Electric Power Systems Research 80 (2010) 1267–1276

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Allocation of reactive power support, active loss balancing and demand interruption ancillary services in MicroGrids

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ARTICLE INFO

Article history:
Received 11 December 2009
Accepted 29 April 2010
Available online 31 May 2010

Keywords:
MicroGrids
Electricity markets
Ancillary services
Reactive power/voltage control
Active loss balancing
Load curtailment

ABSTRACT

MicroGrids represent a new paradigm for the operation of distribution systems and there are several advantages as well as challenges regarding their development. One of the advantages is related with the participation of MicroGrid agents in electricity markets and in the provision of ancillary services. This paper describes two optimization models to allocate three ancillary services among MicroGrid agents – reactive power/voltage control, active loss balancing and demand interruption. These models assume that MicroGrid agents participate in the day-ahead market sending their bids to the MicroGrid Central Controller, MGCC, that acts as an interface with the Market Operator. Once the Market Operator returns the economic dispatch of the MicroGrid agents, the MGCC checks its technical feasibility (namely voltage magnitude and branch flow limits) and activates an adjustment market to change the initial schedule and to allocate these three ancillary services. One of the models has crisp nature considering that voltage and branch flow limits are rigid while the second one admits that voltage and branch flow limits are modeled in a soft way using Fuzzy Set concepts. Finally, the paper illustrates the application of these models with a Case Study using a 55 node MV/LV network.

1. Introduction

MicroGrids emerged in recent years as a very promising concept to allow wide spreading small generation sources namely in low voltage networks together with the incorporation of control devices associated both to small generation sources and low voltage loads [1–4]. This means that a MicroGrid can be seen as an association of a low voltage network with a number of components, as illustrated in Fig. 1. These components include loads, small scale generation devices (as small turbines, fuel cells, PV panels and wind turbines), storage devices (as flywheels, capacitors and batteries) and control devices. These control devices are associated with the micro-sources – MC controllers, with the controllable loads – LC controllers as well as with the MicroGrid Central Controller – MGCC, located in the beginning of the LV feeder [5]. According to this architecture, the MGCC acts as an interface both with the upstream Distribution Management System, DMS, of the Distribution Network Operator, DNO, and with the downstream Micro-source and Load Controllers – MC and LC.

As mentioned above, MicroGrids are contributing to change the still dominant paradigms associated with distribution network operation and with distributed generation. Distribution networks, namely LV networks, will no longer be passive ones but will incorporate a number of small sources getting generation closer to the demand and so contributing to turn the demand more aware of generation issues. On the other hand, the incorporation of control devices allows these small sources to provide a number of services upon request of the MGCC or of the upstream DMS system. This means that networks will have a larger amount of resources, not only in terms of providing energy but also in terms of different types of ancillary services. Regarding the demand, the incorporation of control devices can induce its participation in electricity markets, contributing to create more efficient mechanisms to profit from some demand elasticity as well as to enlarge the use of interruptible loads, provided that they receive an adequate remuneration. This means that the association of an LV network with small generation sources, loads and control devices can prove to be very powerful and effective in modernizing distribution networks and in integrating small scale distributed generation in a more natural way in power systems. Ultimately, MicroGrids can contribute to pass from the connection of large amounts of volatile DG paid in several countries according to subsidized feed-in tariffs to a more reasonable and natural way of integration while creating the conditions for their participation in markets and contributing to provide several services.

According to several authors [5,6], the development of MicroGrids brings several advantages to power systems namely the ones related with operation and investment issues, environmental

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0378-7796/$ – see front matter
doi:10.1016/j.epsr.2010.04.013