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The Impact of Electric Vehicle Functions in Utility Grids That Use Wind Energy and Have Energy Storage Devices

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ABSTRACT

Recently, electric vehicles (EVs) have shown that they can greatly reduce pollution and are a great way to use green energy sources (RESs) instead of fossil fuels. The growing number of electric vehicles (EVs) on the road has made it more popular to use them for other tasks. In power grids. Wind energy has been used as an example of a renewable energy source (RES), taking into account its random nature and the fact that it changes continuously with wind speed. Additionally, the superconducting magnetic energy storage system (SMES) device is picked due to its promising long-life operation. The proposed study looks at different points of point of common coupling (PCC) voltage changes, reactive power support, levelling active power during the on-peak time, and power losses. Moreover, fuzzy logic controller (FLC) systems have been suggested for controlling EVs and the SMES device. The energy management between the installed EVs, SMES, wind, and utility grid side is achieved through the coordination of the FLC devices. The results show that reduced peak and mean values of total power losses and line active power are achieved by the proposed coordination method. Moreover, improved profiles of the PCC voltage, reactive power support, and active power levelling, and sustainable and reliable power supply are achieved by the proposed method for wide operating ranges and modes of operation.

Keywords — Electric vehicles (EVs), energy management, fuzzy logic controller (FLC), renewable energy, superconducting magnetic energy storage (SMES), wind energy.

INTRODUCTION

IN the last decade, an exponential rise of renewable energy source (RES) installations has been achieved in utility grids to get over the various problems of traditional fossil power sources. Among the various current RESs, wind energy represents one of the most promising directions, as a reduced cost and high power generation source. Therefore, high uptake levels of wind energy systems have been found world-widely. Based on the annual energy reports, the capacity of installed RESs hit more than 200 GW by the year 2019. In which, the world share of wind energy generations was about 19% of the total installed RESs by 2019. There are several production types for wind energy systems, including the doubly-fed induction generator (DFIG), permanent magnet synchronous generator (PMSG), and squirrel cage induction generator (SCIG) systems.

The SCIG wind systems have found wide applications due to their lower cost and high reliability. In addition, SCIG systems remove the need for the components that require continuous maintenance, such as the brushes, exciter, and slip rings. Means of transportation without fossil fuel needs. The fossil fuel-powered conventional transportation systems were the first choice earlier, which have led to increased demands of fossil fuel. Therefore, study and industry efforts have been directed towards new transportation systems that can be powered from another new, renewable, and clean sources. In 2019, the sales of EVs have achieved an increase by more than 2.1 million cars with respect to the achieved sales in 2018, which make for about 2.6% of global car sales. Meanwhile, the stock of EVs has increased to 7.2 million, which represents 1% of the global car stock in 2019. The continuous movement towards using the new technologies of electrification in different types of EVs has led to a significant expansion of their markets. Thence, ambitious plans have been put by several countries for increasing share of EVs in the market, which depend on regulatory and other structural measures, including zero-emission vehicles mandates, and fuel economy standards. However, wind energy systems have displayed a fluctuating nature due to the dependency of the output power on the operating wind speeds. Additionally, the connected loads in the utility grids are constantly subjected to changes in the demanded active/reactive power. The stochastic behavior of wind generation and required loads has imposed several challenges on the operation, control, and sizing of utility network components. The utilization of various types of energy storage systems (ESSs) has proven efficient and important solutions for various utility applications. Several incredible benefits can be gained by employing ESSs in power systems through solving the intermittent power generation issues. Several types of ESSs have been widely used, including the electrical-based ESSs (superconducting magnetic energy storage systems (SMES), and super capacitors), thermal-based ESSs (thermal liquid, ceramic thermal, and hot water), mechanical-based ESSs (flywheel, pumped hydro, compressed air), and chemical-based ESSs (battery and hydrogen fuel cell). Among the various existing ESSs, the SMES is generally preferred due to its fast response, which makes it feasible for responding to fast charging/discharging commands. Additionally, the cooperative management between micro grids, resilient operation of micro grids, energy management systems of micro grids, optimal scheduling of micro grids, have gained wide concerns in recent study. In recent years, utilization of renewable energy technologies has been found to have a significant role in electrical power generation systems. Among the various renewable energy systems, solar photovoltaic (PV) energy systems are employed in several applications, such as residential power supplies, battery charging, etc. The PV generation systems are anticipated to become the biggest renewable energy source by the year 2040. The continuous increase of the installed PV systems in electrical power systems is a direct benefit of their inherent features of having low maintenance cost, no moving parts, low noise, and being eco-friendly technology.

