INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH
R. Naveen et al., Vol.10, No.2, June, 2020

Integration of Renewable Energy Systems for Optimal Energy Needs-a review

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Received: 26.02.2020 Accepted:03.04.2020

Abstract- The thrust for the energy need is ever long persisted to sustain the peak varying demands in all over the countries. The focus is to obtain feasible, sustainable and mainly reliable renewable energy systems to meet the power demands. This is the fact that global modernization and revolutions cause an impact on energy requirements. As of primary concern, the rural energy demands should be met with an uninterrupted reliable supply of energy demands. The development of the rural energy sector through the integration of renewable energy systems, in turn, will pave the way to accomplish the growing demands of power. This can be done through a better understanding of the integration of renewable energy systems. The problem is the type of integration selected for the study will suit the energy needs of the rural site under consideration. This review gives more insight on the researchers for the feasibility and understanding various possible combinations of integrating the renewable energy systems. This paper presents the view of optimal methods adopted to obtain the optimization with different types of integration of the systems. The proposed models are reviewed for simulation and factors or parameters in their studies. This study also reveals the facts, management of integrated system and problems in integrating renewable energy systems

Keywords Renewable energy systems; optimal configurations; Economic modeling.

1. Introduction

The term 'electrification' introduces the various aspects to which the energy requirements sought. The major challenge lies in accomplishing the task to the grid with an uninterrupted supply of energy, especially in the rural villages and remote areas. Forecasting the power demand is always in the trend of cubical order concerning energy demands over the years. various models using the approach of time series method, regression analysis, genetic algorithm, fuzzy logic, and ANN [1–3] of predicting the energy demand presented to give the clear cut estimations of the increasing trend. India accounts for 35% of the world population which does not have electricity access. Energy is undoubtedly is most key to sustainable economic growth of a country.However,85% of the world global energy consumption is today met by the fossil fuels[4].Due to the fact that fossil fuels will run out in future, It has forced the mankind to go for the alternative energy sources[5]. The popularity of Internal combustion engines(ICE) and its use in all sectors have caused a great energy consumption undoubtedly played a major role in depletion of the fossils fuel resources[6].The dominant use of fossil fuels has led to the emerging risks of Global warming, Green house effect and the depletion of the ozone layer[7]. only 1-litre diesel combustion causes nearly 2.9 kg of Green house gases(GHG) and currently global oil consumption averaged 1.6 million barrels per day[8].Transportation accounts for nearly 20% of the total global energy primary consumed and 23% is co_2 emissions and 14% contribute for green house gas emissions[9]. Today, millions of people are dying from the serious deceases and even dying due to Harmful exhaust gases(HEG) arising from burning the fossil fuels such as cancer, respiratory deceases,cardiovascular,visibility reductions[8].on the othe hand many countries signed,kyotprotocol,failed to keep their promise to reduce their GHG level.clearly there is need to improve the methods reducing the GHG emissions at the acceptable level[10].The rural villages in India require electricity mainly for their irrigation purpose rather than lighting, cooking and other comfort requirements [11]. There are High transmission and distribution losses of 22.4%due to inadequate transmission and power supplied from the extended grid and inability to utilize the local resources for generating the power. The solution to the problem was found out by people participation in organizing society and achieved as a successful model for the rural villages [12].The rapid programs initiated by the state governments are not at the level providing subsidy electricity to rural and remote areas. The rural thrust for energy need is mainly on agriculture by which the community feels better comfort. The lack of government support to provide a sufficient electricity supply to the grid for agriculture is the main reason for rural-urban migration in developing countries [13]. The global energy demand is predicted to be rised by 37% in the year 2040[14]. Thus, the economical processing of the energy thrust will seek the need for renewable energy technology through sustainable development. The state governments have to think in the direction of firm installations of the renewable energy systems in all the rural villages and remote areas and study for their reliable performance to accomplish the energy demands. But the intermittent characteristic nature of the renewable energy challenges the reliable supply of electricity. Thus the decision is to be made on the proper integration of renewable energy systems. Any integration of the systems requires for its optimal delivery of the energy demands to take concerning rural sites. This is the biggest and tedious challenge to provide a suitable integrated system solution at the required site. The solution to this problem can be conceived through the modeling approaches or techniques for their proper integration.

2. Potential renewable energy systems

The wind turbine, solar PV, Biomass, Micro Hydro, Fuel cells and including the storage Batteries can be considered as potential sources as an alternative to conventional means of generating electricity. The integration of the system's challenges for its optimal delivery of the energy. The Intermittent characteristic nature of each of the renewable energy can be overcome or compensated employing integrating the systems. Table 1 gives the details of characteristics, assessment, and challenges for their integration. To deliver the energy from a single standalone integrated system poses a high initial cost and the parametric performance of the integrated system assessment is quite difficult.

