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Multi-area generation scheduling algorithm with regionally distributed optimal power flow using alternating direction method

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ABSTRACT

This paper calls attention to the core issue as to the multi-area generation scheduling algorithm in interconnected electric power systems. This algorithm consists in deciding upon on/off states of generating units and their power outputs to meet the demands of customers under the consideration of operational technical constraints and transmission networks while keeping the generation cost to a minimum. In treating the mixed integer nonlinear programming (MINLP) problem, the generalized Benders decomposition (GBD) is applied to simply decouple a primal problem into a unit commitment (UC) master problem and inter-temporal optimal power flow (OPF) sub-problems. Most prominent in this work is that the alternating direction method (ADM) is introduced to accomplish the regional decomposition that allows efficient distributed solutions of OPF. Especially, the proposed distributed scheme whose effectiveness is clearly illustrated on a numerical example can find the most economic dispatch schedule incorporated with power transactions on a short-term basis where utilities are less inclined to pool knowledge about their systems or to telemeter measured system and cost data to the common system operator and nevertheless the gains from trade such as economy interchange are vital as well.

1. Introduction

Since there is a strong possibility that utilities' profits should be vastly changeable due to the complicated interactions between generation and transmission system variables in interconnected power systems, the generation scheduling procedure will have to provide more accurate information on these interactions [1]. For the generation scheduling in interconnected power systems, it seems reasonable to make use of an integrated model of unit commitment (UC) and optimal power flow (OPF). This integrated model can definitely yield the optimal hourly operating states by taking into account the transmission system configuration which is fully reproduced by the OPF problem. Therefore, the generation scheduling problem in interconnected power systems is mathematically formulated as a large-scale mixed integer nonlinear programming (MINLP) problem which contains the continuous variables representing the power outputs and various system states at a specified instant as well as the binary variables indicating the start-up/shut-down (on/off) status of each generating unit in the course of dispatch. Unfortunately, the batch processing of the MINLP problem is highly vulnerable to divergent solutions as well as computational inefficiency. The most typical strategy for solving this MINLP problem is to use the generalized Benders decomposition (GBD) technique [2,3], which divides an original MINLP problem into a master problem consisting of binary variables and sub-problems of continuous variables by eliminating coupling constraints concerned with both binary and continuous variables. The goal is straightforward: it can enhance the computational efficiency by reducing the dimension of a MINLP problem.

This paper is intended to explore the generation scheduling algorithm based on GBD. The proposed scheme also includes the distributed OPF using regional decomposition technique which is really implemented from the alternating direction method (ADM) [4,5]. Since the alternating direction method suitable for the competitive multi-utility environment through its power transactions admits no modifications to the augmented Lagrangian function in the inter-temporal OPF separated by geographical boundaries, it is remarkably faster than any other distributed methodologies using the approximations to the augmented Lagrangian function in terms of computation speed [6].

2. Application of generalized Benders decomposition

As described in [7–10], the generation scheduling problem is mathematically defined as a large-scale MINLP problem which

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