A review on the cost Optimization Control Techniques for Smart Grid Sources

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Abstract

With the ever increasing demand of the energy in the developing countries and the depletion and availability constraints of the conventional energy sources the focus tends to move towards the renewable energy sources. Being nature dependant the sole dependency on renewable energy is not a viable option. This lead to the concept of integration of renewable sources with the conventional sources via smart grid to make the existing grid more effective and reliable. This paper will try to review the study on the cost optimization control techniques applied while integration by different papers and will try and conclude the best method for further investigation and implementation. On the other hand it will try to find the best solution which will yield the least unit cost to the energy consumed on one hand and will increase the use of eco-friendly renewable energy.

Keywords - Smart Grid, Control Techniques, Cost Optimization, Renewable Energy Sources, Integration, PSO.

Introduction

In the present scenario, one cannot imagine a life without energy. Till date the main source is fossil fuel which caters the major need of energy. Oil is the most important share in fossil fuel followed by coal and natural gas. With the advancement of technology nuclear power is also increasing its market share day by day. The technical, manpower, disposal difficulties and safety issues associated with nuclear energy make it unsuitable to be the alternate source of fossil fuels. Only 9.8 % of energy comes from renewable sources till date (Energy Markets in the European Union in 2011).

Power system engineers have to keep in mind that the main aim of a power system is to supply network customers with electricity whenever the customers have a demand for it. With more and more customers connected to the network the demand is increasing in a very rapid manner. Various strategies has been taken to reduce the dependency on the fossil fuel. The first is to reduce the energy consumption by using energy efficient appliances in both domestic and industrial applications.

Secondly, the demand supply gap in the field of power generation is pushing the utilities towards the integration of renewable energy sources. The integration of the renewable energy sources with the conventional grid is leading to many issues like maintainence of voltage and frequency level, shifting from one energy source to other in this absence, economic issues like unit commitment etc. Though integration of renewable energy with the existing grid has started, the major challenges that has developed for the utilities are ensuring voltage stability, power quality and voltage regulation.

Due to rapid increase in distributed renewable energy in integration which has intermittent generation, the grid is more exposed towards demand response. Thus to provide reliable power supply efficient optimization techniques are required for unit commitment. For appropriate system sizing and providing optimized unit commitment various optimization techniques are practiced in the power system engineering.

Optimization Techniques

Unit sizing, unit commitment and voltage regulation of Hybrid RE/AE systems is the most crucial task in integration of renewable energy sources which has been discussed through various optimization tools in various papers over years. Simulation and optimization software tools are the most powerful platform for the evaluation of the performance of hybrid systems. HOMER, HYBRID2, HOGA, HYBRIDS, ARENA, WASPS are the majorly used software tools for designing and economical simulation. It is also important for unit commitment to find an viable optimization technique to select optimum system configuration. It can be done by:

- **Graphical Construction method**: This method collect long term data of the energy sources and use graphical techniques to formulate designing and optimization process.
- **Probabilistic approach:** This method optimizes the hybrid system by using the probability distribution function of the energy resource data. This method cannot represent the dynamic variation of the integrated system.
- **Iterative Technique:** This method uses iterative numerical approach to calculate the generated and demanded power over a long period of time. Various optimization techniques which uses this approach are Hybrid Solar–wind System Optimization (HSWSO) model as proposed by Yang et al. , the LPSP model and Levelised Cost of Energy model for power reliability and system cost etc. This method does not optimize all the designing parameters like PV module slope angle for solar energy, wind turbine installation heights etc which affects the energy production calculations and system costs.
- **Artificial Intelligence:** It is the modern. most used method of optimization in which machine's ability or artifact is used to perform the calculations in the way a human character think and perform. There are various methods using artificial intelligence approach such as Artificial Neural Networks, Genetic Algorithm, Fuzzy Logic, PSO (Particle Swarm Optimization), ACO (Ant Colony Optimization) etc. New methods are also been proposed by hybridizing Artificial Neural Network and Genetic Algorithm methods. This method is very helpful and accurate to find the optimized solution to complex real problems of hybrid power system.

Literature Review

Various authors have tried to optimize the hybrid system design and try to provide economical optimization by using the above mentioned optimization techniques. Literature review of few papers is tried to find out the best optimal technique that is to be implied in integrated system to get better performance and economical output.

Sr. No.	Author	Title	Technique used	Outcomes
1.	Motaz Amer, A. Namaane and N. K. M'Sirdi (Motaz *et al .,* 2013)	Optimization of Hybrid Renewable Energy Systems (HRES) Using PSO for Cost Reduction	PSO	Proposed an optimization of renewable hybrid energy system for cost reduction using Particle Swarm Optimization (PSO) approach.

