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Design of Microgrid for Renewable Energy Sources Power Integration Using Matlab/Simulink

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Abstract: **Recently renewable energy power generation is gaining importance for domestic applications because of the growing power demand and increasing concern in the usage of fossil fuels in conventional power plants in future. Micro grid provides economically attractive electricity supply to customers with less impact on the environment and can be installed with in small localities or on the same building. By observing these advantages an aggregated model is proposed for an integration of renewable sources such as wind and solar power. The power which can be produced from the renewable sources will be synchronized to the AC to DC consumer equipment through Super capacitor and BESS (Battery Energy Storage System). In these operations, Super capacitor and BESS are equipped with the system for reducing power fluctuations, improving power quality and for maintaining power balance. Thus, in this project, a review of wind and solar power integration for the micro grid is given with Super capacitor and Battery Energy Storage for low output fluctuations and storage of surplus energy for future use. Simulation Models are developed on MATLAB/SIMULINK plat form and results are presented.**

Keywords: **BESS; DFIG; Micro grid; PV CELL; Super Capacitor; WECS;**

I. INTRODUCTION

An electrical system that has numerous distributed energy resources and may be operated in parallel with in the border of utility grid is termed as a small grid. Several countries generate electricity in massive centralized facilities, however typically transmit electricity over long distances and may negatively have an effect on the surroundings. Distributed generation permits assortment of energy from several sources and will provide lower environmental impacts and improved security. Distributed generation reduces the amount of energy lost in transmission system as a result of which the quality of power is increased. This additionally reduces the dimensions of power lines. Small grid generation resources will embrace fuel cells, wind, solar or alternative energy sources. In recent years, electricity generation Phtovoltaic cells (PV) or wind generation (WP) has received appreciable attention worldwide. The fusion of wind and alternative energy results in reduced native storage necessities. The combination of the Battery Energy Storage System and super electrical condenser technologies will provide proper energy storage facilities. The battery energy storage system is installed for provision and demand wherever the super electrical condenser provides cache management to complete quick power fluctuations and smoothen the transients encountered by a battery with higher energy capacity. Small grids or hybrid energy systems are shown to be good structure for native interconnection of distributed renewable generation and provide efficient storage. With the continued and increasing demand for improved dependability and energy potency across all industrial buildings, an incredible chance exists to make of more advantageous DC small grids.

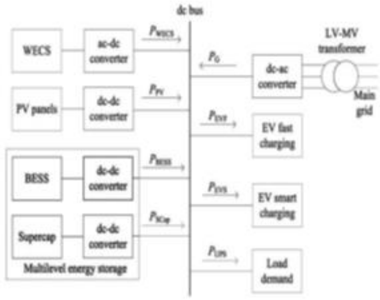

Fig.1(a). Outline diagram of the DC Micro Grid

II. DC MICRO GRIDS

The schematic diagram of DC Micro grid with the arrangement of renewable sources, energy storage comprising BESS and super condenser and including applications quick charging, sensible charging, and grid interface square measure is shown in Fig.1(a). Alternative energy is created from PV panels and this power is fed to the dc bus through dc-dc converter. Wind Energy Conversion requires a DC-DC converter for the process of power generation. Energy storage consisting of Battery Energy Storage System for maintaining the provision in balance condition and will satisfy the demand, whereas Energy Storage consisting of Battery Energy Storage System is required for maintaining provision during Energy balance condition. This also provides compensation of quick fluctuations, this acting as Super Capacitor for cache management. In building integration, a vertical axis turbine could also be put on the upper side. PV panels are often located on upper side and also on facade of the building. Such or similar configurations provide neighborhood handiness of exuberant wind and alternative energy.

