Review on Integration of Wind and Solar DC Microgrid Using Matlab

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Abstract: ***To support the integration of wind and solar power within microgrids operational controls are designed. To support the quantification of the operational reserve for day-ahead and real-time scheduling an aggregated model of renewable wind and solar power generation forecast is proposed. Then, a droop control for power electronic converters connected to battery storage is developed and tested. Compared with the existing droop controls, it is distinguished in that the droop curves are set as a function of the storage state-of-charge (SOC) and can become asymmetric. The adaptation of the slopes ensures that the power output supports the terminal voltage while at the same keeping the SOC within a target range of desired operational reserve. This is shown to maintain the equilibrium of the microgrid's real-time supply and demand. The controls are implemented for the special case of a dc microgrid that is vertically integrated within a high-rise host building of an urban area. Previously untapped wind and solar power are harvested on the roof and sides of a tower, there by supporting delivery to electric vehicles on the ground. Without creating a large footprint the microgrid vertically integrates with the host building.***

Keywords: Distributed energy resources, droop control, electric vehicle (EV), emission constraint.

1. Introduction

About 44.8 GW of new wind energy conversion systems were installed worldwide in the year 2012 [1]. The trend has been toward increasingly larger turbine sizes, culminating in the installation of off-shore wind parks that are located far from the load centers [2]. This can lead to rather large distances between generation and load in the electricity sector. The transportation sector reveals an even larger disconnect between the locations of fuel production and consumption. The energy system proposed in this paper seeks to address both issues related to electricity and transportation sectors. One potential solution is a microgrid that can be vertically integrated with a high-rise building as frequently encountered in urban areas. The harvesting of renewable wind and solar energy occurs at the top of the building. The rooftop generation connects to the ground level via a microgrid where electric vehicle (EV) charging stations are supplied and a battery supports maintaining the balance of supply and demand. The potential value of an urban integration within buildings as considered here comes from the usage of rooftop energy resources, the storage of the latter for offering EV fast charging at the ground level, the contribution to emission-free EV transportation in urban areas, the co-location and integration of generation and load in urban areas, and the grid-friendly integration of the microgrid with the rest of the power system main grid. The combination of wind and solar energy resources on a rooftop was also investigated in [3]. It was verified that the combination of wind and solar energy leads to reduced local storage requirements [4]. The combination of diverse but complementary storage technologies in turn can form a multilevel energy storage, where a supercapacitor or flywheel provides cache control to compensate for fast power fluctuations and to smoothen the transients encountered by a battery with higher energy capacity [5], [6]. Microgrids or hybrid energy systems have been shown to be an effective structure for local interconnection of distributed renewable generation, loads and storage [7]–[12].

Recent research has considered the optimization of the operation on one hand and the usage of dc to link the resources on the other. The dc link voltage was shown to be maintained by a droop control that relates the dc link voltage to the power output of controllable resources. In this paper, it is proposed to set the droop as a function of the expected state of charge (SOC) of the battery according to its operational optimization set point versus the actual real time SOC. The proposed operational optimization is further distinguished in that it quantifies the uncertainty associated with renewable generation forecast, emission constraints, and EV fast charging.

Following this introduction, an outline of the principle of a dc microgrid is given in outline of dc microgrid. In operational optimization of microgrid for Renewable Energy Integration, a method is developed for quantifying the aggregated wind and solar power forecast uncertainty, the resulting required SOC of the battery, and the operational optimization. The optimization-guided droop control is deal with in Proposed technique for BESS.

2. Methodology

In this deals with the description of the different components such as DC Microgrid, Wind power and Solar power system.

2.1 Outline of DC Microgrid

A schematic of the dc microgrid with the conventions employed for power is given in Fig. 1. The dc bus connects wind energy conversion system (WECS), PV panels, multilevel energy storage comprising battery energy storage system (BESS) and supercapacitor, EV smart charging points, EV fast charging station, and grid interface. The WECS is connected to the dc bus via an ac–dc converter. PV panels are connected to the dc bus via a dc–dc converter. The BESS can be realized through flow battery technology connected to the dc bus via a dc–dc converter. The supercapacitor has much less energy capacity than the BESS. Rather, it is aimed at compensating for fast fluctuations of power and so provides cache control as detailed in [13].With the help of multilevel energy storage, the intermittent and volatile renewable power outputs can be managed, and a deterministic controlled power to the main grid is obtained by optimization. Providing uninterruptible power supply (UPS) service to loads when needed is a core duty of the urban microgrid. EV fast charging introduces a stochastic load to the microgrid. The multilevel energy storage mitigates potential impacts on the main grid.

