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Optimization Strategies for Hybrid Energy System: A Review

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Abstract

For financial growth of any country energy sector enlargement is on priority .power needs in every sector like cultivation, business, transportation, market & household sector. Different financial development plans implemented since 1947 to increase the power generation, by this power consumption in India is increasing day by day. & somehow India achieved that point when electricity is used almost everywhere. & we cannot imagine our way of life with power. Two things which increased the living standard & work efficiency are fan & light. Even our house, infrastructure, office & shops are lighted. It is hard to do work in an office without electricity.

This paper presents the wide review on the issue associated with Hybrid renewable energy system (HRES) for modeling, cost & size optimization, control strategies according to different authors. Characteristics for selection of HRES also classified. Uncertainties involved in designing an effective HRES power generation system for isolated areas is accounted due to highly dynamic nature of availability of sources and the demand at the site. Different methodologies adopted and reported in the literature for sizing of the system components are presented. Distributed control, centralized and hybrid control schemes for energy flow management in HRES have also been discussed

Keywords: Software Tools, Modeling, Optimization, Control, Strategies, Policies

INTRODUCTION

The reduction of non-conventional sources has the most important issue to worry so the necessity of some substitute source of power is very important to get constant power at any time. the Generation through conventional sources like is playing a very vital job in this direction. Energy generation is done by Nonconventional sources like photovoltaic (PV), air energy, small water plants, animal & agriculture waists, because of their reimbursement, such as transmission safety, less CO production, & high energy quality, consistency & increase the chance of service for local citizens. The system can improve by the hybrid combination of nonconventional & conventional sources because nonconventional sources are not available continuously in nature. Hybrid Renewable Energy System (HRES) are very much helpful for a distant area; particularly grid link is not possible. Figure 1 shows an example of HRES. Shams et al talked about the functional relationship of first PV/wind HRES & gave the relation between the ambient temperature of PV module & solar irradiance with the help of ARIMA (Autoregressive Integrated Moving Average).

Ramli et al(2016) compared the production & COE (cost of energy) through both air turbine & PV cell in the HRES with the help of different software MATLAB & HOMER & conclude that the PV array is cheaper than wind turbine & also produce more electricity than the wind for western coastal area of Saudi Arabia. For this investigation unmet load and excess electricity used as main parameters. As a result, the author found that the wind turbine and battery worked as the main component to full fill load demand during night time.it is very important to select the best size To decrease the cost of system Thapar(2015) talked about the factors of HES like load, wind speed, universal irradiance, ambient temperature & battery bank capacity (BBC), they levelized COE & Loss of Power Supply Probability (LPSP) used as presentation indicator & different characteristics of these factors concluded with respect to the ambient temperature. Energy balanced approach is used for calculating BBC and LCE at desire LPSP for the preferred system

SOFTWARE TOOLS

Deb et al (2012) used PSCAD software for HRES system & observed different characteristics by using optimization techniques. & showed that the output reaches in stable state after some fluctuation when the wind & hydro work together due some switching transient

Chambers et al (2014)introduced a software which was expected sources load & power resources as input statistics to determine the appropriate energy arrangement solution for tiny village demand Figure 2 shows a complete explanation of the software unit