Table 1 Potential Renewable Energy systems characteristics and factors.

Renewable system	Characteristic Nature	Assessment of energy	Contributing factors	Critical factors
Wind energy	Intermittent	Data collection. Forecasting Models.	Local wind generation. Terrains mountains, lakes	Transmission loss, High twisting winds, low wind generation in critical season and issues related to local people.[15][16][17][18][19][20]
Solar energy	Varying concerning time	Data collection. Solar insolation models.	Latitude of the location,	Less generation during the rainy and winter season.[21][22][23]
Biomass	It depends on the availability of waste.	Production of Biogas from the Digester and gasifier.	Plenty of availability of organic waste.	Issues with human handling organic waste and slurry from the digester and Gasifier. [24][25][26]
Micro Hydro	Source dependent	Availability of water and head at the source.	High Mountains, steep hills, forest regions.	Cost of implementation, less power generation.[26][27][28]
Fuel cells	It depends on the production of Hydrogen.	Package arrangement of Fuel cells	Organic waste, Methane gas.	The high cost of implementation, lack of knowledge in the local people.[29][30][31]

2.1. Integration of renewable energy systems

The sources of renewable energy systems can be easily affordable wherever the requirement of energy is needed. It gives the knowledge of extracting energy in a much better manner. Many studies show that the global wind resource and solar thermal potential corresponds to 90,000,000Mtoe (million-ton oil equivalent) per year which is almost10,000 times the world's primary source of energy supply. The rapid deployment of renewable technologies, their wider development raises the challenges and future scope which leads to the integration of renewable energy systems [32]. Thus sustainable development for the future demands for the integration of renewable systems and is a key solution for the optimal delivery of the energy supply. Table 2 gives the integration of the systems for various objectives taken by the authors in their studies for different configurations.

Table 2 study of integrating renewable energy systems for various applications.

Integrating/stand-alone system□	Objective/s of study	Assessment Factors	References	Remarks
Standalone PV SYSTEM	Variable monthly demand and tilt angles	Economical factors(LLP)	[33]	The practical application is proposed based upon LLP
PV-FC	1.Street lighting 2. continuous power flow 3. power generation	1.Technical factors 2.Technical factors 3.Technical factors	1.[34] 2.[35] 3.[36]	1.Sizing approach 2.system efficiency 3.simulation of power
PV-WIND	1.Powering ventilation devices 2.osmosis desalination plant for remote areas 3. Hydrogen production 4. Household application 5. Mobile Telephony base stations and mobile clinic	1.Technical assessment 2. Technical, Economical and environmental 3.Technical 4.Technical,environmental;□ 5.Techni-economical	1.[37] 2.[38] 3.[39] 4.[40] 5.[41][42]	Experimental setup and procedures are followed and simulations are carried out
PV-MH-BM	.For rural electrification	Technical, Economical factors□	[43]	Modeling and simulations are for optimization□
PV-MH-BM-WIND	For varying load profiles of the uttarkhand village	Techo-economic factors	[44][45]	Simulation of the mathematical model□
PV-WIND –FC	To power the data center applications	Techno- economical	[46]	Simulation of the mathematical models

2.2. Possible combinations of Integrated Renewable energy systems

As said earlier about the potential renewable energy systems, it can be simply formulated using the combination rule such that no renewable energy system is repeated taking two, three, four and five In Table 3 where PV represents solar photovoltaic, WT as wind turbine, BM-Bio mass system, MH-Micro Hydro, and FC as Fuel cell system. FromTable.3 It can be observed that there is a wide variety of combinations with the renewable systems that can be worked upon in suitable situations. The choice of the integrated system must suit to the site, which is under consideration. Thus we have a lot more chances to accommodate the systems for optimal delivery. Most of the combinations require the used battery as the storage device. It also shows that integrating with five potential renewable energy gives the only possible combination. Thus It presents the complete model for the utilization of renewable energy. It can be referred to as the Green Energy Model to which the feasible solutions can be carried out. From the general outer view, the availability of

Micro Hydro is especially site oriented and their integration becomes quite difficult. The choice of integrating the systems depends on the majority of the available renewable energy source at the site recommended. A simple combination procedure is adopted in Table 3 such that the combination is not repeated. The combinations are purely meant to working as a standalone system delivering the load demands. Hybrid combinations are possible by including the battery and Diesel engines as shown in the Table 4. The battery backup control is highly essential for meeting the varying demands.[47].The diesel engines are integrated to form a Hybrid combination is one of the most successful types with the renewables for continuous delivery of power demand. This combination works well for the remote villages[48][49].

