DC Micro grid for Wind and Solar Power Integration Using Fuzzy Logic Controller

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ABSTRACT

This Paper presents a dynamic modelling of a DC Micro grid which has an Solar and Wind as an Distributed Energy Sources (DES).A Multi Port DC –DC converter is used to integrate the renewable sources to the DC bus.. The both solar and wind changes according to the load requirement and also the availability. An Energy Storage Element such as Battery is also integrated with the DC bus so that it can store energy when present in excess. 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. An intellegent Controller Known as Fuzzy Logic Controller is used as a controller to obtain best efficiency. Simulation is Implemented using Matlab/Simulink Software.

Key Words : Distributed Energy Sources (DES), State-Of-Charge (SOC), Energy Storage Element, Fuzzy Logic Controller.

I. INTRODUCION

IN THE year 2012, 44.8 GW of new wind energy conversion systems were installed worldwide [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. Recent research has considered the optimization of the operation on one hand and the usage of dc to link the resources on the other [16]–[18]. 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 realtime SOC.

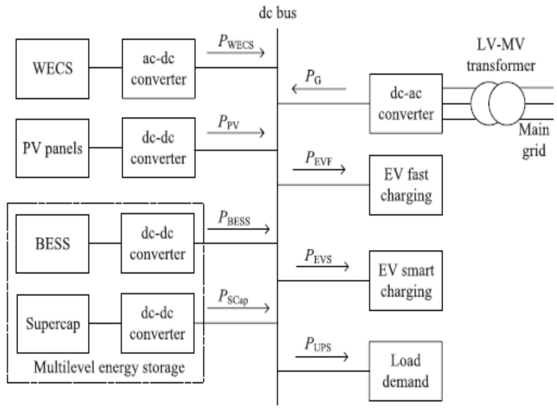


Fig. 1. Layout of the dc microgrid.

II. OUTLINE OF DCMICROGRID

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. Thanks to the 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.

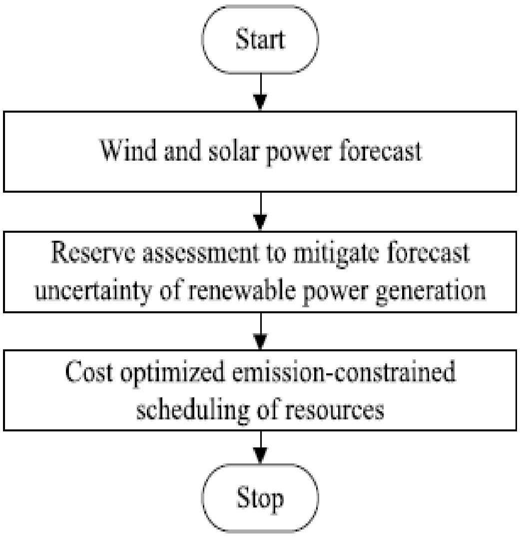


Fig. 2. Overview of optimized scheduling approach.

OPERATIONAL OPTIMIZATION OF MICROGRID FOR RENEWABLE ENERGY INTEGRATION

The algorithm for optimized scheduling of the microgrid is depicted in Fig. 2. 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 shown in Fig. 3. 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. 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.

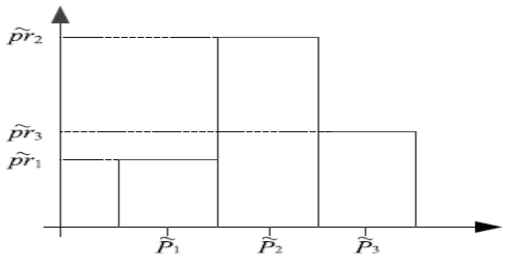


Fig. 3. Wind or solar power forecast uncertainty for 1 h.

III. FUZZY LOGIC CONTROL BASED MPPT

Due to developments in micro controller and DSP technologies, fuzzy logic control has received increased interest in MPPT applications. Fuzzy logic controllers have the advantages of working on systems with nonlinearities [5], not needing an accurate dynamic model and working with imprecise inputs. Fuzzy logic control is based on three stages [7]. The fuzzification stage converts input variables into linguistic variables based on a membership function as shown in Figure. In this case, there are seven fuzzy levels, which are NB (Negative Big),NM(Negative Medium), NS (Negative Small),ZE(zero),PS(Positive Small), PM(Positive Medium), and PB (Positive Big).As number of fuzzy levels increases, the accuracy . a and b are based on the range of values of the numerical variable in Figure 5. In the membership function, some specific fuzzy levels can be designed as unsymmetrical to make them more dominant, in other words to give them more importance. The error E and its variation (E) are inputs to the fuzzy logic-based MPPT controller. E and E can be calculated based on the user's preferences.

The memberships functions and rule base table associated with the fuzzy controller is given in figure (4) and (5).