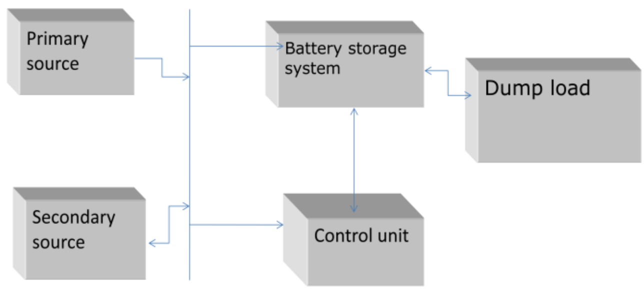

Figure 1: Example of HRE System

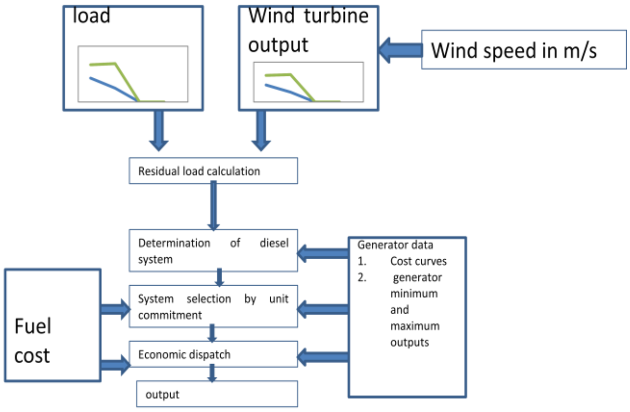

Figure 2: System Model Module Relationships

Residual load calculate by

LD 1-8760 = Load 1-8760 - WTout1-8760 [1]

Where,

LD 1-8760 = residual load (kW) supplied by diesel generator for 1 year

Load 1-8760 = annual hourly average load (kW)

WTout1-8760 = wind turbine output for 1 year

The result obtained gives system units & operation cost based on the loads, resources & fuel coat for 8760 hours of operation. Software tools such as LAPER, CART, HOMER, EDF, NREL used for modeling of Hybrid Renewable Energy System (HRES)

Sinha & Chandel (2010) described 19 software tool used for hybrid energy system & provide current status like capabilities, limitations of the software are to provide basic approach to the researcher & said HOMER was most widely used tool because of its maximum combination of renewable energy system

Pragya Nema et al (2009)showed the art development of wind & PV HES by R&D efforts to improve their performance, establishing techniques author also highlighted the future developments to improve the financial conditions of the system & acceptable by consumers. After reviewing the papers Author concluded that the renewable energy based low emission hybrid systems do not cost competitive against conventional fossil fuel power systems. Although many cost reduction techniques are encouraging in recent years still they remain an expensive source of power. So by the used of controller, it is possible to manage the flow between the component

Khare et al(2016) presented a complete review about different parts of HRES & discussed pre- possibility study, size optimization, designing, controlling & consistency issue & function of research method & game assumption author also presented The application of evolutionary technique and game theory in hybrid renewable energy

Siddaiah et al(2016) reviewed on preparation, layout, designing and optimization techniques of HRES for a stand alone system. Authors also talked about various mathematical models for optimization techniques of off-grid HRE systems to minimize the cost which is based on function object, financial side & consistency study connected drawing parameter for non-conventional sources presented in the local area. Author observed that for a good performance of the system it is very important that the system should be reliable and best size of system can be best

MODELING

Chin et al (2011) modeled a single axis solar tracker with two light-dependent resistor (LDR) in MATLAB to operates at different modes which rotate automatically based on the solar irradiance all through sunlight hours, & sleep mode during night time to save the energy. LDR used for solar irradiation detection. To provide flexibility one tidy follower used which operate at dissimilar mode to achieve efficiency over the fixed solar panel. Song et al (2015) got advanced accurate ANN model by Pneumatic Artificial Muscle (PAM) actuator, with the help of 3 dissimilar approach, like; Back Propagation (BP) algorithm, Genetic Algorithm (GA) & hybrid approach which is the combination of BP algorithm & Modified Genetic Algorithm (MGA) . to get & concluded that the hybrid approach gave the most excellent presentation between the these approaches

DeCarolis et al (2016)applied Modeling To Generate Alternatives (MGA) technique for optimization to changed the model structure by using Energy Model Optimization & Analysis (Temoa) tools which is incorporated into an open source framework .by using MGA authors explore different cost- & CO2-constrained futures & highlighted the significance of iterative study to search the model result gap.

Chang et al(2015) design a PV/wind/ diesel/battery HRES in Monte Carlo simulation, along with simulation-optimization techniques for HRES in an uncertain atmosphere, in terms of cost of power production, allotment & transmission while satisfying the power demand. To solve the model an algorithm used based on meta model-namely A-STRONG

Tanveer Ahmad (2016) proposed dc-link an energy management scheme HRES fed by solar photovoltaic (PV) to reduced current stress on battery & also reduce the current limit on battery & the supercapacitor which compare with the combined cascade manage. DC linked used for voltage directive, successful power organization to let limit the current for both the battery and the supercapacitor. system compare with united cascaded control.

