Jordan microgrid operation

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Microgrid Real-Time Operation, Reactive Power Control, Load Shedding, OPAL-RT, Matlab

MG systems have spurred increasing interest in the electric power industry [1] ? [2] ? [3]. MG is a smart small-scale electric power system that consists of a mix of generating units, controllable loads, storage units, low-voltage transmission lines, transformers and a point of common coupling (PCC) to the main grid. PCC represents the main circuit breaker that is used to switch between two operation modes: islanded and grid connected. The successful implementation of these modes in MG has contributed to its widespread deployment, worldwide [4].

In this paper, OPAL-RT real-time analysis of MG is presented. The objective is to optimally allocate solar power to meet power demand in realtime. In an islanded mode, momentary failures in power generation are introduced and recovery of critical loads is simulated in real-time based on a priority scheme. The impact of power balance while varying the amounts of power generation and demand is examined. In the simulation of MG mode transition, reactive power coordination control is used in order to minimize power loss while load shedding is used in order to maintain generation-load balance. GJU microgrid system is used for illustration. The results show that reactive power coordination control not only stabilizes the MG operation in real-time but also reduces power losses.

The remaining sections of the paper are organized as follow: Section 2 gives details of MG system. Section 3 presents GJU MG for real-time simulation. Reactive power control and load shedding mechanisms are presented in Section 4. Section 5 presents simulation results of GJU case study. Finally, the paper is concluded in Section 6.

As shown in Figure 1, MG generally consists of controllable loads and renewable generation resources (e.g. wind and solar) that are complemented by on-site diesel generators and/or storage batteries. MG is managed and operated in real-time either in a grid-connected mode or an islanded mode mainly controlled

through PCC. In the following subsections, formal models of MG components are introduced as a basis of formulation.

Controllable loads consist of load profiles that are generally time varying and are mainly driven by the type of customer behavior. Methods such as linear regression, time series, autoregressive, exponential smoothing, curve fitting, permutation and machine learning, are used for load forecasting [15]. Using curve fitting and given the dominant load profile at MG site under study, a piecewise function in three-time intervals is developed and gives the forecasted total power demand $P_D(t)$ at time t as follows:

where A and B represent constant values that can be calculated using curve fitting of historical data and o and f denote angular frequency and phase shift of a sinusoidal function that best fits the load profile during 24 hours of a given day, respectively.

Renewable generation consists of solar and wind. Since the output power of solar and wind is intermittent and non-controllable, it is necessary to have storage and/or controllable generation that can replace power shortage and maintain constant local power.

Solar Power: Solar power P p v is produced by large array of photovoltaic cells, formally defined as, [16]:

where G, T, A, i, and a denote solar radiation, ambient temperature, area of panels, system efficiency, and power degradation, respectively.

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