Table 4 Integrating with diesel system

combination	Objective/s of study	References
PV-WIND-DIESEL	Remote area study and optimization of COE	[49][50][51][52] [53][54][55][56]
WIND-DIESEL	Optimization, for compressed air storage application, study on wind farms□	[57][58][59][60]
PV-DIESEL	Optimal design of the system	[61][62][63][64]
PV-BIOMASS-DIESEL	Rural electrification	[65][66]
MH-DIESEL	Rural electrification	[67]

Table3 Possible combinations of Integrating Renewable Energy systems with references

TWO systems	Ref	THREE systems	Ref	FOUR systems	Ref□□	FIVE systems	Ref
PV-WT	[39–42], [53], [68–79],[80][81][82]	PV-WT-BM	[83][84][85][86]	PV-WT-BM-MH	[45]	PV-WT-BM-MH-FC	
PV-BM	[87][88]	PV-BM-MH	[43][89]	PV-BM-MH-FC			
PV-MH	[90]	PV-MH-FC		PV-MH-FC-WT			
PV-FC	[36], [91][34][92]	PV-FC-WT	[93][94]	PV-FC-WT-BM	[95]		
WT-BM	[96][97]	PV-FC-BM		WT-BM-MH-FC			
WT-MH		WT-BM-MH		BM-MH-FC-WT			
WT-FC	[98–106]	WT-MH-FC					
BM-MH		BM-MH-FC					
BM-FC		PV-WT-MH	[107]				
MH-FC							
10 combinations		**9combinations**		**6 combinations**		**1 combination**	

2.3. Different schemes of integrating the Renewable Energy systems.

The various literature studied the integration of the renewable energy systems can be grouped into DC – coupled, AC-coupled and both AC and DC coupled schemes[108].some of the advantages and disadvantages are mentioned in the reference[109].In the DC-coupled systems the problem with the synchronization with the varying loads is not required. The AC- coupled can is of Two types 1. PFAC(Power frequency AC coupled system 2.HFAC(High-Frequency AC Coupled system).High-frequency generators can have high losses with a large amount of Heat dissipation. Dual coupled integrated systems are more flexible and can provide a better efficiency compared to the first two types. The integrating components are AC-AC converter, DC-DC converter, AC-DC converter, DC-AC converter, and the storage systems are integrated with Bi-directional converters. The integrating sources are PV,WT,BMG,MH,FC and storage system as Batteries. PV,FC and storage devices are DC energy sources and WT,BMG,MH are the AC energy sources.

Fig 1 shows the simple schematic representing the AC coupled system which has a good output with fewer conversion losses. The system is quite reliable with the associated components. But controlling the frequency of energy is a major issue due to its varying nature. The storage devices like Batteries are bi-directional and useful when there is a loss of probability of energy from the integrated systems. These act as energy deliverables for a continuous supply of power to the grid.

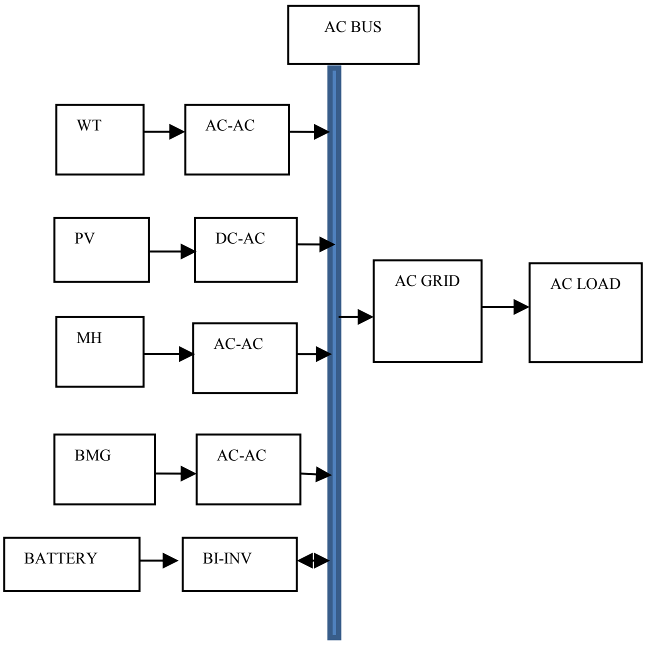

Fig.1. AC coupled configuration

Fig 2 shows the DC-coupled configuration has a good synchronization with the associated components but there are more conversion losses thereby reducing the efficiency of the system. The cost of the system is also more compared to the Ac coupled system.Fig.3 is both a coupled system which has better efficiency compared to the above two. This system has complete integration of the renewable energy systems which includes the use of the Fuel cells which takes the part of the energy from the wind turbine and the PV energy. This scheme is more flexible and losses are very less compared to the other two systems.

