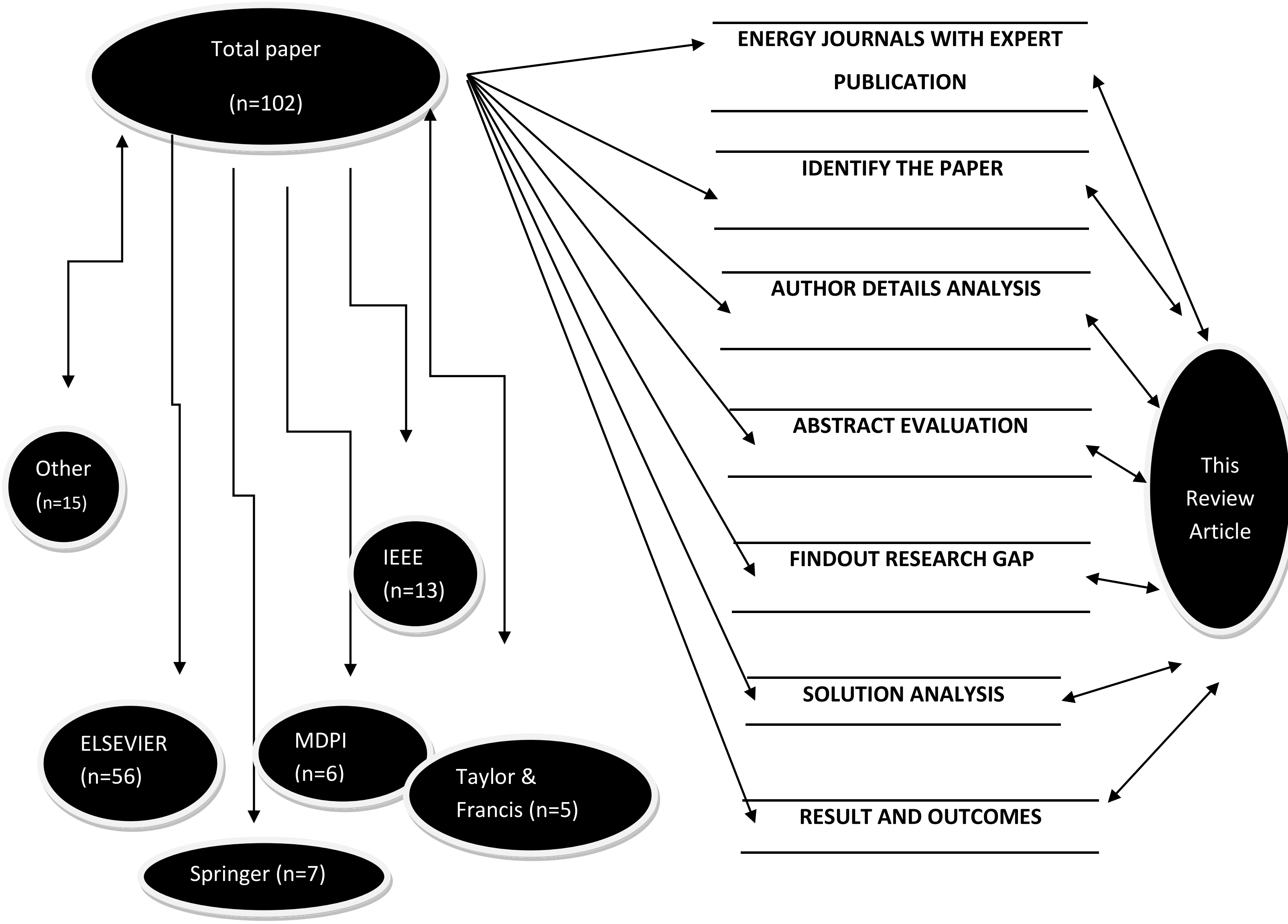


Figure No: 02 Methodologies

For this review, more than 1000 plus paper were taken and it filter by 102 paper as most relevant to this article. Then the figure no:02 express the consideration and methodologies of this review article.