Fakehi et al(2015) modeled an HRES based on air/electrolyzer /PEM fuel cell for Khaf region-Iran which is based on the thermodynamic, electrochemical & mechanical model. Authors concluded that the power effectiveness & energy coefficient is maximum at optimum wind speed

Allegrini et al(2015) modeled an HRES for urban & district level included solar, bioenergy & the wind covered with district heating networks, seasonal storage & the urban microclimate. The authors discussed the key issues arises in urban energy system modeling. Particularly cross-disciplinarily & integration issues

Mohammed et al(2014) discussed primarily like economic factor, storage of power, environmental issues, policies, & specific benefits like reliability increasing, rural electrification option, then design a framework to describe for factors for designing & implementation of HRES in general including simulation & optimization software packages for making such analysis.

Gupta et al (2006)showed the behavior of the basic HES component by mathematical model & solution algorithm. Authors establish the best cost of HES by:

$$\text{Minimize: } TC = d=1dnj=16t=124[Cj\times Ejdt] \quad [2]$$

Where TC = total optimized cost of providing energy for all end uses for operation of the system

Cj= Cost/unit of the jth generating unit (Rs/KWh)

Ejdt= optimal amount of the energy of the generating unit j for end use in a day d, hour t for a particular month

Gupta et al(2007) designed an Air/PV/biomass /hydro HES in which a diesel generator used for a backup system for Jaunpur block of Uttarakhand using C++. The general model was formulated on the basis of linear programming as-

$$TC=\sum Cij * Xij$$

$$\sum Xij = Dj$$

$$\sum Xij/nij \leq Si$$

$$Xij \geq 0$$

Where, TC was the total cost of energy; Cij cost/unit of the ith resource option for jth end use (Rs/kWh); Xij was optimal amount of the ith resource option for jth end use (Rs/kWh); Dj was total energy for jth end use(kWh); Si is availability of the ith resource option for jth end use(kWh); nij was conversion efficiency for the ith resource option for jth end use. Cost optimization is done by using LINDO 6.10 software of optimization.

Gupta et al(2006) developed a time series programming to evaluate the techno-economic performance of HRES to determine the best operation & design together with the evaluation of the financial saturation level of solar cell area by an equation:

$$\text{Minimize } TC =d=1dnj=16t=124[Cj \times Ejdt] \quad [3]$$

Where, TC total cost; Cj cost/unit of jth generating unit (Rs/kWh); Ejdt optimal amount of energy of jth generating unit in day d, hour t for a particular month; it is the number of days depending upon a particular month

Fathima et al (2009)extracted energy from RE & tried to bring the light concept of HRES & use of best tools & technique to small grids, integrating RE, & prepared a framework of various functions which shows the best approach to give power to the small grids.

Gupta et al (2008, 11, 11, 15) achieved the best cost for PV/biomass/biogas/small/hydro/ battery /fossil fuel HES with the help of algorithm-based to dispatched strategy to determine the battery storage type HRES for future supply, and reduce the use of diesel generator again authors gave general mythological structure plan for the micro HRES in remote area by proposed 6 stages namely- selecting cluster of villages, demand assessment, Resource assessment, Estimation of unit cost, Sizing & optimization, Model formulation. A numerical example is also included to demonstrate the action plan

Sen et al (2014) proposed a case study for village PALARI in the state of Chhattisgarh. By the best hybrid technology combination, in PRE HOMER analysis they took residential, institutional, commercial, agricultural load & recognized the best off-grid option & compared with grid extension in future & discussed the issues which affected the understanding of the best explanation.

Tsuanyo et al(2015) proposed a model with variability in solar irradiation & the electrical loads to levelized the cost of energy. Dissimilar size of ideal diesel generators & diesel generators is conventional diesel generators system used of operation. Result confirmation is done by HOMAR software

Zoulias et al (2007) used hydrogen technologies for optimization & conclude that the replaced the fossil fuel generator with hydrogen technology was theoretically possible but not inexpensively feasible.

Hafez et al(2012) minimize the life cycle by using diverse case like diesel only, a fully renewable-based, a diesel-renewable mixed, & an external grid-connected with the help of HOMAR software, and compared their financial, performance & ecological discharge. The author concluded that the diesel-renewable mixed microgrid has the lowest net present cost (NPC) and a fairly small carbon footprint when compared to a stand-alone diesel-based microgrid. Although a fully renewable-based microgrid, which has no carbon footprint, is the most preferred, the net present cost (NPC) is higher.