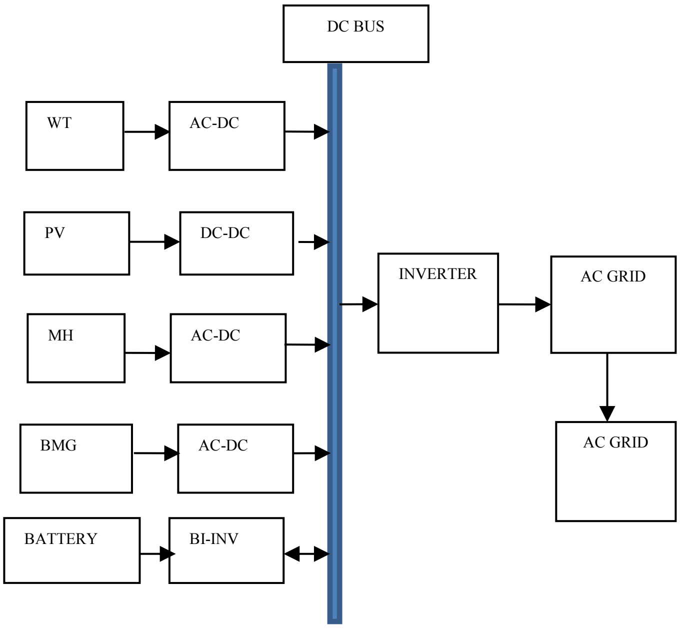

Fig.2. DC coupled configuration

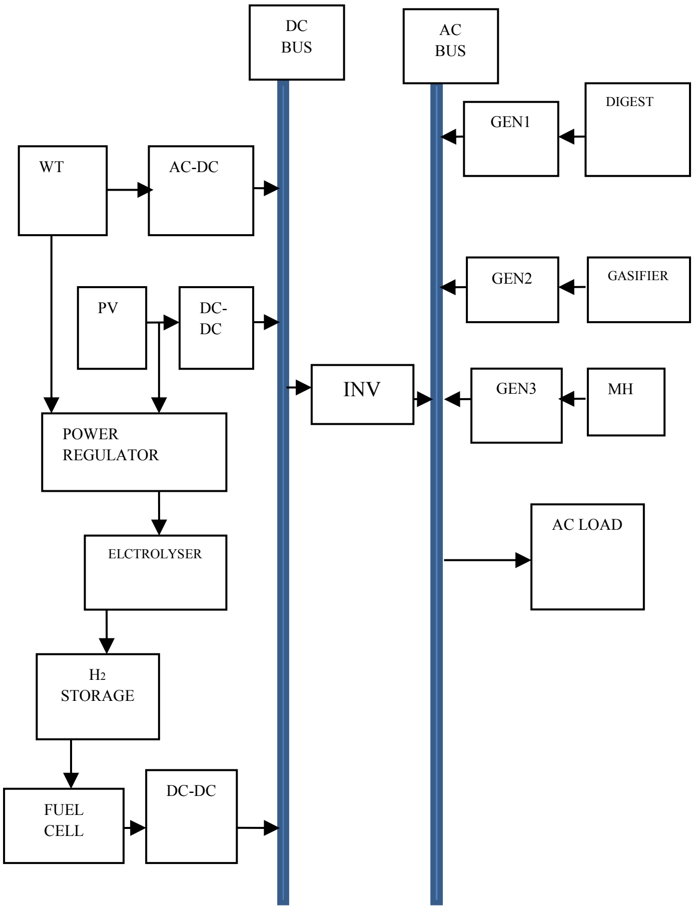

Fig.3. AC-DC coupled configuration

Table 5 gives the converter studies for integrating with renewable systems.These converters form the integral part or the heart of the inetgral systems.The performance of the converters is to be selected on the basis of maximum demand in the location.

Table 5 Research study on converter applications.

Reference	Converter Application	Research study
[110]	AC-DC converter	Designed the controlled loop for Renewable energy systems□
[111][112]	DC-DC converter with MPPT	Simulated for linear, nonlinear dynamic loads and neural networks□
[113][114]	AC-AC/DC-DC/DC-AC converter	Simulation carried for feasibility,compactness and effectiveness
[115]	AC/DC and DC/AC converters with MPPT	Simulated the model work for wind energy conversion
[116]	AC/DC and DC/AC sources	Feasibility and adaptability for wind turbines□