5.0 DISCUSSION

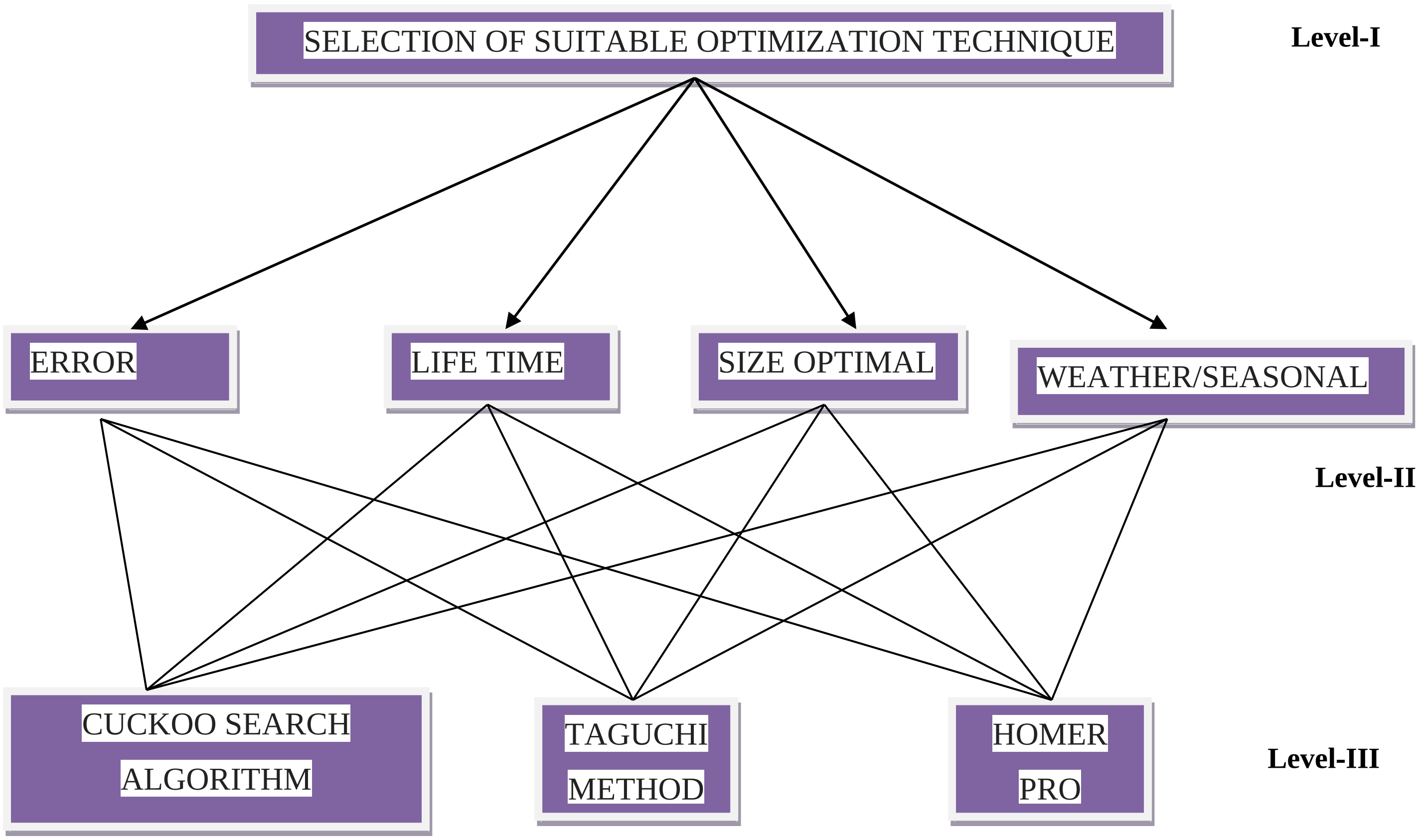
Senthil Kumar J, Charles Raja, S., Jeslin Drusila Nesamalar, J., & Venkatesh, P. states that the most countries are used solar and wind hybrid system as compare to other hybrid renewable energies [77]. By investigator point of view, this paper novelty of comparing best Suitable algorithm for obtained best hybrid renewable energies. Then, it is solar and wind renewable energies. The algorithm is recommended by carefully considering of previous literature view and algorithms/techniques such as cuckoo search algorithm, taguchi algorithm and HOMER PRO. The reason for this recommendation as shown in the table one and table two. These three algorithms were compared by AHP tool that the important factors of HRES like error, life time, space optimal and weather/season. Then the AHP tool as followed.

NETWORK SUMMARY	
Level-I	Aim/Objective
Level-II	Criteria
Level-III	Alternatives

Before selection of optimization technique to know the answer for following question based on the scale of relative alternatives.

ANALYTIC HIERARCHY PROCESS

STAGE-I



STAGE-II

Q.NO	QUESTION
Q1	How much your importance to solve error...?
Q2	How much your importance to lifetime of machine…?
Q3	How much your importance to size optimization of algorithms …?
Q4	How much your importance to consideration of weather…?
Q5	How much your importance to level-III alternatives…?