Yap et al(2015) used ANN for PV/diesel hybrid model, & compare between Simulink model & an obtainable manufacturing model tool for a distant area in the northern Australia, data used for ANN training. Simulation results showed that the developed model is a viable planning and analytical tool for aiding future off-grid PV-to-diesel system integration applications, with $R2$ values ranging from 0.92 to 0.99 and mean relative errors below 5%.

OPTIMIZATION METHODS

A. Cost optimization:

Ramli et al (2015) analyzed benefits of PV/diesel HES as energy sources with the flywheel as a storage system for Makkah, Saudi Arabia using HOMAR software. The analysis focused on the impact of utilizing flywheel on power generation, energy cost, and net present cost for certain configurations of hybrid system, and concludes that the power charge, & NPC, using up of fuel & C discharge can be reduced by using flywheel.

Turkeay et al(2011) evaluated the probability of uses of PV & air power with hydrogen for storage to full fill the power necessity in a pilot area by using HOMAR .

Tzamalis et al (2011)examined independent power supply of rural and remote buildings with the help of PV-diesel & PV-hydrogen supply & showed that the cost of energy (COE) of PV-hydrogen system higher than PV-diesel system, but the reduction of greenhouse gas can be done by PV-hydrogen reduces. Moreover, the sensitivity analysis indicates that COE for the latter system can be further reduced by approximately 50% compared to its initial value in can be reduce by parameters like PEM electrolyser and fuel cell capital costs

Ghasemi et al (2013)presented a comparative analysis among potential configuration of a system best suited to meet the isolated Iranian communities with the help of HOMER software. Author worked on net present cost, renewable fraction and air pollutant emission and showed that the stand-alone hybrid renewable energy system composed of 15 kW PV array, a 20 kW diesel generator and a 20 kW inverter can supply 200 kW h/d energy consumption with a peak demand of 18 kW

Ismail et al (2015)reviewed on the different configurations of hybrid energy system & percentage of excess energy. & also talked about the percentage of reduction of cost in different configuration, and showed that the considerable amounts of excess energy can be left unutilized like Water heating, water pumping, and space heating and cooling to reduce cost of the energy (COE).

Cavazzini et al (2016) divided final cost into three terms which do not depends only on energy & net head, but also on model current charge. Which use to estimate the relationship for Pelton Francis & Kaplan turbines to conclude that little difference in actual asset price is expected the huge change on the whole system.

B. Size optimization:

Hosseinalizadeh et al (2016) studied four particular research center locations in Iran, & used the diverse pairing of different sizes of Air /PV/fuel cell/battery HRES system, & concluded that the HRES including WT /PV/battery is cheaper than other systems.

Zhou et al (2010)talked about merits & demerits of different optimization which is listed in Table 1

Table 1: Advantages & disadvantages of different optimization technique.

Energy organization	**PROS**	**CONS**
HOMER	It is freely available & it can give efficient output.	It cannot show characteristics the initial level linear equation base model.
HYBRID 2 & other software	They are freely available on the internet.	It utilizes "black box" code.
Genetic Algorithm(GA)	Can be used globally & it is suitable for complex parameters.	Its coding is very complex.
Particle Swarm Optimization (PSO)	Easy coding.	Low performance than GA, & not appropriate for the difficult problem.
Simulated Annealing	Easy coding & literature reviews are also available easily	Low performance than GA, & not appropriate for the difficult problem.
Neural networks	Good at their presentation.	It required different training procedure.
Design space based approach	Implementation is easy.	Inadequacy in the calculation.
Ant colony algorithm (ACO)	Easy coding & literature reviews are also available easily.	Low performance as compared to GA, & not suitable for a complex problem.
Artificial immune system algorithm(AIS)	Can be used globally & it is suitable for complex parameters.	Its coding is very complex.
Other promising approaches (tabu search, honey bee, mating algorithm, bacterial foraging algorithm gane theory)	Proposed of future research	

Xiong et al (2015)gave the best size of the Hybrid battery-ultracapacitor power system (HPS). Authors used two nested optimize loop, the external circle for evaluating the chosen parameter using PSO & internal circle generate the best management plan to calculate the cost using active encoding, concluded that best performance can be done by higher voltage degree.