However, research and field experience have addressed that installations of PV systems are subject to many challenges such as partial shading, stochastic behaviour, harmonics content, and grid integration problems. Another challenge exists for PV systems in their integration with future smart home micro grids. In addition, economical operation has imposed challenges on PV systems to compete with conventional energy resources. The efficiency of the PV system is highly dependent on various atmospheric conditions. In practical operating scenarios, the performance of the PV cells are non-uniform due to the partial shading problems that are related to the different weather conditions. The partial shading conditions cause an extreme reduction in the maximum extracted power of the PV system. In partial shading situations, the output PV power of the partially shaded array is less than the algebraic sum of the total output powers of the connected PV modules in the array. In, there are several attempts to decrease the degradation of power in partially shaded systems, wherein the distributed maximum power point tracking (MPPT) methods have shown a good performance. Globally, some governments are taking very different policy approaches to supporting PEVs in the passenger vehicle sector. Perhaps the most extreme difference can be seen by comparing two recognized leaders in PEV-supportive policy, Norway and California. Norway's PEV sales represented 22% of all new vehicles in 2015 (by far, the world's highest national market share) following a largely demand-focused policy approach including generous financial incentives. In contrast, California has pioneered several supply-focused policies including its Zero Emission Vehicle (ZEV) mandate, which requires manufacturers to make PEVs or hydrogen fuel cell vehicles available to consumers in the state. To date, the approaches adopted by both Norway and California seem to have been relatively successful in stimulating PEV demand, though long-term effects are less certain and depend in part on how long each region keeps its policies in place, and at what level of stringency.

LITRATURE SURVEY

The integration of photovoltaic (PV) systems with three-phase four-wire (3P4W) distribution networks has imposed several challenges related to existing unbalanced loads, reactive power generation and harmonics content. In this paper, a multifunctional distributed maximum power point (MPPT) controller for grid integration of PV systems is proposed. The proposed distributed MPPT controller is developed based on employing a four-leg three-level T-type multilevel inverter. The proposed inverter performs multifunctional ties, including distributed MPPT, neutral current compensation for the unbalanced loads, supplying reactive power into the grid and the grid integration. Moreover, the proposed inverter overcomes the stochastic behaviour of both the PV generation with partial shading problems and its operation with unbalanced loads as well. Furthermore, the new proposed controller injects sinusoidal output currents with decreased levels of total harmonic distortion (THD) into the grid. The tested case study is investigated for the various operating scenarios of PV generation and load demands. The results and tabulated performance comparisons have proven the superior performance of the proposed multifunctional PV generation system. [1].

A small-scale standalone wind energy conversion system composed of a squirrel-cage induction generator, a buck converter and a current-source inverter is proposed, as an attractive renewable energy solution for off-grid communities. Geared squirrel-cage induction generators are well-known for their robustness, simplicity, light weight and low cost. Current-source inverters, even though mainly used in medium-voltage, high power applications, and proposed for megawatt-level grid-connected wind energy conversion systems, offer potential benefits in small-scale off-grid wind energy conversion systems that are yet to be investigated and evaluated against those of commonly-used voltage-source inverters. In the proposed system, the generator's shaft speed is controlled by a buck converter to extract maximum available wind power in normal mode of operation, and the wind power is dumped when it is not possible to absorb maximum available power by the storage system and the load [2]. A novel scheme for integration of a battery energy storage system is proposed and an effective power management algorithm is employed to maintain the supply-demand power balance through direct control of dc-link current.

