Role of Particle Swarm Optimization for Optimal Grid Operations

Priyanka[1] Ms. Kirti Bhatia[2]
[1]M. Tech Scholar [2]Head of the Department
[1,2]Department of Computer Science & Engineering
[1,2]SKITM, Bahadurgarh, India

Abstract— A Particle Swarm Optimization (PSO) based methodology is proposed and applied in a smart connected grid for increasing the penetration of renewable energy resources and minimizing the operation costs. Compared with the other existing techniques, the proposed algorithm has been found to perform better in several cases. For the implementation part MATLAB 2016a is used. It stands for 'Matrix Laboratory'. MATLAB 2016a is a high-level language for technical computing. It integrates computation, visualization and programming in an easy-to-use environment where problem and solutions are expressed in familiar mathematical notations. The PSO method has been successfully implemented to solve different convex and non-convex ELD problems with the generator constraints.

Keywords: Renewable Energy Sources; Smart Grid, Economic Load Dispatch; Demand Response

I. Introduction

Renewable energy sources provide an attractive alternative power generation method over fossil fuels with many merits in environmental, economic and political concerns. Even though renewable sources have merits for green power generations, the major drawbacks such as power intermittent and distributed nature of resources introduce difficulties in integrating these systems to the electricity grid. Traditionally electricity grid was developed with the idea of centralized controllable power stations which are transmitting the electricity from source to consumers. However, distributed generation is also getting more popular with the recent development of renewable energy technologies and micro-grid concepts.

Distributed generation (DG) also includes both small scale nonrenewable (oil, gas) electricity generation stations and renewable sources (solar, wind, bio-energy, fuel cell etc.

The integration of distributed renewable energy sources like wind power, solar power, bio energy and fuel cell to the power grid is an important topic. A lot of research is going in grid integration of these sustainable electricity generations.

Particle swarm optimization (PSO) algorithm is recommended as a standout amongst the most valuable and promising methods for optimizing the HRES because of using the global optimum to locate the best solution. PSO algorithm is designed based on swarm intelligence and used to handle the complex optimization problems [2]. Like other population-based optimization algorithms, PSO begins with a random initialization of particles in the search space. Every particle is invested with a random position and a random velocity at the beginning, and then adjusts its search patterns in view of its own experience and experiences of other individuals [3]. Owing to its simplicity, effectiveness and low computational cost; PSO has gained significant popularity and improvements [4].

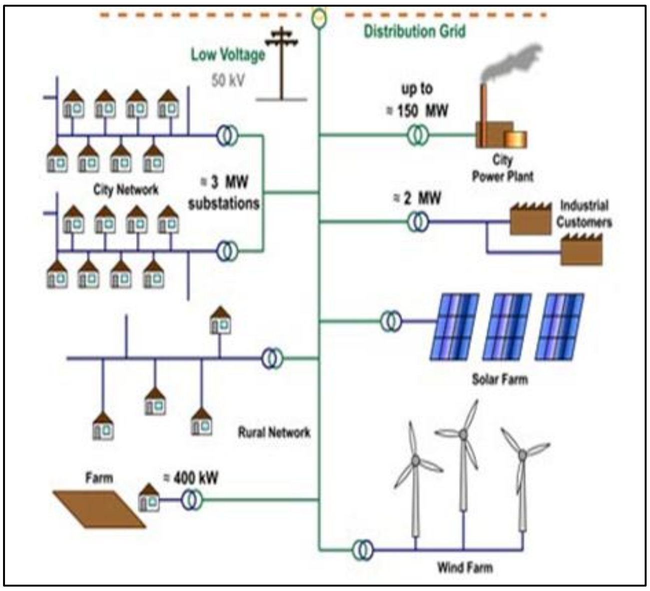

Fig. 1: The electrical grid is an excellent example of a sociotechnical system [1].

The organization of present paper is as follow. Section II presents the literature survey which highlights the facts of various researchers. Section III describes the methodology used for proposed work as in this paper optimization is used. Result analysis is presented in section IV following the concluding remarks in section V.

II. Literature Review

This section will provide the brief description and highlights the contribution, remarks and factors of the work done by the researchers. Many attempts have been made in the past to heavy industry & home automation.

Xu, Zhiwei, et al. (2016) [1] In this paper, we design a data-driven pricing scheme to help the utility achieve system-level control objectives (e.g., minimizing peak demand) by combining hybrid particle swarm optimizer with mutation (HPSOM) algorithm and an iterative algorithm. Case studies have demonstrated the effectiveness of the proposed approach against two benchmark pricing strategies – a flat-rate scheme and a time-of-use (TOU) scheme. we consider a utility who seeks to coordinate the energy consumption of multiple demand-side flexible resource aggregators. Furthermore, the utility can leverage resource aggregator energy consumption via time-varying electricity price profiles. Based on inverse optimization technique, we propose an estimation method for the utility to infer the energy requirement information of aggregators.

