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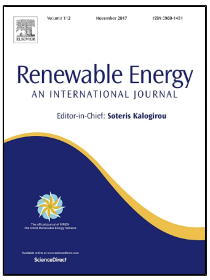

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Optimal Management of Renewable Energy Sources by Virtual Power Plant

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Abstract- In recent years, due to lack of sufficient quantity of fossil fuel, the need of Renewable Energy Sources (RESs) has become an important matter. In addition to the shortage of fossil fuel, global warming is another concern for many countries and companies. These issues have caused a large number of RESs to be added into modern distribution systems. Nevertheless, the high penetration of RESs beside the intermittent nature of some resources such as Wind Turbines (WT) and Photovoltaic (PV) cause the variable generation and uncertainty in power system. Under this condition, an idea to solve problems due to the variable outputs of these resources is to aggregate them together. A collection of Distributed Generators (DGs), Energy Storage Systems (ESSs) and controllable loads that are aggregated and then are managed by an Energy Management System (EMS) which is called Virtual Power Plant (VPP). The objective of the VPP in this paper is to minimize the total operating cost, considering energy loss cost in a 24h time interval. To solve the problem, Imperialist Competitive Algorithm (ICA), a meta-heuristic optimization algorithm is proposed to determine optimal energy management of a VPP with RESs, Battery Energy Storage (BSS) and load control in a case study.

Keywords: Virtual power plant, Renewable energy sources, Optimal energy management, Operating cost, Imperialist competitive algorithm.

1. Introduction

In recent years, major advances in the technology of DGs such as solar, wind, hydro and etc. have led them to be in the center of consideration more than before, because of need for lower cost, less environmental pollution, more flexibility, higher reliability, and better power quality. On the other hand, due to lack of fossil fuel that leads to increase in energy prices and the gradual rise in the global temperature, many industrialized countries have been compelled to alter the focus of their energy policy towards different kinds of energy supplies and deployment of RESs. Since RESs cannot yet supply levels of return on investment similarly to fossil fuels [1], various encouraging plans for RES have been initiated. These contain discount in tariff plan, discount in premium plan and the quota plan. Due to this fact, wind power and photovoltaic are considered more than other sources. In the year 2015, the worldwide wind power capacity reached 433 GW with an annual growth rate of 15% [2], while the installed solar photovoltaic (PV) in the same year reached a cumulative capacity of 233 GW, with an annual growth rate over 30% [3]. For a large number of RESs, it is troublesome to control their output, mainly when the output of the generators such as wind power and photovoltaic fluctuate quickly and are intermittent. A solution to this problem is to aggregate the RESs, so that they emerge generally like a conventional generator with relatively stable output. One of the aggregation approaches is to create a VPP.

VPP is a combination of renewable sources, Energy Storage System (ESS), small conventional power plants and interruptible loads that can supply market actions as a single power plant [4]. However, Hybrid systems in different locations of any country could be controlled by a VPP. In