Many countries and regions are enacting plug-in electric vehicle (PEV) supportive policies in an ad-hoc manner, typically without clear goals or evaluation metrics. In this paper, we develop an evaluation framework based on the likely ability of a package of these policies to achieve one goal: PEVs capturing at least 40% of new passenger Vehicle market share by 2040 (in line with deep GHG abatement targets). We develop simple methods to translate different policy types– including incentives, infrastructure development and supply mandates–into 2040 market share "points" based on policy stringency and duration [3]. The electric vehicle (EV), when aggregated by an agent (Aggregator), is a suitable candidate for participating in demand response in power system operation. As the interface between distribution network and EV users, as well as an independent party at the same time, an optimal scheduling algorithm is necessary with consideration of benefits of three parties, which in return will affect aggregators' sustainable development. Charging/discharging and policy award/penalty, while the benefit of distribution network for the integration of large amount EV loads through aggregator is evaluated by aggregator's load shifting capability through a price based demand response (DR) program under real time electricity price [4].

The optimal scheduling of the aggregator is with an objective of maximizing its own benefit under constraints of EV users' minimum satisfaction and minimum load-shifting capability required by distribution network. The optimization scheduling is tested by a test system, and further analysis is given on the effect of aggregator's facility level and technology (Vehicle to Vehicle) and the operation mode of aggregator group on the benefits of three parties. As the output from wind power generation is intermittent in nature, making the wind power output "dependable" is critical for seamless integration of wind generation. One of the most favourable solutions is incorporating energy storage system (ESS) with wind farms to establish a wind-energy storage hybrid system. Since it requires capital investment for ESS installation, it is important to estimate appropriate storage capacity and charging/ discharging rate of ESS for desired applications. In this paper, the fluctuation feature of wind power output is analysed both in time domain and frequency domain. The degree of fluctuation is extracted and illustrated as quantization index (QI). Based on QI clustering, the wind scenario with largest power fluctuation is selected as "worst performance," according to which, scheduling time horizon, along with the capacity and charging/discharging power of ESS, can be determined [5].

The voltage and frequency stability issues of power systems are the main challenges that arise from high penetration levels of wind energy systems. This paper presents an effective solution for voltage and frequency stability problems by using a superconducting magnetic energy storage (SMES) system controlled with a fuzzy logic controller (FLC). The proposed control system can suppress the voltage and frequency fluctuations due to the high variations of wind speed. In addition, the proposed control system is suitable for both balanced and unbalanced distribution systems with high penetration levels of wind turbines (WTs) [6]. A squirrel cage induction generator (SCIG) is selected in the case study, which represents the worst scenario of WT generation from the voltage and frequency stability aspects. This is due to the high reactive power consumed by the SCIG from the utility grid during steady state and voltage fluctuations that may lead to harmful consequences for power system components.

Multi-area power systems in here complicated nonlinear response, which results in degraded performance due to the insufficient damping. The main causes of the damping problems are the stochastic behaviour of the renewable energy sources, loading conditions, and the variations of system parameters. The load frequency control (LFC) represents an essential element for controlling multi area power systems. Therefore, the proper design of the controllers is mandatory for preserving reliable, stable and high-quality electrical power [7]. The controller has to suppress the deviations of the area frequency in addition to the tie-line power. Therefore, this paper proposes a new frequency regulation method based on employing the hybrid fractional order controller for the LFC side in coordination with the fractional order proportional integral derivative (FOPID) controller for the superconducting energy storage system (SMES) side. The hybrid controller is designed based on combining the FOPID and the tilt integral derivative (TID) controllers. In addition, the controller parameters are optimized through a new application of the manta ray foraging optimization algorithm (MRFO) for determining the optimum parameters of the LFC system and the SMES controllers. The optimally-designed controllers have operated cooperatively and hence the deviations of the area frequency and tie-line power are efficiently suppressed. The robustness of the proposed controllers is investigated against the variation of the power system parameters in addition to the location and/or magnitude of random/step load disturbances.

