A SEMIDEFINITE PROGRAMMING APPROACH FOR SOLVING MULTI-OBJECTIVE ECONOMIC DISPATCH PROBLEMS INCORPORATING WIND POWER UNITS

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ABSRACT

In practical applications of economic dispatch to power systems, stochastic variability is a vital issue as it is a means of ensuring optimal operation of power systems. Therefore, stochastic models are applicable in power dispatch problems as certain inaccurate and uncertain factors which naturally surface in system operations are readily addressed. A semidefinite programming (SDP) optimization approach for solving reformulated extended stochastic multi-objective model for economic dispatch (ED) that incorporates combined heat and power (CHP) units and wind power is presented in this research. This was achieved by converting the stochastic multi-objective model into their deterministic equivalents through their expectation, with the assumption that involved random variables are normally distributed. The multi-objective problem was recast in matrix form as a SDP relaxation problem and subsequently solved with a MATLAB programming suite. The system inequality and equality constraints uncertainty were entered into YALMIP, which is a linear matrix inequality parser. Simulations were performed on modified IEEE 6, 15 and 20 units' networks with 2 CHP units and 20 wind parks for each of the networks. A comparative study was also conducted to demonstrate the effectiveness of the proposed method whereby the results of problem reformulations including stochastic and deterministic models of power dispatch were investigated and then compared with the results of the existing techniques reported in the literature. However, in the generation of the Pareto-front solutions, ideal minimum points were used in the determination of the maximum spread out of the Pareto solutions by the algorithm. This involves the use of standard weighted sum method in generating the Pareto-optimal solution between two objective functions. Different values of the control weight selection parameter k_1 were used in the generation of Pareto points. Fifty one (51) runs were carried out for each parameter value to explore the effect of changes in control weight selection k_1 and compared different cases. In the generation of the Pareto-optimal solution, different values of control weight selection k_1= 1, 5, and 10 were examined.

At value of control weight selection k_1=1, more points are missed from the lower point while a gradual progression in the spread out of the Pareto points were observed at the lower extreme point as the control weight selection k_1 is further increased from 1. Simulation results have differentiated the costs of running power systems obtained by the system that includes both the cogeneration units and wind power penetration for various wind power prices while satisfying all the systems' constraints. The optimization results are close within the order of magnitude 3.5% reductions in the case of modified IEEE six units, while SDP achieved lowest values of the optimized objective functions and Pareto set was formed faster in a single run compared to modified particle swarm optimization (MOPSO), genetic algorithm (GA) and weighted aggregated (WA) methods. The total costs obtained for running the power system that incorporates both the CHP units and the wind power units in the case of modified IEEE six units are 1218.5 \$/hr, 1242.5 \$/hr, 1266.2 \$/hr taking the wind power price as 120\$/pu, 150\$/pu, 180\$/pu respectively are lower compared to the total running cost obtained for the system that incorporates CHP units only which gives 1275.3 \$/hr.

In conclusion, an optimal selection of control weight k_1 parameter which gives a better convergence property and comparatively good extent of the algorithm was empirically determined. The proposed SDP technique has been employed in solving a stochastic power dispatch problem by minimizing the expectation of the multi-objective functions using the Gaussian probability distribution function and also Weibull probability distribution function is used in the characterization of a stochastic wind data, in an attempt to create suitable criteria to a better utilization of the wind power.

Keyword: semidefinite programming, MATLAB, economic dispatch, YALMIP, MOPSO)

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HAPTER ONE

INTRODUCTION

1.1 Background to the Study

Economic dispatch (ED) is defined as the cost minimization of power production in electrical power system analysis (Hetzer *et al.*, 2008). More specifically, in solving the ED problem, one seeks to find the optimal allocation of the electrical power output from various available generators. In a competitive energy market, the economic viability of power systems, demands an optimum combination of all the parameters that affect power generation and its transmission (Jubril *et al.*, 2014). One approach to achieving optimum power dispatch is to consider the transmission losses as one of the objectives in the economic dispatch problem. This becomes a multi-objective optimization problem in which the running cost of the power systems and the transmission losses are minimized simultaneously.

It has become a global issue about the challenge of providing adequate and sufficient amount of power energy for the populace. The depth of concern may vary from developed to underdeveloped nations but the exercise of providing required energy is a major challenge throughout the world. Therefore, there is a need for concerted efforts to be deployed in seeking ways of adequately meeting the growing energy demand of the global population. The finite nature of the conventional sources of energy has made the sources unsustainable.

Moreover, lack of adequate energy to drive an economy is a major source of social and economic poverty.

Prior to the widespread use of alternative sources of energy, the ED problem involved only conventional thermal energy power generators, which use depletable resources such as fossil fuels. It has become apparent that there is a need for alternatives to thermal energy power generation, and one of the sources that is now enjoying more widespread use, particularly outside Nigeria, is the wind energy, consequently, renewable energy resources such as wind power have shown a great potential for power generation in reducing rate of fuel consumption as well as minimization of gas emissions (Lingfeng and Chanan, 2008). One of the major benefits of wind energy is that, after the initial land and capital costs, there is essentially no cost involved in the production of power from wind energy conversion systems (WECS). In addition, the effects of WECS are generally considered to be environmentally friendlier than the effects of thermal energy sources.

In recent years, due to increasing concern about the effects of power generation on the environment, the traditional power system dispatch problems have to include the minimization of gas emissions, such as CO_2, SO_2 and NO_x (Piperagkas *et al.*, 2011). In environmental dispatch, the emissions reduction is introduced either as constrained dispatch, or by introducing a new objective function in multi-objective formulation of problems and using trade-offs with the cost objective functions. Environmental concerns normally lead to priority dispatch in the power system industry due to the significant amount of emission pollutants gases obtained from the fossil based power generation and thus increase of renewable sources penetration into traditional electric power networks in reducing the rate of emission and pollutant gases introduced by the conventional power systems, regardless of their higher cost (Piperagkas *et al.*, 2011).