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A Literature Review on Energy Management with Renewable Energy Sources

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Abstract: Renewable energy sources have emerged as an alternative to meet the growing demand for energy, mitigate climate change, and contribute to sustainable development. The integration of these systems is carried out in a distributed manner via Microgrid systems; this provides a set of technological solutions that allows information exchange between the consumers and the distributed generation centers, which implies that they need to be managed optimally. Energy management in microgrids is defined as an information and control system that provides the necessary functionality, which ensures that both the generation and distribution systems supply energy at minimal operational costs. This paper presents a literature review of energy management in Microgrid systems using renewable energies,

Keywords: microgrids; energy management; renewable energy; optimization; photovoltaic; energy storage.

I Introduction

The exponential demand for energy has led to the depletion of fossil fuels such as petroleum, oil, and carbon. This, in turn, increases the greenhouse effect gases. Energy systems have incorporated small-scale and large-scale renewable sources such as solar, wind, biomass, and tidal energy to mitigate the aforementioned problems on a global scale [1]. Global energy demand will grow by more than a quarter to 2040, when renewable sources are expected to represent 40 percent of the global energy mix. The reliability of the renewable sources is a major challenge due mainly to mismatch between energy demand and supply [2]. Renewable energy resources, distributed generation (DG), energy storage systems, and microgrids (MG) are the common concepts discussed in several papers [3]. The increase in the demand for energy and the rethinking of power systems has led to energy being generated near the places of consumption. This energy is derived from renewable sources, which are becoming increasingly competitive due to a drop in prices, especially in the case of photovoltaic solar and wind energies [4]. Due to strong dependency on climatic and meteorological conditions, in many cases the optimal system is a hybrid renewable energy system (considering one or more renewable sources) with battery storage systems (and in some cases including diesel generator) [5]. The hybrid energy systems are typically used for electricity supply for several applications such as houses or farms in rural areas without grid extension, telecommunication antennas, and equipment, and many other stand-alone Appl. Sci. 2019, 9, 3854; doi:10.3390/app9183854 www.mdpi.com/journal/applsci Appl. Sci. 2019, 9, 3854 2 of 28 systems [6,7]. In many cases these hybrid systems imply the highest reliability and lowest costs compared to systems with only one energy source [8,9]. A microgrid consists of a set of loads, energy storage equipment, and small-scale generation systems [10]. It can be defined in a broader sense as a medium or low distribution grid, which has distributed generation including renewable and conventional sources (hybrid systems) with storage units that supply electrical energy to the end users. The reliability of the microgrid is improved by the storage and it is used to complement the intermittency of the PV and wind output power [11–13]. These microgrids have communication systems that are necessary for real time management [14]. Microgrids can also operate either in isolation or when connected to a grid [15]. Based on the type of source they manage, microgrids can be classified as direct current line (DC), alternating current line (AC), or hybrid (shown in Figure 1). without grid extension, telecommunication antennas, and equipment, and many other stand-alone systems [6,7]. In many cases these hybrid systems imply the highest reliability and lowest costs compared to systems with only one energy source [8,9]. A Microgrid consists of a set of loads, energy storage equipment, and small-scale generation systems [10]. It can be defined in a broader sense as a medium or low distribution grid, which has distributed generation including renewable and conventional sources (hybrid systems) with storage units that supply electrical energy to the end users. The reliability of the Microgrid is improved by the storage and it is used to complement the intermittency of the PV and wind output power [11–13]. These microgrids have communication systems that are necessary for real time management [14]. Microgrids can also operate either in isolation or when connected to a grid [15]. Based on the type of source they manage, microgrids can be classified as direct current line (DC), alternating current line (AC), or hybrid (shown in Figure 1[19]

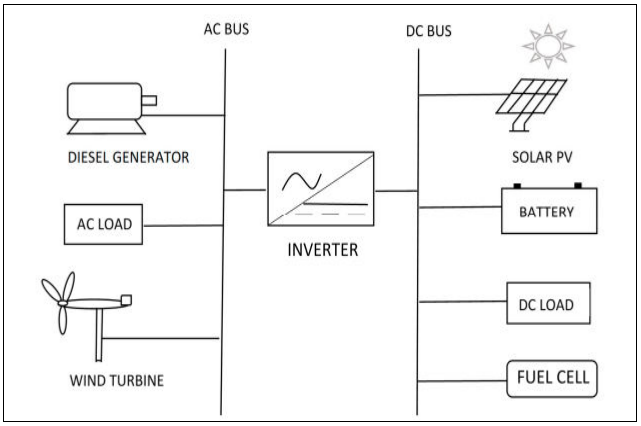

Figure 1. A hybrid isolated Microgrid scheme.