The fluctuated nature represents the main obstacle for increasing the penetration level of photovoltaic (PV) generators in utility micro grids [8]. The energy storage systems (ESSs) represent the main solutions to get over these fluctuations. Among various ESSs, the superconducting magnetic energy storage (SMES) systems have proven themselves as an effective solution. The SMES control systems in the literature result in a shortened lifetime, degraded thermal behaviour, and high AC losses in the SMES. Thence, reliable operation of SMES systems and micro grids has been given wide concerns due to the large fluctuations in micro grids with high levels of PV penetrations.

The intermittent behaviour of wind power generation results in a fast variation of both frequency and voltage magnitudes of isolated micro grids with high wind power penetration. In this paper, a hybrid energy micro grid with wind energy conversion system (WECS) and diesel synchronous generators are analysed during wind gust conditions. Superconducting magnetic energy storage (SMES) is connected at the same node of the WECS to mitigate the intermittent wind power generation. A developed fuzzy logic controller has been applied to achieve active power sharing. The damping of voltage fluctuation depends on SMES reactive power, which is controlled by a voltage source converter. The studied micro grid comprises 33 nodes, two diesel SGs, and two WECSs of squirrel cage induction generator type at 30% penetration level. The results demonstrate the effectiveness of the proposed control strategy to mitigate the frequency fluctuations during the wind speed gusts by smoothing power output from WECSs/SMES system. Moreover, voltage control is achieved by injecting reactive power from the SMES system [9].

A stochastic predictive control algorithm for a number of micro grids connected to the same distribution system [10]. Each micro grid includes a variety of distributed resources such as wind turbine, photo voltaic units, energy storage devices and loads. Considering the uncertainty of loads and renewable-based distributed resources, the power management problem is formulated in the framework of stochastic control. The micro grids operation are coupled through a joint probabilistic constraint which requires the power flow from utility to each micro grid limits to a pre specified range. Utilizing probabilistic distribution function of uncertain variables, the deterministic counterpart of the problem is derived and a close-optimal solution of the problem is achieved.

Integration of power electronic based generation units and small-scale energy resources into MGs reduces the system inertia. Therefore, frequency deviations arising from loss of grid power or fluctuations of renewable energy resources and loads, should be managed. In this paper, a two stage robust day-ahead optimization model for resilient operation of MGs is proposed in which hierarchical frequency control structure of the MG is precisely formulated. Based on this model, the operation cost of MG is minimized while sufficient primary and secondary reserves are scheduled to restrict frequency deviations and avoid load shedding under the worst-case realization of islanding events. A column-and constraint generation (C&CG) algorithm is utilized to efficiently solve the problem. Numerical cases on a test system show the effectiveness of the proposed model and the solution algorithm [11].

CONTROL METHODOLOGY

The micro grid control is done for two main operating modes; one is the islanding or utility reconnection mode. The power generating units like wind generator, solar PV array act according to their wind speeds and solar insolation level. The battery varies its role of charging and discharging on the basis of load demand and total power generation from the micro grid. The availability/outage of the grid triggers the mode shifting controller to move from voltage /current or current/voltage control working mode. The section here discusses each control in depth. The illustration displays how the micro grid is built. An identical replica of a wind turbine is powered by the DC motor in the SG wind generator. The two VSCs, the MSC and LSC, are connected to one another and allow wind production at varying speeds. The single-stage solar PV array and BES are linked at the DC connector. The STS is shown synchronising switches in this design. They allow the main grid and the tiny grid to be seamlessly separated and reunited. Relay and inductor (RL) components realize local loads (diode bridge rectifier) when linked across the output of the DBR. Because of the harmonics the non-linear load produces, grid currents are warped and the PQ suffers. Both switching harmonics and current harmonics are eliminated by the interface inductors and RC filter. Appendix section shows the specification of the micro grid's pieces and control settings. One is the islanding or utility reconnection mode, which is controlled by the micro grid.