Javaid, Nadeem, et al. (2017) [5] In this paper, In recent years, demand side management (DSM) techniques have been designed for residential, industrial and commercial sectors. These techniques are very effective in flattening the load profile of customers in grid area networks. In this paper, a heuristic algorithms-based energy management controller is designed for a residential area in a smart grid. In essence, five heuristic algorithms (the genetic algorithm (GA), the binary particle swarm optimization (BPSO) algorithm, the bacterial foraging optimization algorithm (BFOA), the wind-driven optimization (WDO) algorithm and our proposed hybrid genetic wind-driven (GWD) algorithm) are evaluated. Moreover, these algorithms are tested in two scenarios: (i) scheduling the load of a single home and (ii) scheduling the load of multiple homes. Simulation results show that our proposed hybrid GWD algorithm performs better than the other heuristic algorithms in terms of the selected performance metrics.

Shubham Tiwari, Ankit Kumar et al. (2013) [6] In this paper Economic load dispatch is a non-linear optimization problem which is of great importance in power systems. While analytical methods suffer from slow convergence and curse of dimensionality particle swarm optimization can be an efficient alternative to solve large-scale non-linear optimization problems. This paper presents an overview of basic PSO to provide a comprehensive survey on the problem of economic load dispatch as an optimization problem. The study is carried out for three-unit test system and then for six unit generating system for without loss and with loss cases. We can draw important conclusions on the basis of the work done. Some important conclusions are given as Three Unit Systems: In PSO method selection of parameters c1, c2 and W is very much important. It is stated in various research papers that the good results are obtained when c1 = 2.0 and c2= 2.0 and W value is varied from 0.9 to 0.4 for both cases loss neglected, and loss included. We can see from Table 4.3 and Table 4.5 that Classical PSO gives better result than GA. In PSO method numbers of iterations are not much affected when the transmission line losses are considered. In both cases for loss included and loss neglected it is approximately 50 iterations for Classical PSO method.

Vinay K. Jadoun, Nikhil Gupta et al. (2015) [7] In This paper presents improved PSO (IPSO) to solve Multi Area Economic Dispatch (MAED) problem. The objective of MAED problem is to determine the optimal value of power generation and interchange of power through tie-lines interconnecting areas in such a way that total fuel cost of thermal generating units of all areas is minimized while satisfying operational constraints. The control equation of the proposed PSO is modified by suggesting improved cognitive component of the particle's velocity by suggesting preceding experience. The operating parameters of the control equation are also modified to maintain a better balance between cognitive and social behavior of the swarm. The application results show that IPSO is very promising to solve large-dimensional MAED problem.

De Craemer, et al. (2014) [8] In this paper addresses the challenges of integrating existing PHEV charging algorithms, which optimize PHEV charging per market timeslot (e.g., 15 minutes), into an environment with realistic communication conditions. A case study of 1000 PHEVs shows that it is possible to achieve results on par with the timeslot based algorithm but with significantly reduced communication with the PHEVs.

Jiejin Cai, Qiong Li et al. (2012) [9] In this paper developed a new method for solving the economic dispatch (ED) problems considering the valve-point effects in power systems. The method is based on a hybrid algorithm consisting of chaotic particle swarm optimization (CPSO) algorithm and sequential quadratic programming (SQP) techniques. The CPSO is the main optimizer of the algorithm and the SQP is used to fine tune its results to improve the solution. The proposed method was applied to three different cases of power systems. The economic effect, solution quality, convergence property and computation efficiency of the proposed method have been explored through the comparison with the existing techniques for the ED problems considering the valve-point effects. The simulation results demonstrate the applicability and effectiveness of the proposed algorithm to the practical ED problems.

III. Frame Work for Implementation

This study illustrates utilization of particle swarm optimization (PSO) method for cost-efficient energy management in multi-source renewable energy micro grids. PSO algorithm is used to find out optimal energy mixing rates that can minimize daily energy cost of a renewable micro grids under energy balance and anti-islanding constraints. The introductory sections provide the new way to implement renewable energy power system using particle swarm technique. Subsequent sections cover recent trends of PSO development in renewable energy power systems. This technique would be useful to determine the powerful energy management strategy so as to meet the required load demand at minimum operating cost while satisfying system equality and inequality constraints.

The objective function of DR problem may be written as

$$Ft = \min(\sum_{i=1}^{m} Fi(Pi)) \quad \ldots\ldots(5.1)$$

$$= \mathrm{m} \sum_{i=1}^{m} ai + biPi + ciP_i^2 \quad \ldots\ldots(5.2)$$

where Fi(Pi) is the ith generator's cost function, and is usually expressed as a quadratic polynomial; at, b,. and c, are the cost coefficients of the ith generator; m is the number of committed generators to the power system; Pi is the power output of the ith generator.

