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Real Time Active Power Ancillary Service using DC Community Grid with Electric vehicles and Demand Response

Nikhil Sasidharan[a*], Nimal Madhu M[a], Jai govind Singh[a], Weerakorn Ongsakul[a]

[a]*Asian Institute of Technology, Klong luang, Pathumthani,12120, Thailand*

Abstract

The introduction of restructuring the electric power system has led to the scenario, making the customer a significant market/player. This has also made the maintenance of reliability and stability in the power system a financially crucial task. .Self-sustainable community grid is a realization of reliable and stable system at a base level as individual households with solar photovoltaics or other renewable system can sustain itself even if the power grid fails. In this paper, active power imbalance ancillary services provision for the grid using a DC community grid, stabilizing the electric power system is proposed. A community of 100 houses with individual solar installation along with a centralized DC-wind turbine and EV charging station compose the grid that is considered. Different cases of energy imbalance and corresponding system behavior are simulated in MATLAB environment and obtained results indicate that the proposed system ensures a better reliability for the power grid by using the ancillary services.

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Keywords: Ancillary services; DC community Grid; EV Charging; Three phase Inverter

1. Introduction

The integration of renewable energy is increased worldwide in last decades surpassing a share of 25% of world power generation capacity [1]. They are no longer considered only as alternative sources of energy but also as instruments to reduce negative health and environmental impacts associated with fossil fuels and greenhouse gases, improving educational prospects, creating new job opportunities, reducing poverty and enhancing energy security. Due to the restructuring of electrical power system, the power sector becomes more competitive and market oriented.

*Corresponding author. Tel.: 66851246306.
E-mail address: st115365@ait.asia

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Customers become a significant commodity by having a choice to select utilities according to their performance such as power quality, services and reliability. There comes the ancillary services to ensure quality and reliability of the supply system. But owning an ancillary services for any entity is very difficult, expensive and needed only for a very short period. FERC [2] categorized mainly six services that can be considered as ancillary services. They are mainly scheduling and dispatch, reactive power and voltage control, loss compensation, load following, system protection and energy imbalance.

Nomenclature

DC	Direct Current
EV	Electrical vehicle
$P_s(t)$	Maximum power produced by the solar panel at time *t*
$I_s(t)$	Solar radiation at time *t* (kW/m^2)
η_s	Solar panel energy conversion efficiency (%)
A	Area of the solar panel (m^2)
T_o	The nominal temperature in degree Celsius (^{o}C)
P_w^k	Electric output power from wind turbine at kth hour (kW)
P_r	Rated power of wind turbine (kW)
v	Wind velocity at kth hour (m\sec)
Vin	Cut in velocity for the wind turbine
$Vout$	Cut off velocity for the wind turbine

The different characteristic of ancillary services, type, operational difficulties and international different practices of using ancillary services are discussed in literatures [3-5]. Since ancillary services are of short term operation, different literatures investigates the role of renewable energy in the ancillary services market like solar, wind etc [6-9]. Due to climate conditions, these types of renewable sources will fail to meet the agreed services. The installations of these renewable sources will cause also huge financial burden for utilities. To tackle this problem, unconventional sources of energy like batteries, fuel cells and electric vehicles are used[10-12]. But life of these type of sources is a big concern and maintenance should be frequently done which requires a lot of man hours. A pumped storage ancillary services [13] also has come in literature in simulation model of Taiwan power system.

The community grid is a state of art term proposed by NREL to define a community whose all loads are met with renewable energy sources. If a system has renewable energy sources like solar, wind and electric vehicles, through proper coordination control, it can be transformed into community grid. Mariam L et.al [14] proposes a new terminology community grid which consists of a number of houses with wind based micro generation system. This paper defines a method to develop sustainable electric system, with the proposed community micro grid, without changing any rules and regulations. Zhu J et.al [15] proposed a community grid with energy management within grid. The supply and demand should match within the system. The load curtailment is also one's choice by giving preferences to particular load. The role of battery management system in a community grid is explained in literature [16].

Patterson B [17] has proposed the DC micro grid, its advantages and challenges of making a complete DC home micro grid. Moreno-Munoz A et al [18] proposes a distributed DC UPS for the solution of Power quality problems and energy efficiency problems. This paper illustrated that the efficiency of DC UPS system is 5 to 15 % more than that of an AC UPS system in an IT enabled building.VossosV et al [19] has analyzed the efficiency of residential building when it is converted into DC house than the conventional AC distribution house. They analyzed the data of 14 states in USA which used 380 V and 24 V voltages for DC distribution at home. There is a 33 % saving when the AC equipment are replaced with DC equipment.