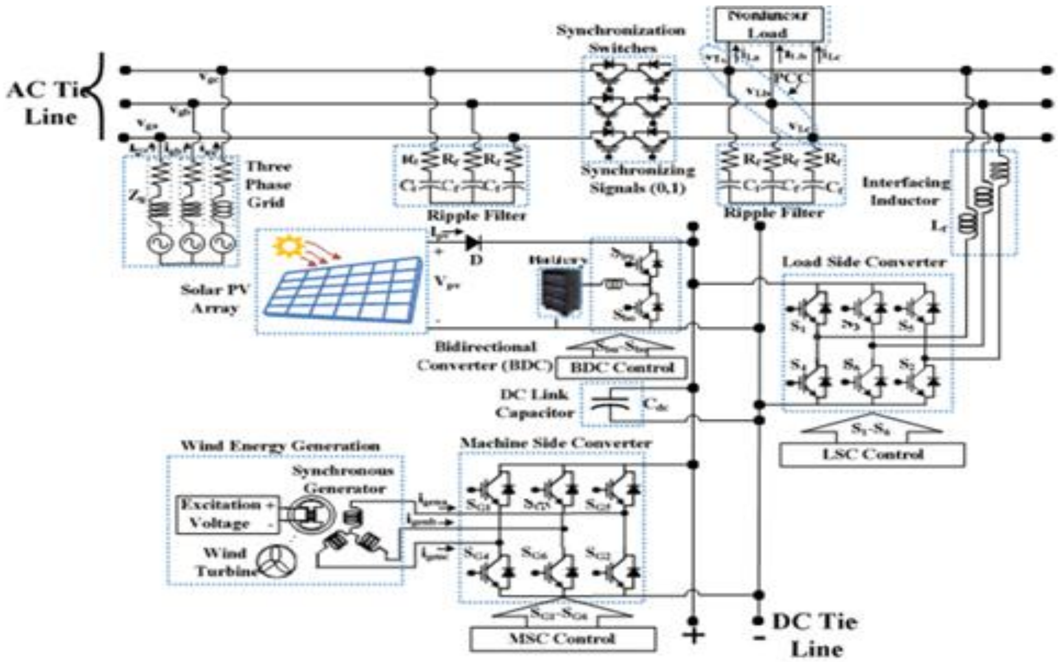

Fig 1 Architecture of Proposed System

RESULT AND DISCUSSION

The results of a MATLAB simulation of the tested for possible conditions of solar and of dc load measurement modes. The wind speed variation as well as solar insolation change are undertaken. The observed performance is provided in this section.