For the implementation part MATLAB 2012b is used. It stands for 'Matrix Laboratory'. MATLAB 2012b is a high-level language for technical computing.The MATLAB consists of five main parts:

A. The MATLAB Language:

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output and object-oriented programming features. It allows both 'programming in the small' to rapidly create quick and dirty throw-away programs, and 'programming in the lagre' to create complete lagre and complex application programs.

B. The MATLAB Working Environment:

This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging and profiling M-files, MATLAB's applications.

C. Handle Graphics:

This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete Graphical User Interfaces on your MATLAB applications.

D. The MATLAB Mathematical Function Library:

This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions and fast Fourier transforms.

E. The MATLAB Application Program Interface (API):

This is a library that allows you to write 'C' and 'FORTRAN' programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

IV. RESULT ANALYSIS

MATLAB platform has been used to evaluate the results. Some assumptions are made to simulate the results as discussed The different parameters used in proposed work are given in table 1. The performance parameters are analyzed using MATLAB 2016a.

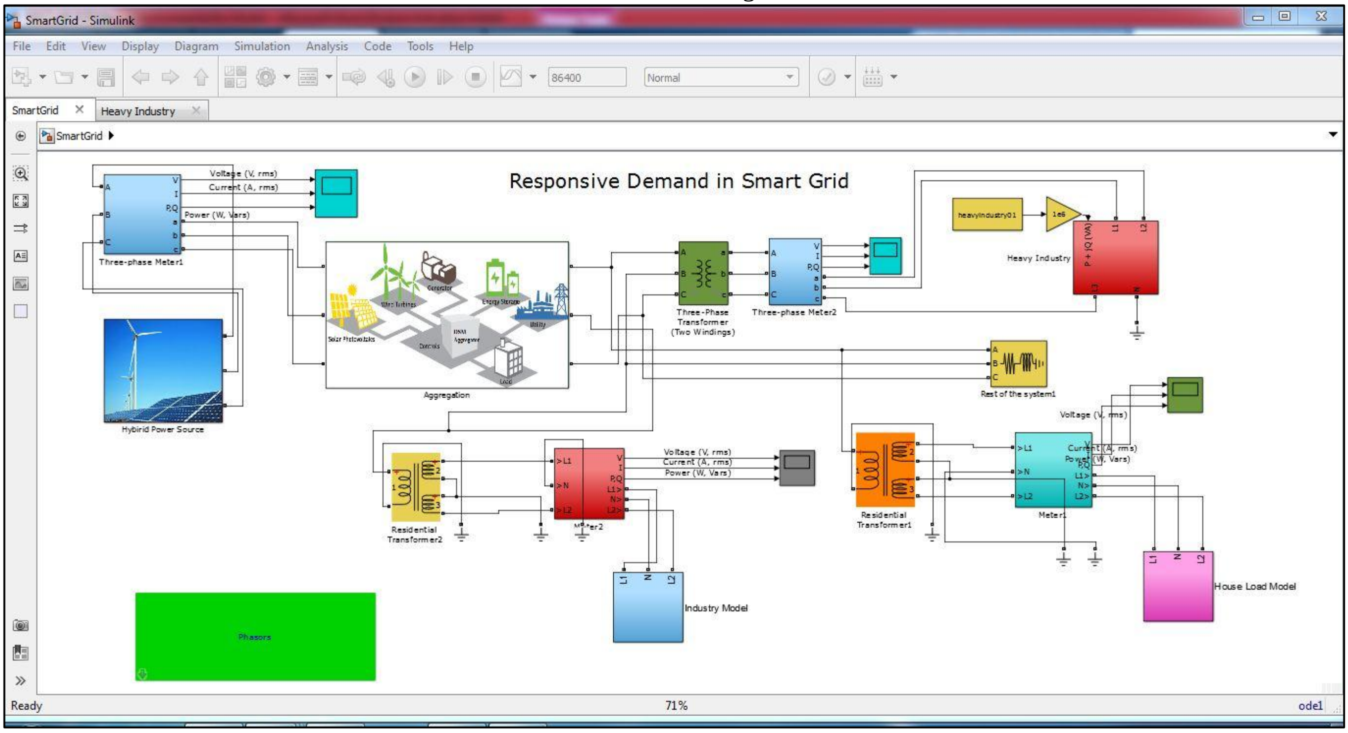

Fig. 2: Simulink model for Demand Response Management

Fig 2 gives the Simulink model for demand response Management Simulink model. In this complete model is design to give the demand response. This system is used to design the different power supply, different controller.