2.4. Various approaches for finding the optimal solutions

The optimal solution is one that gives the best feasible economical options related to the Net Present Cost of the system, Cost of Energy obtained, loss of probability of supply power and others subjected to the different constraints based on their requirements. The various literature as summarized in Table 6 recommends the feasible techniques adopted for different kinds of objective functions to which sensible solutions are achieved. The selection of the optimization technique depends on the researcher to carry out the possible solutions. Any optimization technique chosen will have its advantages and disadvantages. The possible solution should be justified Which are mainly based on the objective function which is defined as subjected to the available constraints. Any combination of the system to be carried out for a particular location, the interventions related to technical aspects, social aspects, and economics of the future delivery is to be assessed in proposing suitable combinations for the sites selected. The majority of the research work carried out a lack in predicting and assessing the potentiality of renewable sources. The tools provide the data in procession with suitable models for generating potential data. This is only one possible route to which the possible solutions obtained for nearly accurate to the expected outcomes. The various optimization techniques and tools make any researcher in adopting it and finally end up with the one particular technique which gives one possible solution. But the practicality of integrating the system seems to be different, which poses some technical, meteorological and reliability problems. The solutions are obtained based on the optimal technique used and usually vary if the solution is solved in any other technique.

3. Different sizing Methods

From the Literature it can be inferred that the options for integrating the Renewable Energy systems are broad and can be confined to the respective choice of integrating the system. The reference authors in all their studies carried out the Modeling of each renewable system, optimization and in some found with Energy Management of the integrated system. These studies are explained in categorized subsections.□

From the summary Table 6, optimal studies carried for different renewable configurations depend on the software tools used and some analytical procedures are involved. The Linear approximation technique is found to be a simple technique for carrying out optimal solutions. This approximation involves linear behavior of the integrated systems, but in actual, the energy and its associated power electronics systems will not behave in linear. The cost of the total integrated system which is the primary factor in deciding the optimal results also has to be assumed linear.

The sizing methodologies for the integrated system can be categorized into the following[117].

3.1. probabilistic Methods□

These are the simplest techniques that can be utilized to perform one or two performance indicators to size the components of the systems. These methods [118] relay upon the probability density function of the data. This requires TMY(Typical Meteorological Data) for the study and asses the system performance.□

3.2 Computational Methods

The various tools are commercially available to perform the sizing and optimization of the various parameters. In this direction, reference author[119] has provided the 19 software details which include HOMER, Hybrid2, RETScreen, iHOGA, iGRHYSO, HYBRIDS, SOMES, HySim, HySys, RAPSIM Dymola/Modelica, ARES, SOLSIM, HYBRID DESIGNER. TRNSYS, IPSYS, SOLSTOR, HybSim, and INSEL. But the status of some of the software is not reported. HOMER(Hybrid

Optimization Model for Electric Renewables) has emerged As a powerful simulation tool for optimal sizing. The sensitivity analysis made for systems seems to be more robust and also provided with graphical results. Hence the practicality of the simulation of these systems is closely in agreement with the results from the HOMER.

Table 6 summary of various approaches carried out from References in Table 4

Integrating Energy System	**Optimal approach/ Tools used**	**Optimal parameters considered**
PV-WT	HOMER, MATLAB/SIMULINK□ MATLAB(GA+TS), TRNSYS,□ Genetic Algorithm, Simulated annealing algorithm, iterative□□ Optimization using dynamic simulation,Ant colony optimization	NPC,COE,SOC,Hydrogen Production,Emissions,operating and Management Cost, Energy deficiency, LPSPAnnualized capital cost, Loss of Load probability, demand response□
PV-BM	HOMER, LabDER□	NPC,CRF,LCOE
PV-MH	Matlab(iterative optimal process)algorithm, HOMER□	The inclination of PV systems, Hydroelectric production.□
PV-FC	Genetic algorithm(SIMPLORER), Matlab(Modelling), HOMER□ Fuzzy regression Model	SOC,Total cost,No Fuel cells,Energy management,power estimation,NPC,MPPT
WT-BM	Data load assessment, Matlab□	COE and system costs
WT-FC	HOMER, TRNSYS, FUZZY MODEL□ PSO, algorithm, Matlab/Simulink□	Economic factors for H_2 cost, annual operating cost, Total cost, system analysis□ Life cycle analysis, System efficiency□
PV-WT-BM	HOMER,LABDER	Assessment of surplus energy, Annual fuel savings, the contribution of energy source□
PV-BM-MH	Mixed Integer Linear programming,C++ programming	Total cost,NPC,SOC,Economic analysis□
PV-FC-WT	Minimum linearized model, Multi-objective optimization, Genetic Algorithm	Cost of the power system, fuel consumption,□ Energy management strategy, unmet load,co_2 emissions, LCOE□
PV-WT-MH	Numerical Iterative Algorithm	Unit sizing, COE□
PV-WT-BM-MH	C++ Programming	Energy Index ratio, Avg generation cost, COE□
PV-WT-BM-FC	General Algebraic Modelling (GAMS)Using CPLEX solver	Microgrid integration, total profit, sensitivity analysis, cost minimization□