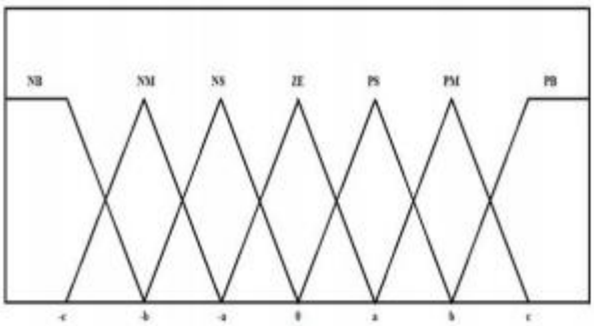


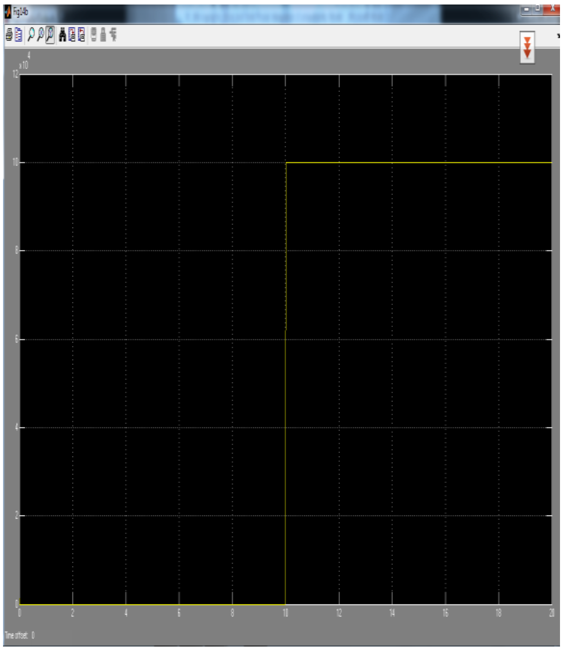
Fig 4: Membership function

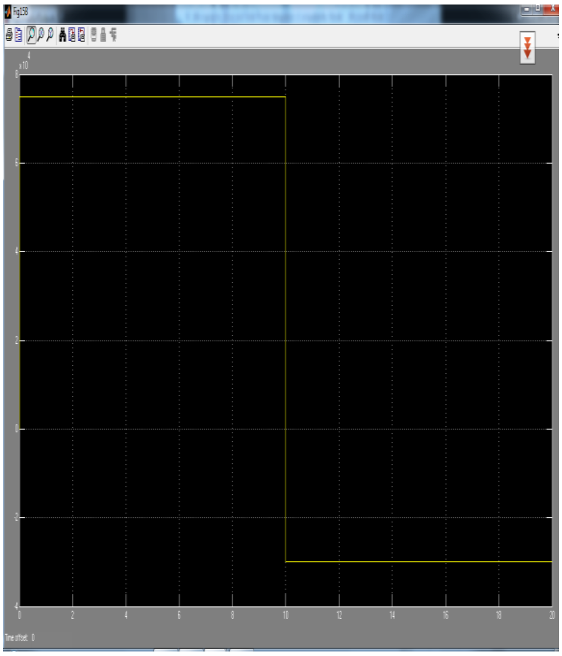
E / ΔE	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	ND	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

Fig 5: Rule base table

The error expressed in is the sum of the instantaneous and incremental conductance and goes to zero while becoming closer to the MPP. Generally, the output of the fuzzy logic controller is the change in duty ratio D of the power converter. This change in the duty ratio can be calculated and converted to the linguistic variables. Different combinations of the error, E, and its variations, E, can be used as the linguistic variables assigned to D. For a boost converter, Table can be used for this purpose. For example, if the operating point is far to the right of the MPP, and E is NB and E is ZE, then a large decrease is required in the duty ratio to decrease the voltage, that is D should be NB to reach the MPP. The fuzzy logic controller output is converted from a linguistic variable to a numerical variable using a membership function as shown in figure (4) in the defuzzifcation stage. By defuzzifcation, the controller produces an analog output signal, which can be converted to a digital signal and controls the power converter of the MPPT system. Voltage and power are measured to calculate E and E. Then, these values are evaluated by a fuzzy rule base table similar to Table 1. The output of the fuzzy rule base table is the required change in duty cycle. In the defuzzification stage, the numerical value of the duty cycle is determined via the conversion from linguistic values. Finally, through an analog to digital (A/D) converter and a gate driver, the necessary switching signal is applied to the power converter of the MPPT. Under varying atmospheric conditions, the fuzzy logic controllers show good performance in MPPT applications. On the other hand, the effectiveness of the fuzzy logic controller depends on the accuracy of the calculation of error and its variations and the rule base table developed by the user. For better efficiency, the membership functions and rule base table can be continuously updated or tuned to achieve the optimum performance similar to an adaptive fuzzy logic controller. In this way, fast convergence to the MPP and minimal fluctuation around MPP can be achieved. In addition, the tracking performance depends on the type of membership function.

IV. RESULTS





V. CONCLUSION

A dc microgrid for renewable power integration has been Proposed by using Fuzzy Logic Controller. Interaction with the main grid was controlled as a result of an operational optimization that seeks to minimize cost and emissions. The battery is parallel-connected with a supercapacitor to form a multilevel energy storage. The latter plays a critical role in compensating renewable power fluctuations and providing the power needed when EVs stop by for fast charging. For the special case of an urban location, the vertical integration within a tower building offers renewable wind and solar power harvesting on the top and energy delivery at the bottom on the ground level, for example for EV charging. The structure contributes to closely co-locating renewable power generation and delivery to local stationary and mobile EV energy resources.

VI. REFERENCES

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