Answers were selected from the below standard scale of relative alternatives table

SCALE OF RELATIVE ALTERNATIVES	
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values
1/3,1/5,1/7,1/9	Values for inverse comparison

To form the pairwise matrix

Based on Aim	Error	Life Time	Size Optimal	Weather/Seasonal
Error	**1**	3	4	6
Life Time	1/3	**1**	1/2	3
Size Optimal	1/4	2	**1**	3
Weather/Seasonal	1/6	1/3	1/3	**1**

Based on Aim	Error	Life Time	Size Optimal	Weather/Seasonal	Criteria weight
Error	**1**	3	4	6	**0.55**
Life Time	0.33	**1**	0.5	3	**0.17**
Size Optimal	0.25	2	**1**	3	**0.22**
Weather/Seasonal	0.17	0.33	0.33	**1**	**0.0703**
Sum value	**1.75**	**6.33**	**5.83**	**13**	**1.01**

To find the weighted sum value

Based on Aim	Error × Criteria weight	Life Time × Criteria weight	Size Optimal × Criteria weight	Weather/Seasonal × Criteria weight	Weighted Sum Value
Error	**0.55**	0.51	0.88	0.4215	**2.36**
Life Time	0.182	**0.17**	0.11	0.210	**0.672**
Size Optimal	0.14	0.34	**0.22**	0.210	**0.91**
Weather/Seasonal	0.094	0.056	0.0726	**0.0703**	**0.292**

To find the ratio for Weighted Sum Value to Criteria weight

Based on Aim	Criteria weight	Weighted Sum Value	Ratio
Error	0.55	2.36	4.29
Life Time	0.17	0.672	3.95
Size Optimal	0.22	0.91	4.13
Weather/Seasonal	0.0703	0.292	4.17

To find the λ_{max}

$$\lambda_{max} = \frac{4.29+3.95+4.13+4.17}{4} = 4.135$$

To Find the Consistency Index (C.I)

$$C.I = \frac{\lambda max - n}{n-1}$$

$$C.I = \frac{4.135-4}{4-1}$$

$$\boxed{C.I = 0.045}$$

To find the Consistency Ratio (C.R)

$$C.R = \frac{C.I}{RI}$$

Here the R.I (Random Index) is below the standard table value.

n	1	2	3	4	5	6	7	8	9	10
R. I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

$$C.R = \frac{0.045}{0.90} = 0.05$$

$$\boxed{\mathbf{C.R=0.05}}$$

To check the consistency ratio value C.R=0.05<0.10

Criteria	Criteria weight
Error	0.55
Life Time	0.17
Size Optimal	0.22
Weather/Seasonal	0.0703

Hence the consistency ratio is reasonable.

STAGE-III

Based on criteria 1	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**
Cuckoo Search Algorithm	**1**	4	5
Taguchi method	1/4	1	1/7
HOMER PRO	1/5	7	1

Based on criteria 1	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**
Cuckoo Search Algorithm	**1**	4	5
Taguchi method	0.25	**1**	0.142
HOMER PRO	0.2	7	**1**
Total Sum Value of Column	1.45	12	6.142

Based on criteria 1	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**	**Priority-I**
Cuckoo Search Algorithm	0.689	0.33	0.814	0.611
Taguchi method	0.172	0.083	0.023	0.093
HOMER PRO	0.137	0.583	0.163	0.294

Based on criteria 1I	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**
Cuckoo Search Algorithm	**1**	5	4

Taguchi method	1/5	**1**	1/3
HOMER PRO	1/4	3	**1**
Based on criteria 1I	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**
Cuckoo Search Algorithm	**1**	5	4
Taguchi method	0.2	**1**	0.33
HOMER PRO	0.25	3	**1**
Total Sum Value of Column	1.45	9	5.33

Based on criteria 1I	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**	**Priority-II**
Cuckoo Search Algorithm	0.689	0.555	0.75	0.665
Taguchi method	0.138	0.111	0.062	0.104
HOMER PRO	0.172	0.333	0.188	0.231

Based on criteria 1II	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**
Cuckoo Search Algorithm	**1**	7	3
Taguchi method	1/7	1	1/5
HOMER PRO	1/3	5	1

Based on criteria 1II	**Cuckoo Search Algorithm**	**Taguchi method**	**HOMER PRO**
Cuckoo Search Algorithm	**1**	7	3
Taguchi method	0.142	**1**	0.2