3.3. Iterative Methods

These methods are more inspiring and advanced which follow an iterative process in obtaining the possible feasible solutions[120]. These methods are having the advantage of analyzing the Nonlinear systems. These have a unique technique that is more acceptable and justifiable from their usage. There is no proof of adopting the technique is justified. But the literature demands the use of these techniques for a better understanding of these techniques. These methods include GA (Genetic Algorithm) ANN (Artificial Neural Network) PSO (Particle Swarm Optimization), TS(Tabu Search) and MOPT(Multiobjective Programming Technique). These optimal techniques have a technical assumption that is performed under the assistance of the MATLAB environment.□

3.4 .Hybrid Methods

These methods are Multidimensional which is a combination of any two iterative techniques like GA-TS[80] ANN-GA, GA-PSO approach and ANN-SA likewise we can accomplish the good results. This requires a high computational environment and computational time along with with with developed GUI (Graphical User Interface) environment run by the MATLAB tool. These methods are more comparable and can give better modeling of the systems.□

In all the above optimal methods, the Major parameters were confined to the sizing the integrated systems, obtaining the solutions related to the COE(Cost of Energy), LPSP(Loss of probability of Power Supply) and NPC (Net Present Cost) of the system.□

The most deciding factor is Modeling the objective function and corresponding decision variables or constraints affecting the objective function. The objective function modeled should be as linear as possible. Otherwise, it will be difficult to get the feasible solutions. These cases can be solved through iterative techniques.

4. Objective functions for cost/COE optimization

The objective functions are defined to minimize COE, Total cost of the system and Net Present cost(NPC)

B.ould et al.[121] carried out for LCE for PV/wind/Diesel as

$$\text{Minimize } LCE = \frac{J(x)}{E_{annual}}$$

Where $J(x)=C_{acap}(x)+C_{amain}(x)+C_{arep}(x)$

Balamurugan.P et al[86] minimized the Dumped energy for PV/Wind/Biomass using the equation□

$$Min\sum_{t=1}^{24}\left\{\sum_{i} p_i I_j(t) - Q_{dump}(t)\right\}$$

Wher P_i is the demand load *i* at time t,$I_i(t)$ is the fraction of time t that the load *i* is supplied the energy.

S. Ashok[107], minimized the Total cost of the system for PV/wind/Micro hydro as□

$$C_c = \sum_{h=1}^{N_h} C_h + \sum_{w=1}^{N_w} C_w + \sum_{s=1}^{N_s} C_s + \sum_{g=1}^{N_g} C_g + \sum_{b=1}^{N_b} C_b$$

Where N_h, N_w N_s, N_g,, N_b, are the total number of micro-hydro,wind solar,PV,diesel generator and battery units,respectively and C_k, C_w, C_s C_g, C_b are the associated capital costs.,

S.Rajanna et al.[122][45] minimized the for COE to the pv/wind /Biomass/Micro hydro as

$$COE = \frac{TNPC * crf}{\sum_{t=1}^{8760} E_{gen}(t)}$$

And Minimizing the Total cost of the system[123] is given by

$$TC_G = \sum (LCE)_J \times E_{R_{ij}}$$

Hugo morais.et.al[124] carried out the objective function using the mixed integer linear model for pv/wind/fuelcell

for minimizing the marginal optimal cost for 24hr period as

$$C = Min\left[\sum_{t=1}^{24}\times\begin{pmatrix} P_{wind(t)}\times C_{wind(t)} + P_{\mathrm{photo}(t)}\times C_{\mathrm{photo}(t)} \\ +P_{\mathrm{Fuel}(t)}\times C_{\mathrm{Fuel}(t)} - P_{\mathrm{storaebatt}(t)}\times C_{\mathrm{storagebattery}(t)} \\ +P_{wind(t)}\times C_{wind(t)} + undeliverenergy(t)\times C_{undeliverenergy(t)} \\ -Excessenergy(t)\times \mathrm{C}_{Excessenergy(t)} \end{pmatrix}\right]$$

where $P_{i(t)}$ and $C_{i(t)}$ represents the energy and associated cost of the *i* th system.

Katsgiannis et.al[80] proposed the COE function for wind PV systems using the Hybrid GA-TS approach developed in the MATLAB in simplified model as

$$COE = \frac{C_{antot}}{E_{anloadserved}}$$

Where $E_{anloadserved}$ is theAmount of load demand that cannot be satisfied.

Jeremy lagorse et.al[34]expressed the minimization of cost function for PV-FC-Battery as

$$C_{total} = C_{PV} + C_b + C_{FC} + C_{Penalty} \quad \text{where}$$

$$C_{penalty} = \begin{cases} \left\{UC_{Q_b} E_{surplus}^2 \quad if \quad E_{b_{\min}} > 0 \right. \\ \left\{UC_{Q_b}\left(E_{b_{\min}}^2 + E_{surplus}^2\right) \quad if \quad E_{b_{\min}} > 0 \right. \end{cases}$$

The first part in the equation is cost of each component and each cost modeling is carried out, the second part of the equation contains the penalty cost function which depends on the energy stored in the battery, which is the square function of the energy stored in the battery over one year.

