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Hybrid Smart Grid Connected Photovoltaic and Fuel System

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Abstract: Smartgrids are a subset of the modern power structure; using distributed generation (DG) to supply power to communities rather than vast regions. The reduced scale mitigates loss allowing the power produced to do more with better control, giving greater security, reliability, and design flexibility. This paper explores the performance and cost viability of a hybrid grid-tied microgrid that utilizes Photovoltaic (PV), batteries, and fuel cell (FC) technology. The concept proposes that each community home is equipped with more PV than is required for normal operation. As the homes are part of a microgrid, excess or unused energy from one home is collected for use elsewhere within the microgrid footprint. The surplus power that would have been discarded becomes a community asset, and is used to run intermittent services.

Keywords: Hybrid system, photovoltaic, fuel cell, microgrids

Literature Survey:

P.Vijayapriya et al. (2018) Microgrids have emerged as new paradigm for next generation power systems as they are capable of hosting multiple renewable energy resources in local community distribution systems and also can supply reliable electric power to customers. Microgrids are considered as controllable units with utility perspective because the common entities of microgrids such as DERs (Distributed Energy Resources) and controllable loads can more effectively control the power consumption or generation. A Battery energy storage system (BESSs) effectively compensates the intermittent output of RES (Renewable Energy Sources). This paper presents a hybrid model of microgrid for connecting to grid with 3 generating sources. The proposed SIMULINK model consists of subsystem modules of renewable energy sources (PV, Wind and FC) that are connected to a suitable converter whose output is fed to an inverter. The output is this Microgrid is analysed in grid connected mode.

S. Sathish Kumar et al. (2014) Performance optimization, system reliability and operational efficiency are key characteristics of smart grid systems. In this paper a novel model of smart grid-connected PV/WT hybrid system is developed. It comprises photovoltaic array, wind turbine, asynchronous (induction) generator, controller and converters. The model is implemented using MATLAB/SIMULINK software package. Perturb and observe (P&O) algorithm is used for maximizing the generated power based on maximum power point tracker (MPPT) implementation. The dynamic behavior of the proposed model is examined under different operating conditions. Solar irradiance, temperature and wind speed data is gathered from a grid connected, 28.8kW solar power system located in central Manchester. Real-time measured parameters are used as inputs for the developed system. The proposed model and its control strategy offer a proper tool for smart grid performance optimization.

Th.F. El-Shatter et al. (2012) In this paper, a hybrid Photovoltaic (PV)-fuel cell generation system employing an electrolyzer for hydrogen generation is designed and simulated. The system is applicable for remote areas or isolated loads. Fuzzy regression model (FRM) is applied for maximum power point tracking to extract maximum available solar power from PV arrays under variable insolation conditions. The system

incorporates a controller designed to achieve permanent power supply to the load via the PV array or the fuel cell, or both according to the power available from the sun. Also, to prevent corrosion of the electrolyzer electrodes after sunset, i.e. when its current drops to zero, the electric storage device is designed so as to isolate the electrolyte from the electrolysis cell.

T.Kranthi kumar et al. (2011) This paper presents a method to operate a grid connected hybrid system. The hybrid system composed of a Photovoltaic (PV) array and a Proton exchange membrane fuel cell (PEMFC) is considered. Two operation modes, the unit-power control (UPC) mode and the feeder-flow control (FFC) mode, can be applied to the hybrid system. In the UPC mode, variations of load demand are compensated by the main grid because the hybrid source output is regulated to reference power. Renewable energy is currently widely used. One of these resources is solar energy. The photovoltaic (PV) array normally uses a maximum power point tracking (MPPT) technique to continuously deliver the highest power to the load when there are variations in irradiation and temperature. The disadvantage of PV energy is that the PV output power depends on weather conditions and cell temperature, making it an uncontrollable source. Furthermore, it is not available during the night. In order to overcome these inherent drawbacks, alternative sources, such as PEMFC, should be installed in the hybrid system. By changing the FC output power, the hybrid source output becomes controllable. Therefore, the reference value of the hybrid source output must be determined. In the FFC mode, the feeder flow is regulated to a constant, the extra load demand is picked up by the hybrid source, and, hence, the feeder reference power m ust be known. He system can maximize the generated power when load is heavy and minimizes the load shedding area. When load is light, the UPC mode is selected and, thus, the hybrid source works more stably. The changes in operating mode only occur when the load demand is at the boundary of mode change; otherwise, the operating mode is either UPC mode or FFC mode. Besides, the variation of hybrid source reference power is eliminated by means of hysteresis. The proposed operating strategy with a flexible operation mode change always operates the PV array at maximum output power and the PEMFC in its high efficiency performance band, thus improving the performance of system operation, enhancing system stability, and decreasing the number of operating mode changes.

Rashid Al Badwawi et al. (2015) Due to the fact that solar and wind power is intermittent and unpredictable in nature, higher penetration of their types in existing power system could cause and create high technical challenges especially to weak grids or stand-alone systems without proper and enough storage capacity. By integrating the two renewable resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes more reliable and economical to run. This paper provides a review of challenges and opportunities / solutions of hybrid solar PV and wind energy integration systems. Voltage and frequency fluctuation, and harmonics are major power quality issues for both grid-connected and stand-alone systems with bigger impact in case of weak grid. This can be resolved to a large extent by having proper design, advanced fast response control facilities, and good optimization of the hybrid systems. The paper gives a review of the main research work reported in the literature with regard to optimal sizing design, power electronics topologies and control. The paper presents a review of the state of the art of both grid-connected and stand-alone hybrid solar and wind systems.