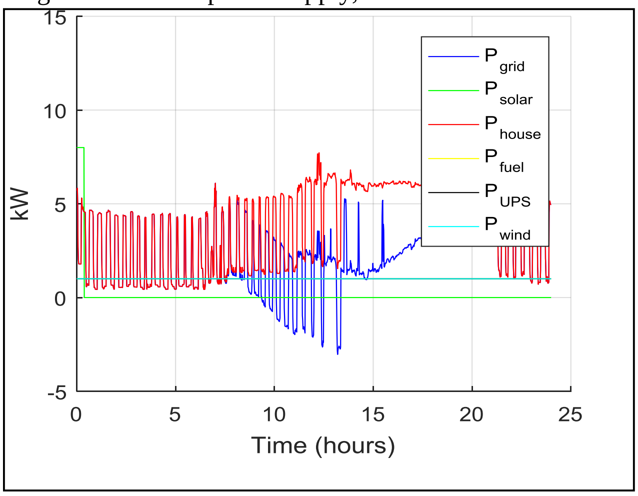

Fig. 3: Demand (KW) P_{house} from houses and Grid Response for various sources Solar, House, fuel and Wind sources.

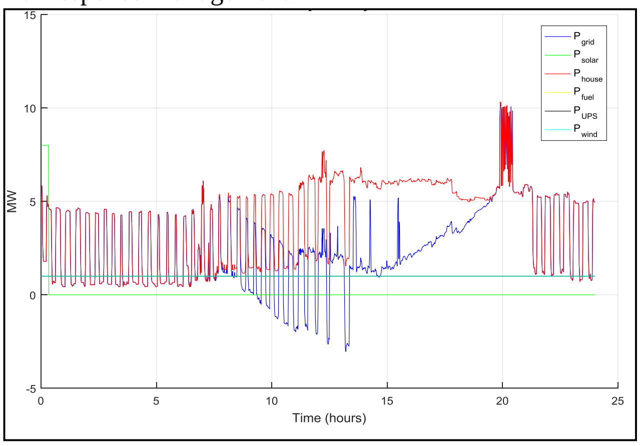

Fig. 4: Visualization of Heavy industry Demand Response

Fig 3 & 4 shows the visualization of heavy industry demand response. The demand response is given by different industry. The local society .personal office & home demand response is given in the Simulink design.

V. CONCLUSION

The PSO method has been successfully implemented to solve different convex and non-convex ELD problems with the generator constraints. The PSO algorithm has the ability to find the better-quality solution and has better convergence characteristics, computational efficiency, and robustness. Many nonlinear characteristics of the generator such as ramp rate limits, valve point loadings, multi-fuel options, prohibited operating zone, etc. have been considered. It is clear from the results obtained by different trials that the proposed PSO method has good convergence property and can avoid the shortcoming of premature convergence of other optimization techniques to obtain better quality solution. Due to these properties, the PSO method in the future can be tried for solution of complex unit commitment, dynamic ELD problems in the search of better-quality results.

REFERENCES

[1] A wikispaces, Social Construction of Technology, 2016 https://conceptsinsts.wikispaces.com/Sociotechnical+Systems+(Banks)
[2] Fang, Xi, Satyajayant Misra, Guoliang Xue, and Dejun Yang. "Smart grid—The new and improved power grid: A survey." Communications Surveys & Tutorials, IEEE 14, no. 4 (2012): 944-980.
[3] Siano, Pierluigi. "Demand response and smart grids—A survey." Renewable and Sustainable Energy Reviews 30 (2014): 461-478.
[4] Fang, Xi, Satyajayant Misra, Guoliang Xue, and Dejun Yang. "Smart grid—The new and improved power grid: A survey." Communications Surveys & Tutorials, IEEE 14, no. 4 (2012): 944-980.
[5] Aghaei, Jamshid, and Mohammad-Iman Alizadeh. "Multi-objective self-scheduling of CHP (combined heat and power)-based microgrids considering demand response programs and ESSs (energy storage systems)." Energy 55 (2013): 1044-1054.
[6] Tiwari, Shubham, Ankit Kumar, G. S. Chaurasia, and G. S. Sirohi. "Economic Load Dispatch Using Particle Swarm Optimization." International Journal of Application or Innovation in Engineering of Management 2, no. 4 (2013).
[7] Jadoun, Vinay K., Nikhil Gupta, K. R. Niazi, Anil Swarnkar, and R. C. Bansal. "Multi-area Economic Dispatch Using Improved Particle Swarm Optimization." Energy Procedia 75 (2015): 1087-1092.
[8] De Craemer, Klaas, Stijn Vandael, Bert Claessens, and Geert Deconinck. "An event-driven dual coordination mechanism for demand side management of PHEVs." IEEE Transactions on Smart Grid 5, no. 2 (2014): 751-760.
[9] Cai, Jiejin, Qiong Li, Lixiang Li, Haipeng Peng, and Yixian Yang. "A hybrid CPSO–SQP method for economic dispatch considering the valve-point effects." Energy Conversion and Management 53, no. 1 (2012): 175-181.