HOMER PRO	0.33	5	**1**
Total Sum Value of Column	1.472	13	4.2

Based on criteria 1II	Cuckoo Search Algorithm	Taguchi method	HOMER PRO	Priority-III
Cuckoo Search Algorithm	0.679	0.538	0.714	0.644
Taguchi method	0.096	0.077	0.0476	0.074
HOMER PRO	0.224	0.385	0.238	0.282

Based on criteria IV	Cuckoo Search Algorithm	Taguchi method	HOMER PRO
Cuckoo Search Algorithm	**1**	5	3
Taguchi method	1/5	1	1/2
HOMER PRO	1/3	2	1

Based on criteria 1V	Cuckoo Search Algorithm	Taguchi method	HOMER PRO
Cuckoo Search Algorithm	**1**	5	3
Taguchi method	0.25	**1**	0.5
HOMER PRO	0.33	2	**1**
Total Sum Value of Column	1.58	8	4.5

Based on	Cuckoo Search	Taguchi method	HOMER PRO	Priority-IV

criteria 1V	Algorithm			
Cuckoo Search Algorithm	0.633	0.625	0.67	0.642
Taguchi method	0.158	0.125	0.11	0.131
HOMER PRO	0.209	0.25	0.22	0.226

STAGE-IV

DECISION MATRIX

Criteria Weight	0.55	0.17	0.22	0.07025
	Priority -I	**Priority -II**	**Priority -III**	**Priority -IV**
Cuckoo Search Algorithm	0.611	0.665	0.644	0.642
Taguchi method	0.093	0.104	0.074	0.131
HOMER PRO	0.294	0.231	0.282	0.226

	Priority -I × Criteria Weight	Priority -II × Criteria Weight	Priority -III × Criteria Weight	Priority -IV × Criteria Weight
Cuckoo Search Algorithm	0.336	0.113	0.142	0.0451
Taguchi method	0.051	0.018	0.016	0.009
HOMER PRO	0.162	0.039	0.062	0.0159

	Sum of Row	Priority Value	Rank
Cuckoo Search Algorithm	0.336+0.113+0.142	0.6361	I

Taguchi method	0.051+0.018+0.016	0.094	III
HOMER PRO	0.162+0.039+0.062	0.2789	II

Thus, the result expresses the most suitable algorithm for HRES is cuckoo search algorithm. It is future optimization tool to optimize the output and provides the high efficiency on HRES problems

6.0 CONCLUSION

Hybrid Renewable Energy System (HRES) is the future power sources for upcoming generation. The best optimization techniques and hybrid renewable energies are tabulated. The best optimization techniques in hybrid renewable energy system are such as ANN, PSO, DPSO, GA, MPPT, HOMER and HOMER PRO. Depend upon the researcher application their choose suitable optimization technique. However, the cuckoo search algorithm has more optimal and flexible technique for solar & wind energies. In HRES main and most common research gaps are consider as the following key points

- Size of hybrid system
- Capital cost of hybrid system
- Energy supply
- Levelized cost of energy
- Maintenance of hybrid system
- Voltage drops
- Load issues
- Battery storage issues.
- Cost of output power
- Energy demand
- Weather conditions
- Natural disasters and Environmental factors.

The Hybrid Renewable Energy System optimization techniques were analyzed by AHP tool and the most hybrid renewable energies are reviewed successfully by this paper. Thus, the novelty of this paper, best algorithm for recommended such a solar and wind energies. Then, it has analytically proposed by the AHP tool. It may applicable practically for give the maximum utilize the input sources and getting the better output.

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Abbreviation

HRES	Hybrid Renewable Energy System
ANN	Artificial Neural Network
AHP	Analytic Hierarchy Process
DVR	Dynamic Voltage Restorer
HES	Hydrogen Energy System
GA	Geospatial Approach
ASCA	Adaptive Sine Cosine Algorithm
PSO	Particle Swarm Optimization
BBO	Biogeography Based Optimizations Algorithm
HOMER	Hybrid Optimization Model for Electric Renewable
MPPT	Maximum Power Point Tracking
DPSO	Dynamic Particle Swarm Optimization
PMS	Power Management Strategy
AIM	Accurate Iterative Methodology
CA	Classical algorithm
DA	Division Algorithm
GPSBBO	Greedy Particle Swarm & Biogeography-

	Based Optimizations Algorithm
ARIMA	Autoregressive Integrated Moving Average
PHANN	Physical Hybrid Artificial Neural Network
PLC	Program Logic Controller
SCADA	Supervisory Control And Data Acquisition
GIHRES	Grid independent hybrid renewable energy systems
TNPC	Total Net Present Cost
MATLAB	Matrix laboratory