2	S.Ashok (Ashok *et al.,* 2007)	Optimised model for community-based hybrid energy system	HOMER and PSO	Designed an optimized model to add wind, solar and micro-hydro hybrid energy which senses wind velocity, solar radiation and load requirement to actually control the hybrid system.
3.	Banu Y. Ekren & Orhan Ekren (Banu *et al.,* 2009)	Simulation based size optimization of a PV/wind hybrid energy conversion system with battery storage under various load and auxiliary energy conditions.	ARENA 12.0	Simulation of PV/Wind system with battery storage is performed using ARENA 12.0 using different loads.
4.	Saeid Lotfi Trazouei, Farid Lotfi Tarazouei, Mohammad Ghiamy (Saied *et al.,* 2013)	Optimal Design of a Hybrid Solar -Wind-Diesel Power System for Rural Electrification Using Imperialist Competitive Algorithm	PSO and ACO	Used the imperialist competitive algorithm, particle swarm optimization and ant colony optimization to determine the optimum configuration of a integrated supply consisting of solar, wind and diesel as sources.
5.	Acakpovi, A., Hagan, E. B., Fifatin, F.X. (Acakpovi *et al.,* 2015)	Cost Optimization of an Electrical Energy Supply from a Hybrid Solar, Wind and Hydropower Plant	HOMER and PSO	Implements a solution to a cost optimization problem of solar-wind-hydro hybrid energy system with the Homer software and finally compare the results with optimization
6.	Bansal, A.K., Gupta R.A., Kumar, R. (Bansal *et al.,* 2010)	Optimization of hybrid PV/Wind Energy System using Meta Particle Swarm Optimization (MPSO)	MPSO	Perform the cost optimization using a Meta Particle Swarm Optimization technique to of a hybrid wind, solar and storage battery.
7.	Lhassane Idoumghar, Mahmoud Melkemi, René Schott, and Maha Idrissi Aouad (Lhassane *et al.,* 2011)	Hybrid PSO-SA Type Algorithms for Multimodal Function Optimization and Reducing Energy Consumption in Embedded Systems	PSO and SA	Used a combination of Particle Swarm Optimization (PSO) and Simulated Annealing (SA) algorithms that overcomes the defect of simple PS.
8.	Deepali Sharma, Prerna Gaur, and A. P. Mittal (Sharma *et al.,* 2014)	Comparative Analysis of Hybrid GAPSO Optimization Technique With GA and PSO Methods for Cost Optimization of an Off-Grid Hybrid Energy System	PSO and GA	Applied a combination of GA and PSO named as hybrid GAPSO (HGAPSO)to overcome the difficulties like low speed convergence in GA and premature convergence in PSO

9.	Zhou Wei (Zhou *et al.,* 2008)	Simulation and optimum design of hybrid solar-wind and solar-wind-diesel power generation systems	GA	Used genetic algorithm approach to determine the optimum sizing of a PV-Wind hybrid system.
10.	G. Naveen Ram , J. Devi Shree2 , A. Kiruthiga (Naveen *et al.,*2013)	Cost Optimization Of Stand Alone Hybrid Power Generation System Using PSO	PSO	Used MPSO approach to design of a distributed hybrid power generation plant consisting of wind turbine ,solar panels and batteries together with a diesel
11.	H. Gharavi , M.M. Ardehali , S. Ghanbari-Tichi (Gharavi *et al.,* 2015)	Imperial competitive algorithm optimization of fuzzy multi-objective design of a hybrid green power system with considerations for economics, reliability, and environmental emissions	Fuzzy Logic for Multi-objective optimization	Design an autonomous and non-autonomous hybrid green power system (HGPS) to supply a specific load demand with considerations for economics, reliability indices, and environmental emissions.
12.	Harsh, Dr. Sunil Kumar Singal (Harsh *et al.,* 2014)	Integration of Renewable Energy Sources Using Artificial Intelligent System	algorithm to employ dynamic programmin g technique	The study reveals the research referring to the optimal configuration and Intelligent Control of Hybrid System. Renewable Energy sources like. Solar, Biomass, Wind, Small Hydro Power, etc. in integration with the National Grid System and DG's.
13.	Amevi Acakpovi (Amevi *et al.,* 2016)	Performance Analysis of Particle Swarm Optimization Approach for Optimizing Electricity Cost from a Hybrid Solar, Wind and Hydropower Plant	PSO	This paper deals with the cost optimization of a integrated solar, wind and hydropower plant using a PSO approach
14.	Soroudi A, Ehsan M, Zareipour H. (Soroudi *et al* .,2011)	A practical eco-environmental distribution network planning model including fuel cells and non-renewable distributed energy resources	I-GA(immune genetic algorithm)	presented a futuristic multi-objective planning model for expansion of distribution network, using an (I-GA) algorithm for optimizing costs and emissions.

