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Fuzzy logic-based direct load control of air conditioning loads considering nodal reliability characteristics in restructured power systems

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ABSTRACT

A fuzzy logic-based direct load control (DLC) scheme of large air conditioning loads (ACL), which considers the reliability characteristics of nodes where the ACL are connected, is proposed for restructured power systems. Transmission system reliability is integrated into the determination procedure of the DLC scheme of ACL using nodal reliability indices. Fuzzy dynamic programming (FDP) is utilized to determine the optimal DLC scheme of ACL which can achieve a good tradeoff among peak load shaving, system operating cost reduction and system reliability improvement. The IEEE reliability test system (RTS) is used to illustrate the proposed technique.

1. Introduction

Power industries have been undergoing restructuring and deregulating in many countries over the world since the 1980s. The previous monopolistic regulated public utilities are being replaced by restructured power systems. The expected benefits of power system restructuring are cheaper electricity through competition and innovation, and improved generation and planning efficiency and economies. However, the restructuring of power systems has also been accompanied by some problems, including capacity shortage, transmission congestion, wholesale price volatility, and reduced system reliability. Load management has re-emerged as an important element of the fine-tuning of restructured power systems [1].

The most common load management program is end-use equipment control known as direct load control (DLC). The purpose of DLC is to shape the load curve by cycling customers' large current drawing appliances. A number of DLC schemes have been developed to reach both peak load shaving and operating cost saving.

An effective optimization method for scheduling load management was developed in Ref. [2] based on an analytical model of the load under control which allowed any length for the control periods and any cycle rates. The impact of dynamic dispatch of DLC on generation system reliability performance was studied in [3] using the Monte Carlo simulation methodology. Duty cycle model, the demand-side design and analysis workstation were described in [4]. The dispatch of DLC was first combined with system unit commitment to achieve the minimization of system production cost using dynamic programming [5]. The dynamic DLC model is coupled with a fast piece-wise linear incremental cost economic dispatch scheme to study the production cost implications of the dynamic DLC model [6]. The multi-pass dynamic programming method is utilized to dispatch air conditioning direct load control to obtain both peak load reduction and production cost saving [7]. An effective optimization method for scheduling DLC in the commercial buildings was presented to minimize the load reduction so as to lessen the effects of customers' discomfort and to maintain the Taiwan Power Company's total income [8]. A fuzzy load model for the direct load control of appliances was first developed and a methodology for optimizing both customer satisfaction and utility unit commitment savings was presented based on this fuzzy DLC load model [9]. Based on the cost/market price function, a profit-based DLC strategy is developed to maximize the profit of the utilities [10]. The scheduling of the DLC and the unit commitment was integrated into the fuzzy dynamic programming (FDP) methodology to reduce the system peak load as well as the total operating cost [11,12]. Physically based electrical models of heating, ventilation and air conditioning residential loads were developed to evaluate all direct load control actions [13]. An efficient approach was proposed in [14] to cluster the DLC curves through a structure of self-organizing maps to evaluate the performance of direct

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