Chun-hua et.al[35] proposed the cost function for a PV-FC battery system as

$$COE = \frac{C_{tac}}{E_{ae}} \quad \text{where}$$

$$C_{tac} = C_{acap} + C_{arep} + C_{aom}$$
$$= \sum_{components}\left(C_{acap.comp}\left(C_{acap.comp}, i, L_{proj}\right)\right)$$
$$+ \sum_{components}\left(C_{arepp.comp}\left(C_{arepp.comp}, i, L_{proj}\right)\right)$$
$$+ \sum_{components}\left(C_{aom.comp}\left(C_{aom.comp}, i, L_{proj}\right)\right)$$

Ajai Gupta et.al[43]performed the minimization of Total cost of Hybrid energy system of PV-BM-MH as

$$TC = \sum_{d=1}^{dn}\sum_{j=1}^{6}\sum_{t=1}^{24}\left[C_j \times E_{jdt}\right]$$

Where TC is the Total cost, C_j is the cost/unit of the *j* th generating unit,E_{jdt} is the optimal amount of the energy of the generating unit *j* for end-use in a day *d* ,hour *t* for particular month, d_n is the number of days of the particular month and *j* represents the energy source type.

A.B kanase-patil et.al[44] employed the COE function for PV-MH-BM-WIND configuration having multiple inputs into useful forms with amortization period, the Average Generation cost (Rs/Kwh) is given by

$$C_{av} = \frac{\left\{\frac{r(1+r)^n + m}{(1+r)^n - 1}\right\}\sum_i P_i R_i}{(87.6)\sum_i R_i K_i}$$

Where *i* is the summation index,K_i is the load factor for the

Energy source *i,m* is the operation and maintainence charge rate in per unit, n is the amortization period in years, P_i is the capital cost /KW for the *i* th device,R_i is the rating in KW of the *i* th device.

Zachariah et.al[46] determined the Levelized cost function for the PV-WIND-FC system as a simple model with some modification in the cost modeling as

$$COE = \frac{(FCR * ICC)}{AEP_{net}} + AOE$$

$$AEP_{net} = \sum_{i=1}^{n=8760}\left(P_{\text{Ren}}(i) - P_{Dump}(i) + P_{FC}(i)\right)$$

Where FCR and ICC are the fixed charges rate and initial capital cost of the hybrid system.AOE is the annual operating expenses which is taken as10%of ICC ,while P_{ren}, P_{dump} and P_{FC} are the combined energy produced by the wind ,FCand the dumped losses at the given hour (t).The Loss of power supply is modified in the calculations.

Anindita et.al[125] proposed the simple model for the cost of energy which includes the capital recovery factor as

$$COE = \frac{ACC + AOM}{E_{dem}} \quad \text{where}$$

$$ACC = \sum_i C_{oi} \times CRF_i \quad \text{where}$$

$$CRF_i = \frac{d(1+d)^{n_i}}{(1+d)^{n_i} - 1}$$

AOM is the annual operating and maintenance cost,E_{dem} is the total annual energy delivered,CRF is the capital recovery factor,C_{oi} is the capital cost of the *i* th system,*d* is the discount rate,ACC is the annualized capital cost and n_i is the life of the component *i* .

The dynamic simulation is proposed by xiaonan et.al[126] for the Total cost of the system as

$$TC = \min\left(C_i^{capitaldaily} N_i + C_i^{operating}\sum_t R_t^i\right)$$

Here $C_i^{capital\ daily}$ is the capital cost of the components converted to daily basis as well as $C_i^{operatting}$ costs, *i* represents the renewable components,R_t^i is the power flow rates with respect to demand, storage to demand and loss from storage,N_i is the number of components.The Modeling of total cost, cost of energy and the NPC depends on the type of the components,number of components and its associated various costs.The type of the model selected for optimization may or may not give the accurate results and its depends on the researcher to modify the equations associated with number of constraints defined for optimization studies. The objective function is the main criteria where the researcher can arrive at the faithful results.Rajanna et al[127] referred the various economic reliability models for the economic analysis of integrated Hybrid systems.