Gopinath Subraman et al. (2017) Under the current energy sector framework of electricity tariff in Malaysia, commercial and industrial customers are required to pay the maximum demand (MD) charge apart from the net consumption charges every month. The maximum demand charge will contribute up to

20% of the electricity bill, and will hence result in commercial and industrial customers focussing on alternative energy supply to minimize the billing cost. This paper aims to review the technical assessment methods of a grid-connected solar photovoltaic (PV)—battery storage system—with respect to maximum demand shaving. An effective battery storage system can provide the extra energy needed during the peak energy consumption periods, as well as when renewable energy (RE) sources go offline. Based on the reviews, maximum demand shaving with good Return-of-Investment (ROI) can be achieved by considering the actual load profile, technical, and economic aspects of the solar PV-battery system and the Malaysian electricity tariff for commercial and industrial customers.

E. M. Natsheh et al. (2013) Performance optimization, system reliability and operational efficiency are key characteristics of smart grid systems. In this paper a novel model of smart grid-connected PV/WT hybrid system is developed. It comprises photovoltaic array, wind turbine, asynchronous (induction) generator, controller and converters. The model is implemented using MATLAB/SIMULINK software package. Perturb and observe (P&O) algorithm is used for maximizing the generated power based on maximum power point tracker (MPPT) implementation. The dynamic behavior of the proposed model is examined under different operating conditions. Solar irradiance, temperature and wind speed data is gathered from a grid connected, 28.8kW solar power system located in central Manchester. Real-time measured parameters are used as inputs for the developed system. The proposed model and its control strategy offer a proper tool for smart grid performance optimization.

Noor – ul –Ain et al. (2018) Conventional energy resources are being replaced by Renewable energy sources mainly due to increasing environmental concerns. Photovoltaic (PV) and Fuel cell (FC) are suitable to be used in modern DC microgrids due to their DC output. In this research work, a DC microgrid structure is proposed for small residential areas using hybrid PV and FC generation. Power Electronic converters are used to regulate generated voltage of the two sources for integration to a common DC bus. Proposed system is simulated using MATLAB SIMULINK to observe its performance. Simulation results show that output voltage is properly maintained at different DC buses of the microgrid. FC is suitable to cope up the variation in PV output and maintain load requirements.

Rupesh S.Patil et al. (2018) The energy is the very important parameter for survival or today's growth we can transfer the energy from one form to other. The mainly wind and solar energies are the most available among other renewable energy sources in all over the world. In the present years, because of the rapid advances of power electronic systems the production of electricity from wind and photovoltaic energy sources have increased significantly. In this paper, the performance of the wind/PV hybrid system is studied under different grid perturbation conditions. Based on the benchmark solid oxide fuel cell (SOFC) dynamic model for power system studies and the analysis of the SOFC operating conditions, the nonlinear programming (NLP) optimization method was used to determine the maximum electrical efficiency of the grid-connected SOFC subject to the constraints of fuel utilization factor, stack temperature and output active power. The optimal operating conditions of the grid-connected SOFC were obtained by solving the NLP problem considering the power consumed by the air compressor. With the optimal operating conditions of the SOFC for the maximum efficiency operation obtained at different active power output levels, a hierarchical load tracking control scheme for the grid-connected SOFC was proposed to realize the maximum electrical efficiency operation with the stack temperature bounded.

Houssem CHAOUALI et al. (2017) This work aims to develop an accurate energy management strategy for a hybrid renewable energy system feeding a pumping

station. A developed model under Simulink environment is used to compare the performance of the pumping system when it is only fed by a photovoltaic generator, by a hybrid photovoltaic and fuel cell system and finally by a hybrid photovoltaic, fuel cell and a super capacitor system. The developed control strategy is based on Fuzzy Logic control technique. Several simulations in different dramatic scenarios of working conditions show that the developed control strategy brought major enhancements in system performance and that the use of the super capacitor makes economic profits by reducing the fuel cell production during critical solar irradiation periods.

Conclusion: This paper has provided a review of challenges and opportunities on integrating solar PV and fuel energy sources for electricity generation. The main challenge for grid-connected system as well as the stand-alone system is the intermittent nature of solar PV and fuel sources. By integrating the two resources into an optimum. Combination, the impact of the variable nature of solar and fuel resources can be partially resolved and the overall system becomes more reliable and economical to run. This definitely has bigger impact on the stand-alone generation. Integration of renewable energy generation with battery storage and diesel generator back-up systems is becoming a cost-effective solution for stand-alone type. The fuel battery-diesel hybrid configuration can meet the system load including peak times. Energy management strategies should ensure high system efficiency along with high reliability and least cost. Good planning with accurate forecasting of weather pattern, solar radiation and fuel speed can help in reducing the impact of intermittent energy. Voltage and frequency fluctuation, and harmonics are major power quality issues for both grid-connected and stand-alone systems with bigger impact in case of weak grid. This can be resolved to a large extent by having proper design, advanced fast response control facilities, and good optimization of the hybrid systems. The paper gave an overview of different research works related to optimal sizing design, power electronics topologies and control for grid-connected and stand-alone hybrid solar PV and fuel systems. Solar PV and fuel hybrid system can be connected in a common DC or common AC bus whether they are working in a grid-connected mode or a stand-alone mode.

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