Micro grid may be a small-scale grid that is designed to provide power for native communities. A Micro grid may be a combination of multiple Distributed generators (DGs) like renewable energy sources, typical generators, in association with energy storage units. A Micro grid includes Distributed generation sources like electrical panels, tiny wind turbines, fuel cells, diesel and gas micro-turbines etc; Distributed energy storage devices include batteries, Super capacitors, flywheels etc. Energy storage devices are used to make amendments for energy shortage or surplus energy available inside the Microgrid. The power shortage during a transient is provided by energy storage devices. tiny scale Distributed generation is interconnected to the medium or low voltage distribution systems like a residential building, industrial building, may be a market or maybe a village. DC Microgrid is an associate economical methodology for fusion of a system of high dependability and also to compensate losses within the system. It will eliminate DC/AC or AC/DC power conversion stage and therefore has benefits such as low cost, decreased system size and better performance. A DC Microgrid inside a building (or serving many buildings) will minimize or eliminates entirely AC/DC and DC/AC conversion losses. PV array (PV) and different distributed DC generator are often fed by a DC source, via the DC Microgrid, thus eliminating conversion loss (DC to AC to DC), DC Microgrids will optimize the employment of electronic devices, electrical storage, and distributed generation. DC Microgrids will form power systems that are economical and additionaly compatible with the quickest growing sections of the load nowadays.

III. PROPOSED SYSTEM

In the proposed system, the solar and wind energy are employed for Distributed generation system. The integrated power is smoothened with Super capacitor and also the energy is held on within the battery energy storage system such that it is accessible for DC and AC customers. Solar PV generation involves the generation of electricity from solar power. With the additional improvement in electrical converter technologies, PV generation is currently most popular worldwide as Distributed Energy Resources (DERs). The most important advantages of a PV system are:

(a) Proper utilization of solar power

(b) Positive environmental impact

(c) Longer lifetime and

(d) Quiet operation.

Most usually used model for a PV cell is that the one-diode equivalent circuit as shown in Fig 3(a).

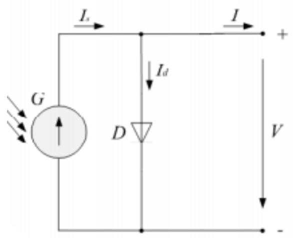

FIG.3(a) One Diode Equivalent circuit

The equivalent circuit PV cell is a current source in parallel with a single-diode. The configuration of the simulated ideal PV cell with single-diode is shown in Fig.3(a). G is the solar radiance, is the photo generated current, Id is the diode current, I is the output current, and V is the terminal voltage. Since the shunt resistance, Rsh is massive, it may be neglected. The 5 parameters model shown in Fig.3(b) and simplified four parameters model shown in Fig.3(c).

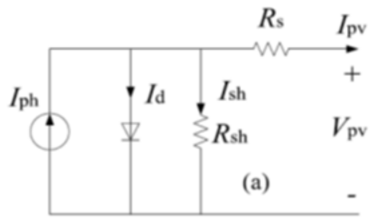

Fig.3(b) Five Parameters Model.

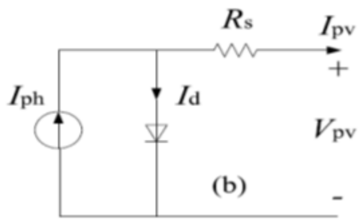

Fig.3(c) Simplified Four Parameters Model.

The VPN is that the output voltage, Rs is that the series resistance, the VT is that the thermal voltage, Tc is that the cell temperature and the most PV parameters measure Vmp, Imp, Voc, Isc, Pmax. Solar PV generation system consist of PV battery array, PV device, system controller and Storage. Its rated output power is calculated taking of illumination intensity 1000w/m2 and temperature , an25^0C in to consideration.

IV. WIND TURBINE

The turbine design in wind energy conversion systems (WECSs), includes turbine technology, power natural philosophy technology, and system management technology. The wind turbines can be classified as fixed-speed wind turbines and variable-speed wind turbines supported whether or not the operation speed is governable. Nowadays, most of the wind turbines applied in trade are variable-speed wind turbines are categories most generally applied in industry:

(1) Doubly-Fed Induction Generator (DFIG) based WECSs with reduced capacity power converters,

(2) Geared/Gearless Squirrel-Cage Induction Generator (SCIG) based WECSs with full-capacity power converters,

(3) Geared/Gearless Wound-Rotor Synchronous Generator(WRSG), Permanent Magnet Synchronous Generator (PMSG) based WECSs with full-capacity power converters.