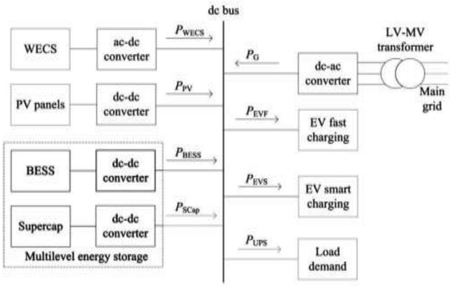

Figure1: Outline diagram of the dc microgrid

In building integration, a vertical axis wind turbine may be installed on the rooftop as shown in Fig. 2. PV panels can be co-located on the rooftop and the facade of the building. Such or similar configurations benefit from a local availability of abundant wind and solar energy. The fast charging station is realized for public access at the ground level. It is connected close to the LV–MV transformer to reduce losses and voltage drop. EVs parked in the building are offered smart charging within user-defined constraints.

Figure 2: Wind and PV-based power generation for the vertically integrated Microgrid

2.2 Operational Optimization Of Microgrid For Renewable Energy Integration

The algorithm for optimized scheduling of the microgrid is depicted in Fig. 3. In the first stage, wind and solar power generation are forecast. The uncertainty of the wind and solar power is presented by a three-state model. An example of such a forecast is State 1 represents a power forecast lower than the average power forecast. This state is shown by the power forecast of _P1 with the forecast probability of _pr1 assigned to it. The average power forecast and the probability of forecast assigned to it give state 2. State 3 represents a power forecast higher than the average power forecast. Then, wind and solar power forecasts are aggregated to produce the total renewable power forecast model. This aggregation method is formulated in Aggregated Model of Wind and Solar Power Forecast. The aggregated power generation data are used to assign hourly positive and negative energy reserves to the BESS for the microgrid operation. The positive energy reserve of the BESS gives the energy stored that can be readily injected into the dc bus on demand. The negative energy reserve gives the part of the BESS to remain uncharged to capture excess power on demand. Energy reserve assessment is performed according to the aggregated renewable power generation forecast. In order to compensate for the uncertainty of the forecast, a method is devised to assess positive and negative energy reserves in Energy Rserve Assessment for Operation of Microgrid. Finally, emission constrained cost optimization is formulated to schedule the microgrid resources for the day-ahead dispatch.

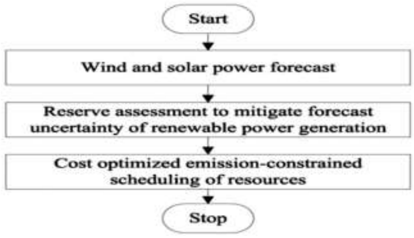

Figure 3: Overview of optimized scheduling approach.

2.3 Proposed Technique for BESS

In this section real time operation of the microgrid in the interconnected and the autonomous mode is studied. In the interconnected mode of operation, an adaptive droop control is devised for the BESS. The adaptive droop characteristic of the BESS power electronic converter is selected on the basis of the deviation between the optimized and real-time SOC of the BESS. In autonomous mode of operation, the BESS is responsible for keeping the voltage of the dc bus in a defined acceptable range for providing UPS service.

2.3.1 DC Voltage Droop Control in Interconnected Mode

The change of the battery power _PBESS is modified as a function of the dc voltage. It can be noted that the acceptable real time SOC is determined through definition of upper and lower boundaries around the optimized SOC. If the real-time SOC is within these boundaries, the droop control of the BESS power electronic converter is selected two of the three devised droop characteristics are asymmetric to support the dc voltage. The dc–ac converter connected to the main grid is also controlled by a droop. The droop parameters are adjusted to support the droop control of the storage. The boundaries must respect the capacity of the converter. In real time operation and interconnected mode, the SOC of the BESS is measured and compared against the optimized SOC of the BESS, and the proper droop will be selected.

2.3.2 DC Voltage Droop Control in Autonomous Mode

In the autonomous mode, the main grid is disconnected. Then, the fast charging service has less priority compared with the supply of other loads. The control of the BESS converter is also defined by the voltage–power droop as discussed. The BESS so supports the voltage of the dc bus.

3. Conclusion

At present, renewable energy is frequently used. Distributed energy sources such as wind power, solar power and so on that can be operated in parallel with a wider utility. Nowadays, most of people interested to use renewable energy sources such as solar energy, wind energy, wave energy, tidal energy, geothermal energy and so on. Generation of DC power is done by Microgrid. In this paper, integration of wind and solar power DC Microgrid, simulation thereof will be done for the effective utilization of solar and wind power using MATLAB.

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