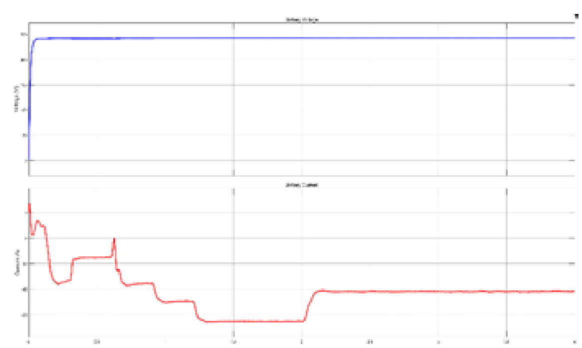

Fig 2: Battery Management

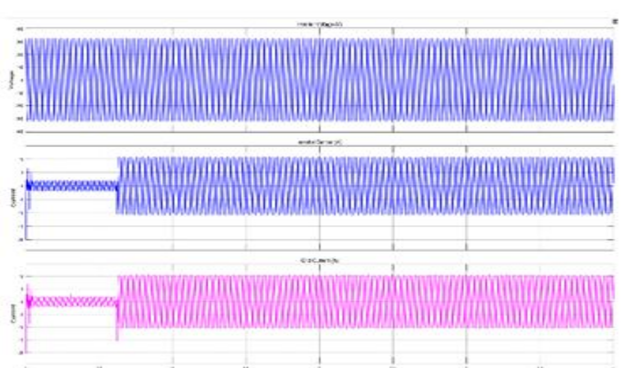

Fig 3: Inverter and Grid

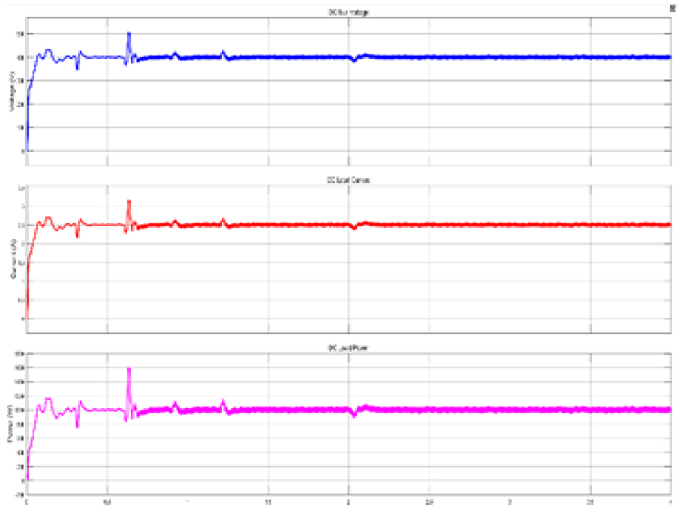

Fig 4: DC Load Measurement

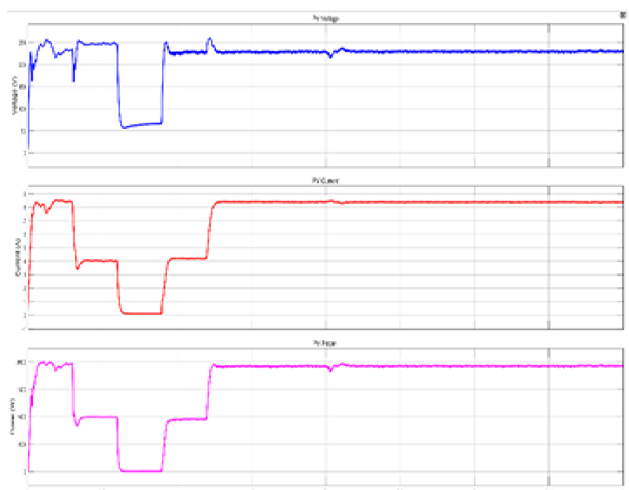

Fig 5: PV Measurement

The fluctuations observed during transition period are negligible shown in fig 5. The DC link voltage remains constant, the grid and load currents are unaltered shown in fig 4. The load power is being provided in each operating condition. Depicts power variations during the mode transition from grid integrated/grid isolated operating mode. During grid outage the power being fed to the grid, becomes zero and then the battery starts charging itself (shown in the negative direction). The load demand is fulfilled all the time and the wind power is achieved at its rated value. The solar power is attained at its maximum insolation level. Depicts the grid and load voltages performance, when the micro grid shift from grid integrated/grid isolated mode.

CONCLUSION

A comprehensive study for the various impacts of different integration/control approaches of EVs on the enhancement of utility grid performance. The proposed study takes into consideration the stochastic properties of wind power generation and residential loads based on practical daily loading profiles.

Moreover, the proposed study presents the effects of cooperative operation of energy storage systems with installed EVs in the utility grids. Two FLC methods are proposed in this paper for the SMES and EVs, respectively. The share of the different devices is achieved through the proposed management algorithm for supporting the local active/reactive power supply for the connected loads.

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