Castaneda et al(2013) used different Simulink Design optimization (SDO) & control strategies like operating modes, several operational states, & modes of technical-economic operation for energy management of PV/hydrogen/battery HRES

Busaidi et al (2016) discussed Different sizing criteria & optimization techniques like Graphic Construction, Probabilistic, Iterative, & Artificial Intelligent (AI) for logistical ecological & reasonable concern for HRES in Oman.

Erdinc & M Uzunoglu (2012)compared dissimilar approach apply for the sizing of the HRES which is shown in Table 2

Table 2: Different Approach for the Size Optimization of HRES.

Software tools	**Advantages**	**Disadvantages**
HOMER	It is freely available & it can give efficient output	Cannot enable the client to naturally select suitable design apparatus
HOGA HYBRIDS	1. Genetic Algorithms(GA) can use, 2. It can be used for single & many objectives for optimization 3. It requires very high knowledge for system operation	It can simulate single design at one time
Optimization techniques	Can be used globally & it is suitable for complex parameters	Its coding is very complex.
Graphics construction method Probabilistic approach Iterative technique	It doesn't need & data as time & series because any dynamic changing dies not affect the work	It can include only two parameters for optimization

Upadhyay & Sharma (2014)compared different sizing methodologies which are shown in table 3

Table 3: Table 3: Sizing methodology & their limits

S.no.	**Methods**	**Key parameter**	**Power resources**	**Limitations**
1	Graphic construction method	Average wind speed & solar radiation data of each hour & month	Less system included like PV/battery & PV/wind	Slope angle of PV module & height of wind it was not included
2	hypothetical methods	solar & wind system size approach was Hypothetical	PV, wind, batteries	It cannot represent active performance of HRES
3	logical methods	Average wind speed & solar radiation data of each hour & month	Solar, wind, batteries etc. which was depended on software tool ex. HOMER	Flexibility is less
4	frequent methods	Average wind speed & solar radiation data of each hour & month this approach was Hypothetical	solar, wind, batteries	Slope angle of PV module & height of wind it was not included
5.	Artificial intelligence methods	Average wind speed & solar radiation data of each hour & month	solar, wind, batteries etc.	complex design
6	Hybrid methods	Average wind speed & solar radiation data of each hour & month this approach was Hypothetical	solar, wind, batteries etc.	complex design

Ekren et al(2008 & 10) used Response Surface Methodology (RSM) & Simulated Annealing (SA) algorithm for size optimization & of HRES by Loss of Load Probability (LLP) & autonomy analysis to explain the relationship between input & output variables by METAMODEL & gave a flowchart to explain that model which is shown in fig: 3, & conclude that SA algorithm is particularly supportive if there were different choice variables & huge explore legroom to best an power arrangement.

