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A Two Stage Increase-Decrease Algorithm To Optimize Distributed Generation In a Virtual Power Plant

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Abstract

A two stage algorithm is proposed in this paper to optimize cost of generation with application to a virtual power plant. First stage of the algorithm presents a methodology to draw a hierarchy for the choice of distributed generators based on the cost of generation. Second stage of the algorithm optimizes generation to minimize cost. An Additive Increase and Multiplicative Decrease algorithm, which is already used for optimization in microgrids is improved further and is presented as Modified Additive Increase Multiplicative Decrease algorithm and is applied in the second stage of the algorithm for optimization. The Modified Additive Increase Multiplicative Decrease algorithm is validated by implementing to schedule generation of distributed generators with intermittent power availability in a Virtual Power Plant in grid connected mode to optimize the cost of generation. The Modified AIMD algorithm is proved to be much more effective than the original AIMD algorithm.

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*Keywords:*Optimizaaation;Generation schedule;Cost of generation;Increase-Decrease algorithm;Virtual power plant

1. Introduction

Fast dwindling conventional energy sources worldwide is pushing forward the need for harnessing energy from the renewable energy sources (RESs) and distributed generators (DG), paving path for decentralization of generation. The quest to reduce distribution losses in such decentralized generation systems developed the concept

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of small scale generation in the proximity of loads. The operation and control of such distributed systems comprising of small generation units along with local loads fed from them have led to the formation of Virtual Power Plants (VPP). A VPP is a cluster of DG units, loads both controllable and uncontrollable, storage systems and communication, aggregated to mimic a "single virtual generating unit" that can act as a conventional one and capable of being visible or manageable on an individual basis [1]. Autonomous or grid connected mode of operation of a VPP with intermittent generation and demand is quite a demanding task as balancing the generation and demand is essential for the stability of the system. The words VPP and microgrid are used interchangeably in the sections to follow.

The policy shift of governments in many countries towards slowly withdrawing themselves from playing a direct role in energy sector and inviting private parties into active role, augmented by technological advances in operation and control of microgrids for profit maximization are proving attractive for smaller investors. In addition, harnessing energy form RESs is gaining importance due to many reasons like improved efficiencies of PV units, reduced costs of generators, substantial increase in capacities of wind turbines from kW to MW, improved energy storage facilities and attractive subsidies by the governments [2]. These developments enabled even smaller investors to venture in energy sector in the fields of generation and distribution on smaller scales, particularly in microgrids, enforcing a strict competition among them. Offering generation and distribution at lower prices is the key to success in business and is the need of the hour, which requires reduced costs of generation. Of the many methods to reduce the cost of generation, optimum generation scheduling has a major role. Thus the role of optimization of generation is vital in energy market and is prompting a lot of research. Optimization in a VPP is more challenging in view of uncertainty of loads and intermittent power availability from RESs. Deviations between forecasted and real time power availability from solar and wind generators add to the complexity.

Many optimization techniques based on linear programming, fuzzy logic and heuristic search methods etc are developed and are being developed for application in microgrids to different optimization problems. A few applications of optimization techniques in a microgrid operation and control are optimal power flow, load shedding, demand side management, emission reduction, etc. [3]. A heuristic algorithm is used in [4] to optimize the fuel consumption and cost of emission in adjusting generation to demand on-line in a microgrid when connected to grid. A two stage stochastic based algorithm is used in [5] to optimize the size of energy storage facility in different forms of hydrogen, thermal and battery type to balance the generation and demand over 24 hours. A Genetic Algorithm based technique is applied to optimize the energy and power delivery/charging capacity of a battery storage facility in a microgrid to reduce the cost of operation [6]. A modified Bacterial Foraging Algorithm based energy management system is proposed in [7] to optimize the cost of operation of a microgrid having uncertain RESs and energy storage facilities. A Fuzzy logic based energy management system is formulated in [8] to control the charging/discharging of a energy storage system under day ahead generation scheduling in a microgrid with intermittent energy sources. All the methods proposed [3-8] are heuristic search based methods requiring complex computational processes

The present paper proposes a Linear Program based two stage algorithm, to schedule the generation task in a microgrid for optimization of a utility function of interest. The DGs considered are given a priority index based on the function to be optimized in the first stage. A Modified Additive Increase Multiplicative Decrease (MAIMD) algorithm is used in the second stage for generation scheduling among the available DGs.

The original Additive Increase Multiplicative Decrease (AIMD) algorithm, which is a simple linear increase-decrease algorithm, is well adopted and tested for congestion avoidance in communication networks [9, 10]. As a communication network resembles a distribution network in many operational principles, the AIMD algorithm, which is proven effective in communication network, is adopted for solving the problem of optimum generation scheduling in a microgrid environment with intermittent renewable energy sources [11]. This paper identifies a few drawbacks in the AIMD algorithm as applied to microgrids and proposes a few improvements to it to enhance its performance.

2.1 Problem statement

It is assumed that the microgrid considered operates in grid connected mode and always supplies the demand, by drawing grid power if required i.e., at any given time *t* the demand is supplied totally.

$$\sum_{i=1}^{x} S_i(t) = d(t) \quad (1)$$

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