DFIG for Double Fed Induction Generator, a generating principle widely used in wind turbines. It is based on an induction generator with a multiphase wound rotor and a multiphase slip ring assembly with brushes for access to the rotor windings. It is possible to avoid the multiphase slip ring assembly (see brushless Doubly-Fed Electric Machines), but there are problems with efficiency, cost and size. A better alternative is a brushless wound-rotor doubly-fed electric machine.

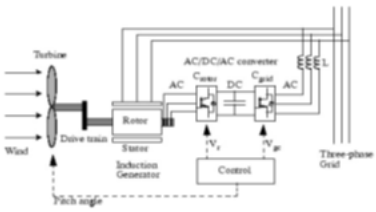

Fig.4(a).DFIG based WECS with necessary components

The principle of the DFIG is that rotor windings are connected to the grid via slip rings and back-to-back voltage source converter that controls both the rotor and the grid currents. Thus rotor frequency can freely differ from the grid frequency (50 or 60 Hz). By using the converter to control the rotor currents, it is possible to adjust the active and reactive power fed to the grid from the stator independently of the generator's turning speed. The control principle used is either the two-axis current vector control or direct torque control (DTC). DFTC has turned out to have better stability than current vector control especially when high reactive currents are required from the generator.

The doubly-fed generator rotors are typically wound with 2 to 3 times the number of turns of the stator. This means that the rotor voltages will be higher and currents respectively lower.

V. SIMULATION RESULTS AND DISCUSSIONS

The optimized scheduling of a vertically integrated urban Micro grid with renewable energy harvesting as shown in Fig5.1(a). And EV charging on the ground is verified for the following assumptions.

1) A vertical axis wind turbine with a generation capacity of 100 kW is installed on the rooftop.

2) Photovoltaic panels with a generation capacity of 50 kW are mounted on the building.

3) A flow battery with the energy capacity of 1000 kWh, power rating of 400 kW, and charging and discharging efficiencies of 0.95 and 0.90, respectively, is placed in the basement of the building. The SOC of the BESS at the beginning of the optimization is assumed to be 300 kWh. The *DOD* of the BESS is 80% of the maximum energy capacity, which gives a minimum possible discharge to SOC of 200 kWh.

4) A Super capacitor storage with a capacity of 100 kW is installed.

5) The BESS and Super capacitor together form a multilevel energy storage, where the Super capacitor provides fast dynamic response under an energy cache control scheme.

6) The DC bus capacitance is distributed among converters according to rating and in sum is 40 mF.

7) A grid interface with the capacity of 300 kW is provided.

8) The energy cost diagram for 1 kWh energy is given.

9) The power generation forecast curves of the wind and PV-based power generation are shown .

10) A fast charging station to serve one EV at a time is provided. The charging power is 100 kW. A uniform distribution function is employed to simulate the demand of fast charging in each quarter of an hour from 7 AM to 9 PM. The simulated fast charging profile is provided .

11) The average amount of CO_2 emission to generate 1 kWh electricity in the power system (*EMS*) is 0.61235 kg/kWh [21]. The emission penalty–bonus factor (*EPBF*) of 3 c$/kg CO_2 is chosen for the optimization.

12) The UPS service is devised for 50 kW power and 4 h of continuous supply from 8 AM to 4 PM.

13) EVs are available for smart charging from 8 PM to the next day at 7 AM. The maximum smart charging power of the aggregated EVs is 20 kW. The daily demand of EVs is forecasted to be 50 kWh.