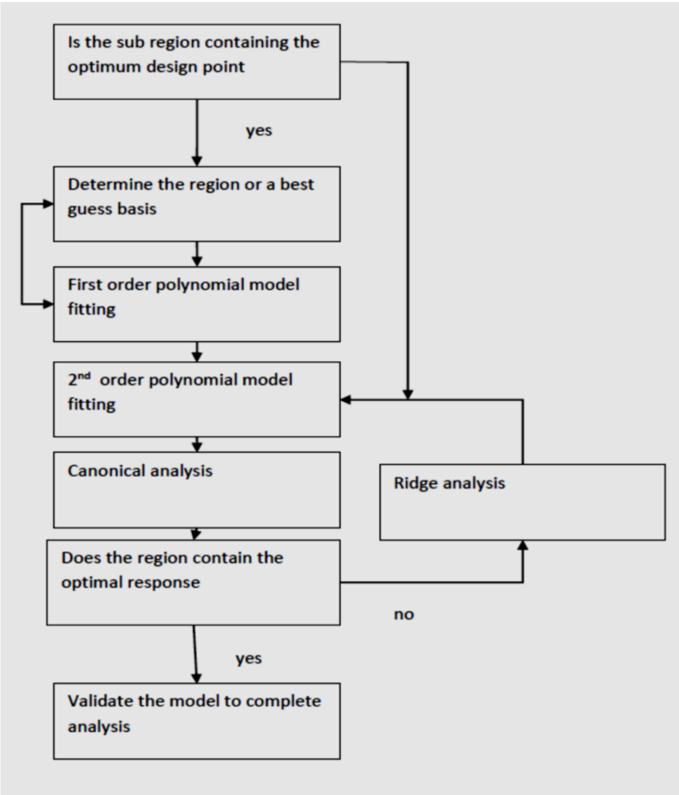

Figure 3: Flow chart for metamodel

Belmili et al(2013) evaluated the Loss of Power Supply Probability (LPSP) algorithm for size optimization of HRES to satisfy the load profile

CONTROL STRATEGIES FOR HRES SYSTEM

Upadhyay et al (2016)presented different strategies like cycle charging, load following & peak shaving for energy management by using GA, PSO optimization techniques in which energy index ratio kept at 1, they also worked on net present cost, cost of energy, renewable fraction & emissions of CO2 from diesel generator also & conclude that the 10th combination of cycle charging strategy is most cost-effective as compared to other dispatch strategies.

Arul et al (2015)discussed the control concept & control schemes in HRES system stabilization.

Feroldi et al (2015) proposed a strategy to predict the behavior of the RE sources in prospect & the load to presentation improvement in terms of power loss of supply in a PV/wind/fuel cell/battery HRES by using autoregressive models from historical data & several simulation tests were performed for validation & robustness of the power system has been improved.

Sigarchain et al (2014)gave a comparative study between different manage & power administration strategy which is shown in Table 4 & Table 5 gives the summary of this paper.

Table 4. Different manage & power administration strategy

Control paradigm	**Summary**	**Advantages**	**Drawbacks**
Centralized control paradigm	The centralized controller used for microgrid parameters	Can be achieved Multi objective energy management system	It has heavy computation burden & is focus only one point failures
Distributed control paradigm	Local controller used for energy sources	Harden of controller reduced & it does not have any one-point failure problems	Complex system
Hybrid control paradigm	Used central control within each group to achieve Local best result While sharing control used in dissimilar grouping to achieve the best result globally	Minimize the technical load of controller & problem of one - point failure	Complex system
Multilevel control approach	Used central control within each group to achieve Local best result While sharing control used in dissimilar grouping to achieve the best result globally	Minimize the technical load of the controller. real-time operation of energy units also controls the	Complex system

Table 5: Summary of review

Area		**Summary on work carried out by various authors & our observations & analysis**
Software tools		Ref [3-8] talked about different software tool which can be used for designing the energy system & many authors concluded that the HOMER software is best suited & easily available software for modeling an energy system Modeling
Modeling		Ref [9] used solar tracker using LDR [10-11&30] used MGA & ANN for modeling [12] used Monte Carlo simulation [13] reduce current stress by using energy management schemes [20] developed a time series programming [29] minimize the life cycle by using diverse
Optimization	Cost optimization	Ref [31-37] talked about different methods to minimize the cost of the HRES [31] used flywheel to reduce NPC [33] worked on COE
	Size optimization	Ref [38-43] talked about different methods to minimize the size of the HRES [39] gives merits & demerits of different optimization [40] optimize by using two nested loops in HRES [43] compared dissimilar approach to reducing size While [44]compared different sizing methodologies [45-46] used Response Surface Methodology (RSM) & Simulated Annealing (SA) algorithm & prepare a metamodel
Control strategies for HRES system		Ref [48-51] gives different control strategies for [48]used GA, PSO optimization techniques for energy management HRES [51] gives Different manage & power administration strategy

CONCLUSION

Different literature reviews show methods & technologies for hybrid energy system. New researches Need for latest technologies & sources which can be used in lower sizes whereby challenge linked with the condition of the secure moveable source can be addressed. Some latest approach requires to lesser in general price, strong & extra useful than a present option for the power generation due to the renewable energy system**.**

CHALLENGES AND FUTURE SCOPE

- There are some challenges exist in power generation from renewable sources
- High capital cost as compared to conventional sources.
- Lower efficiency for PV generation
- Need power converters which increased cost
- Depend on environment condition
- Renewable sources are not able to meet peak demand

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