5. Energy management of IRES

The Energy management of the system is nothing but the systematic simulation of the proposed systems using the conditional algorithm for proper delivery of the systems for the load demand needs. The energy management[128] can be studied using the two main technical approaches classified as 1. Linear programming approach 2. Artificial Intelligence approach for both stand-alone and Grid-connected integrated systems. For the Smart grid oriented applications, the process through SCADA and Zig Bee approach can be carried out. The use of Fuzzy logic and Fuaay controllers help in obtaining desired results.The algorithms .Mohammed et al [129] explained about the real-time management during the peak hour and the peak off-hours and proposed the energy management algorithm.j Lagorse et al.[130] conducted fuzzy logic approach which is multitasking and developed the energy management algorithm.Roumila et al.[131] conducted the fuzzy logic controller for the wind/PV/Diesel combination. As we know the renewable sources are always intermittent in Nature, the energy is to be balanced with the cost of compensating from one to another source. This possible a proper conditional is put together and simulated using any one of the computational programmings. These kinds of algorithms should be embedded in the power conditioner system to monitor the functioning of the integrated systems. Reference[132],[133] gives the details about the use of micro-controlled based controlling the Hybrid systems using the MATLAB/simulink environment. Reference [134], also gives an idea about the Intelligent flow of the energy management system. To asses, this SIMULINK or C programming tool can help in obtaining the simulations.

6. Problems associated with Integration of systems.

There are few literature findings related to the technical, social and economic problems for integrating renewable systems. The Power quality of the integrated system is affected by the low power factor of the components, Low-frequency phenomenal distortion in the waveform and current flow with different potentials are the severe cases[135] . The technical issues related to the power quality, which include harmonics, frequency and voltage fluctuations. The power fluctuations corresponding to small time and long time or seasonal delivery have to be clarified[136]. Anees et.al [137] has cited all the Technical a non-technical issues which occur during the integration of the renewable energy systems.

The practicality and behavior of the system are still unknown. There is a lot of issues to be taken into this account as like some Government approvals, various land issues for proper installations, the flexible cost of the systems, maintenance problems, and transmission problems. If there is a chance for connecting it to the Microgrid or the substations available, that can be reduced to some extent. The concept of a smart grid can help in this direction, but it takes a lot of time to implement. The literature works are based upon selecting the choice of renewable systems and work for the optimal costs. The solutions to the basic problems can be worked out based upon the field studies in their integration.

7. Conclusions

This paper presents an overview of the integration of renewable energy systems carried out from the various literatures. The hybrid system concept is possible and will give the feasible solutions for determining the optimal energy needs.Conducting the various optimal studies for various possible combinations of renewable energy systems will th pave the way for its feasibility and releiability of the performance.The optimal combinations are more feasible and more prouductive as a alternative resources.Moreover,the application of these potential resources can reduce the burden on the use of fossil fuels.The literature studies show that more of the work is being carried out on the PV-WIND combinations and Governaments are more suggested on these combinations.In order to utilize and adopt any inetgration, thorough assessment of the potential resources have to be carried atleast for the data for one year.The load demand which is of dynamic nature has to b met by the inetgrating resources ,if these are acting as standalone resources.Now a days,it is better to connect to the online grid as a smart grid opportunity.The smartgrid technology for integrating these renewable energy systems seems to be the better option.The tools,techniques and system technologies are more faithful and prouductive in carrying out the sensitvity analysis. The optimizations and simulations of the respective integrated system are necessary for predicting the energy reliability of the system. Any technique adopted will have its own feasible solution and results may slightly vary if it is carried out with any other technique. These techniques empower the chances for predicting more accurate results. The accurate results obtained are not nearly make the permanent solutions to the integrated systems. Some facts related to energy management and problems associated with the integration are need to be carried out as a part of the future work.

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Nomenclature

ANN	Artificial neural network	E_{gen}	Energy generated
PV	Photovoltaic cells	C_{antot}	Total annualized cost
MH	Micro-hydro	C_{pv}	Total cost of PV system
BM	Biomass	C_b	Total cost of battery
FC	Fuel cells	C_{FC}	Total cost of fuel cell
WT	Wind turbine	C_{tac}	Total annualized cost
LLP	loss of load probability	E_{ae}	Annual electricity usage

COE	Cost of energy	C_{acap}	Annualized capital investment
BI-INV	Bi directional inverter	C_{arep}	Annualized replacement cost
GEN1,23	Generator 1,2&3	C_{aom}	annualized operating and maintainece cost
MPPT	maximum power point tracker	i	interest rate
GA	Genetic Algorithm	L_{projct}	Life time of component in years
TS	Tabu search		
NPC	Net present cost		
TRNSYS	Transient system software		
LPSP	Loss of power supply probability		
CRF	capital recovery factor		
LCOE	Levelized cost of energy		
PSO	particle swarm optimization		
SOC	state of charge		
J(X)	levelized cost of system		
E_{annual}	Annual consumed energy		
C_{acap}	levelized capital cost		
C_{amain}	levelized maintaince cost		
C_{arep}`	levelized replacement cost		
TNPC	Total net present cost		