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5.1 SIMULATION OF PROPOSED DROOP CONTROL BASED RESPONSES TO WIND FLUTUATION AND FAST CHARGING WHEN SOC BATTERY IS FOR CASE(B) :

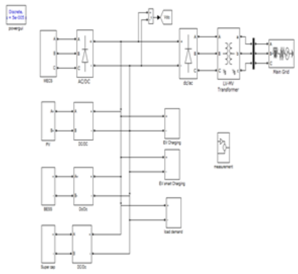

FIG.5.1.Simulink model for case A

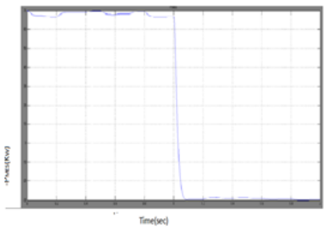

Fig.5.1(a) Multilevel energy storage system(MES) charging power from the dc bus

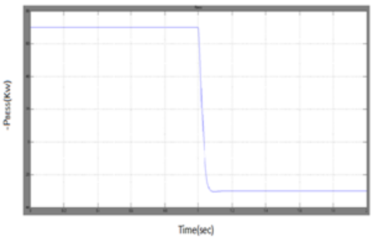

Fig.5.1(b) Battery charging power from the dc bus

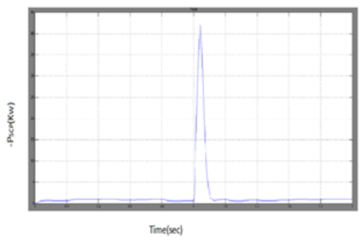

Fig. 5.1(c) Super capacitor discharging power to the dc bus

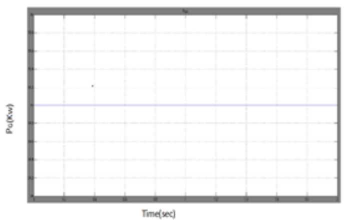

Fig.5.1(d) Grid power to the dc bus

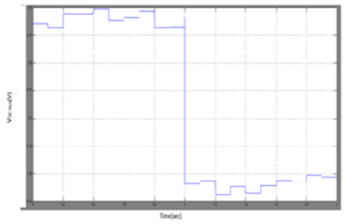

Fig.5.1(e) DC bus voltage profile

5.2 SIMULATION OF PROPOSED DROOP CONTROL BASED RESPONSES TO WIND FLUCTUATION AND FAST CHARGING WHEN SOC BATTERY IS LOWER FOR CASE(A) :

