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Reserve constrained multi-area economic dispatch employing differential evolution with time-varying mutation

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ABSTRACT

For a power pool that involves several generation areas interconnected by tie-lines, the objective of economic dispatch (ED) is to determine the most economical generation dispatch strategy that could supply the area load demands without violating the tie-line capacity constraints. The objective of multi-area economic dispatch (MAED) is to determine the generation levels and the interchange power between areas which would minimize total fuel cost while satisfying power balance constraint, upper/lower generation limits, ramp rate limits, transmission constraints and other practical constraints. In reserve constrained MAED (RCMAED) problem inter-area reserve sharing can help in reducing the operational cost while ensuring that spinning reserve requirements in each area are satisfied. The tie-line limits too play a pivotal role in optimizing the cost of operation. The cost curves of modern generating units are discontinuous and non-convex which necessitates the use of powerful heuristic search based methods that are capable of locating global solutions effectively, with ease. This paper explores and compares the performance of various differential evolution (DE) strategies enhanced with time-varying mutation to solve the reserve constrained MAED (RCMAED) problem.

The performance is tested on (i) two-area, four generating unit system, (ii) four area, 16-unit system and (iii) two-area, 40-unit system. The results are found to be superior compared to some recently published results.

1. Introduction

In the power sector, economic dispatch (ED) is used to allocate power demand among available generators in the most economical manner, while satisfying all the physical and operational constraints. The cost of power generation, particularly in fossil fuel plants, is very high and economic dispatch helps in saving a significant amount of revenue [1]. Although, ED of a single area has been studied extensively, multi-area economic dispatch has received limited attention. Many utilities and power pools have limits on power flow between different areas/regions over tie-lines. Each area/region has its own pattern of load variation and generation characteristics. They also have separate spinning reserve constraints. The objective of RCMAED is to determine the generation levels and the interchange power between areas which would minimize fuel costs in all areas while satisfying area-wise power balance, upper/lower generation limits, area-wise spinning reserve requirements and transmission constraints. Power utilities try to achieve high operating efficiency to produce cheap electricity. In the present competitive power market the operating cost of a power pool can be reduced if the areas with more economic units generate larger power than their load and export the surplus power to other areas having more expensive units. The benefits thus gained will depend on several factors like the characteristics of a pool, the policies adopted by utilities, types of interconnections, tie-line limits, spinning reserve constraints and load distribution in different areas. The present paper focuses on the importance of transmission capacity constraints and area reserve constraints in the optimal scheduling of generating units in electric power systems.

Multi-area generation scheduling with import/export constraints between areas was presented in Ref. [2]. Transmission constraints with linear losses were considered in Ref. [3] while solving the multi-area economic dispatch problem by spatial dynamic programming. Desell et al. [4] proposed an application of linear programming to transmission constrained production cost analysis. Farmer et al. [5] presented a probabilistic approach for transmission constrained multi-area power systems. MAED was solved with area control error in Ref. [6]. A heuristic multi-area unit commitment with ED was proposed in Ref. [7]. Wang and Shahidehpour [8] proposed a decomposition approach using expert systems for nonlinear multi-area generation scheduling. The Newton–Rapshon's method was applied to solve multi-area economic dispatch problem [9]. An incremental network flow programming algorithm was

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