15.	Niknam T, Firouzi BB (Niknam *et al.*,2009)	A practical algorithm for distribution state estimation including renewable energy sources.	NMS and PSO	proposed a method that combines NMS and PSO, and compared the results with PSO, Honey Bee Mating Optimization (HBMO), ANN, ACO, and GA.
16.	Niknam T, Meymand HZ, Nayeripour M. (Niknam *et al* .,2010)	A practical algorithm for optimal operation management of distribution network including fuel cell power plants.	fuzzy adaptive PSO	proposed a fuzzy adaptive PSO algorithm to solve the optimal operation management of distribution networks including fuel cells power plants which obtains better results in comparison with conventional optimization algorithms.
17.	Mahor A, Prasad V, Rangnekar S. (Mohar *et al* .,2009)	Economic dispatch using particle swarm optimization: A review	PSO	applied PSO to solve this problem, and concluded that its performance was better than conventional optimization techniques.
18.	Brini S, Abdallah HH, Ouali A. (Brini *et al.,* 2009)	Economic dispatch for power system included wind and solar thermal energy.	MOEA, GA	solved the economic dispatching problem of a integrated power system including solar thermal energies using a MOEA that simultaneously minimizes the fuel costs
19.	Ould B, Sambou V, Ndiaye PA, Kébé CMF, Ndongo M. (Ould *et al.,* 2010)	Optimal design of a hybrid solar-wind-battery system using the minimization of the annualized cost system and the minimization of the loss of power supply probability (LPSP).	multi-objective GA	proposed a multi-objective GA for designing a stand alone hybrid system consisting of solar, wind and battery to minimize the system cost and the loss of power supply.
20.	Kaviani AK, Riahy GH, Kouhsari SHM. (Kaviani *et al.*,2009)	Optimal design of a reliable hydrogenbased stand-alone wind/PV generating system, considering component outages.	PSO	optimized a integrated system consisting of solar and fuel cells using PSO taking reliable supply as constraint and minimizing annual cost.

21	Yang H, Zhou W, Lu L, Fang Z. (Yang *et al.,*2008)	Optimal sizing method for stand-alone hybrid solar-wind system with LPSP technology by using genetic algorithm.	GA	design a hybrid system consisting of solar, wind and battery using GA taking number of photovoltaic modules, slope angle and wind turbine installation height as constraints.
22	Del Real AL, Arce A, Bordons C. (Del *et al,*. 2009)	Optimization strategy for element sizing in hybrid power systems.	proposed procedure of GA and PSO	designed a procedure for optimal sizing of integrated systems to cater residential demands.

Results and Discussion

Recent researches in hybrid energy technologies show that the systems must continue to improve their performance in terms of their output and reliability and also integrate them with conventional sources .In the quest of meeting the energy demand gap the need of optimization technique is increasing day by day in the recent years. This techniques makes the design more cost effective and reliable making it more acceptable in the common market. In this aim various multi-objective algorithms have been proposed over the recent years. The conventional optimization techniques failed to solve the problems on local optimum solution convergence as problems like nonlinearity, non-convex type objective function with intense equality and inequality constraints are associated with practical economic dispatch. Mahor (Mahor *et al.*, 2009) applied PSO to solve this problem, and concluded that its performance was better than conventional optimization techniques and it also enhances the optimum system design with better performances. Rajak (Razak *et al*., 2009) in his study presented an optimization method for reducing the excess energy and unit cost of energy in a hybrid renewable system that combines pico hydro turbines, wind turbines, solar photovoltaic panels and diesel generator. The result showed that in order to reduce the energy cost the amount of excess energy the system produces needs to be reduced.

Conclusion

The papers mentioned in the literature review presented a comparison scenario in simulation, optimization and control technologies for the integrated energy systems, and tries to predicting the output of the renewable systems accurately and integrate them reliably with conventional power generation sources. Current scenario states the integration of renewable sources with the conventional grid and ensure that the load demand to be supplied from the cheapest renewable sources. This will not only ensure eco-friendly generation source but will also lower down the per unit generation cost for consumers. The above comparison shows PSO and GA optimization techniques are the most successful techniques to design and optimize such system in mere future.

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