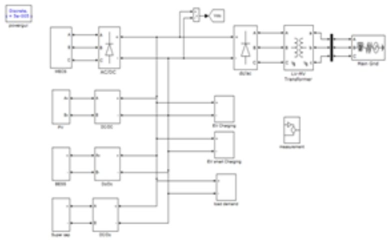

FIG.5.2.Simulink Model for case B

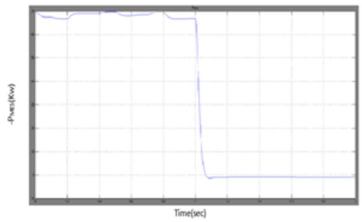

Fig.5.2(a) Multilevel energy storage system(MES) charging power from the dc bus

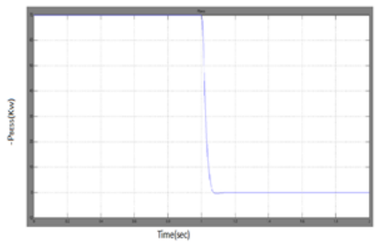

Fig.5.2(b) Battery charging power from the dc bus

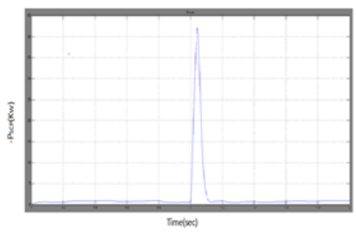

Fig. 5.2(c) Super capacitor discharging power to the dc bus

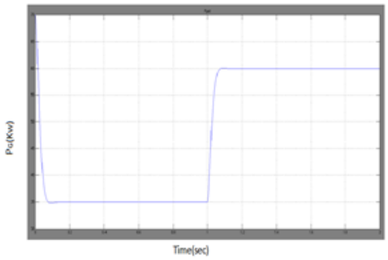

Fig.5.2(d) Grid power to the dc bus

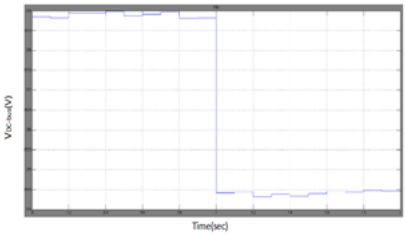

Fig.5.2 (e) DC bus voltage profile

As a result, the BESS droop control as depicted is selected. In the new droop control, γ is 0.33. All other assumptions are the same as in case A where the fast charging load is connected to the dc bus at time 10s.The simulation results are depicted. With the asymmetric droop curve of the BESS, the multilevel energy storage in case B does not provide full compensation of renewable fluctuations and the heavy fast charging EV. So, the droop control of the grid is also activated, and the main grid contributes to the fast charging power demand. The BESS power is without fluctuation to the Super capacitor, which absorbs the rapid power fluctuations. The dc bus voltage drops to around 374.4 V. The voltage drop is higher than in case A. This is due to the wider range of droop control characteristics of the main grid converter and less contribution of the BESS to voltage control. The functionality of the BESS and grid droop control can be recognized. The comparison of the results shows the importance of coordinating the droop settings with the scheduling in Microgrids with wind and solar power. The SOC of the battery is as desired according to the scheduling, the SOC of the battery has become lower than expected due to forecast uncertainty. In the latter case, the asymmetric droop avoids further significant discharging, but has full droop contribution on the charging side. On the reduced discharging side, the droop of the other power electronic converter connecting to the main grid kicks in to keep up the dc voltage. It can be seen that the droop response of the grid converter becomes active at *V*DC-bus = 375 V. Above that level, the droop control of the converter connected to the storage acts on its own. As it does so at a lower response compared with the case where the SOC is not below the scheduled level, the steady-state ripple of *V*DC-bus in the first 10s is higher in CASE B than it is in CASEA.

VI. CONCLUSION

A DC Microgrid for renewable power integration has been planned. The operational optimization and power-electronics based voltage–power droop management was developed, and therefore the functioning was in contestible through simulation. Interaction with the Most grid was controlled as a result of associated operational optimization that seeks to reduce value and emissions. A way to quantify the uncertainty related to with the forecast of aggregative wind and PV-based power generation was created and accustomed quantify the energy reserve of the battery energy storage system. The battery is parallel-connected with a Super capacitor to create a construction energy storage. The latter plays a crucial role in compensating renewable power fluctuations and providing the ability required once EVs stop by for quick charging. In accordance with the Microgrid paradigm. The operation is additionally supported in autonomous mode to support UPS once the association to the most grid is unavailable. Through out such periods, quick charging isn't supported, because the priority shifts to supply crucial native masses. Power physics could be a key enabling technology in connecting all energy resources to the dc bus. The converters support the dc voltage through a droop management theme. The management planned here is adjustive in this the voltage–power droop curves are changed reckoning on the end result of the operational optimization. As a novelty, uneven droop curves were planned for the converters connected to the storage therefore on additionally support the target of transportation the particular battery SOC near the specified one as regular. This ensures, above all for the construction energy storage, that the contribution toward dc voltage management doesn't compromise its role in providing adequate energy reserve. For the special case of associate urban location, the vertical combination among a tower building offers renewable wind and solar energy gathering on the highest and energy delivery at very cheap on the bottom level, as an example for heat unit charging. The structure contributes to closely co-locating renewable power generation and delivery to native stationary and mobile heat unit energy resources. This project contributes to the Microgrid paradigm a completely unique droop management that takes under consideration storage SOC once adaptively setting the slopes of the voltage–power droop curves. The planned forecast supported aggregation of renewable power generation contributes to quantifying energy reserve. In associate urban setting, a tower-integrated installation to co-locate gathering of wind energy and native delivery of fresh energy is an alternate. The optimization for power exchanges and dc voltage management mistreatment adjustive management are performed through power electronic converters that function interfaces to any or all resources. The ensuring energy system serves native stationary and EV-based mobile shoppers, and it's a decent national among the most grid because it reduces emissions by native usage of the wind and solar power.

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