In a Microgrid, it is essential to maintain the power supply-demand balance for stability because the generation of the intermittent distributed sources such as photovoltaic and wind turbines is difficult to predict and their generation may fluctuate significantly depending on the availability of the primary sources (solar irradiation and wind). The supply-demand balancing problem becomes even more important when the Microgrid is operating in stand-alone mode where only limited supply is available to balance the demand. Energy management optimization in microgrids is usually considered as an offline optimization problem .Microgrids supported with renewable energies can be classified as smart grids, which provide a set of technological solutions to allow information exchange between the consumers and the distributed generation. An energy management system (EMS) is defined as an information system, which provides the necessary functionality when supported on a platform to ensure that generation, transmission, and distribution supply energy at minimal cost Energy management in the microgrids involves a control software that permits the optimal operation of the system .This is achieved by considering the minimal required cost and two Microgrid operation modes (isolated and interconnected). The variability of resources such as solar irradiation and wind speed must be accounted for when considering microgrids with renewable energy sources.

II REVIEW OF LITERATURE

Chung-Hsinz Chao et al. (2019) presents a regulatory architecture developed to steer electric golf cart hybrid power with an extended action of 5 kW. A hybrid power system consists of a fuel cell stack, batteries, ultracapacitors banks and individual power conditioner units. The proposed strategy consisted of three levels with different frequency and duration of use to optimize the overall operation. The power demand of each energy source is determined in real-time according to the frequency distribution and the cutoff frequency defined in the dynamic capacity of the energy source. In this study, to consider the characteristics of each energy source, it is easy to find the optimal set point for them. We have acquired a functional simulation that ensures that the power is in proper battery and Supercapacitor charge. The fuel cell requires a soft current to operate under safe operating conditions. The results also show that the control strategy can adjust the DC bus voltage with the CYCUDDS golf cart drive cycle to the load profile.
Zahra Amjadi et al. (2019) described the stability of the use of a switched-capacitor converter (SCC) topology with cell equalization for batteries in hybrid energy storage systems (ESS) and ultracapacitors (UC) modules. The main advantage of using SCC for energy management in electric vehicles and plug-in hybrid electric vehicles (EV/PHEV) is a simple and easy control strategy that reduces the size and cost of low electromagnetic interference (EMI) energy ESSs without transformers and inductors.
RajarshiSaha et al. (2019) a power management technique for use in hybrid electric vehicle (EV) systems is described in this paper. In today's world, renewable energy sources such as solar power, fuel cells, and wind power are extremely important, and one of the many application fields for these sources is hybrid electric vehicles. Because of its great efficiency and dependability, photovoltaic (PV) energy was chosen as the principal power source for electric vehicles (EVs) in the current study. However, in order to ease the problem of solar cell intermittent news, supplemental sources must be used in conjunction with PV. PV with MPPT alone will not be able to meet load demand without the assistance of a backup source, especially when the load is of a high-power requirement. As a result, hybrid energy systems that include PV, batteries, and ultracapacitors are taken into consideration. As a backup power source, battery cells and

supercapacitors are employed. A bidirectional DCDC converter stores extra solar energy and discharges it to the load when the power is required. On the PV side, two cascade boost converters are employed in conjunction with each other. Through the use of a P & O (MPPT) controller, the primary conversion is utilized to extract the greatest power possible, while the secondary conversion is employed to establish the DC link voltage in a stable manner. When there is a load fluctuation, the results of the MATLAB simulation are observed to depict the response behavior of the PV modules under various lighting situations using the MPPT method, as well as to reflect the power coordination between the PV cell battery and the ultracapacitors.

Zahra Amjadi et al. (2020) A control strategy for fuel cells (FC), batteries and Ultracapacitors (UC) modules in electric vehicles (EV) and hybrid electric vehicles (HEV) is being proposed and studied in 4Quadrant (4Q) switch capacitors became (SC) Luo DC/DC bidirectional converter. The FC strategy is also one of EVs' most popular and favorite energy storage systems (ESS) due to its high efficiency and ability to use hydrogen as fuel. FC and UC modules can be combined to produce a high-speed dynamic response and high output, making them ideal for automotive applications. FC also contains a high energy density, and its weight is 8-14 times that of a lithium-ion battery (Li-ion), and the FC stack can extend the battery life of EVs and HEVs. This white paper describes a novel topology and intelligent balancing strategy proposed for EV and HEV energy storage system (ESS) applications.

MohdShadman et al. (2018) contains information about the most reliable electric car (EV) with an extended energy source. The most important energy source includes Solar-PV, PIN and (UC). The battery acts as an important energy source for the system connected to the electrode capacitor. It acts as an energy source in the transition time, for example, during the engine's start and breaks. PV solar cells operate in stable arrangements with an improved range of movements, thereby reducing the battery size with improved battery life and rapid reaction most of the time. There is a lack of performance if there is uneven sunlight, so the system requires energy storage devices. Normally, this type of app valve (VRLA) lead-acid battery (VRLA) is used. However, the battery plate will be invalid due to the decline to provide a large demand for electrical current during the engine start process. Other methods to provide great needs include additional VRLA batteries and supercapacitors to build a new hybrid storage system. The battery immediately functions as a continuous power source and Supercapacitor in this hybrid system. This article summarizes different methods to improve the efficiency of electric vehicles.

Lizhou Liu et al. (2019) Hybrid Energy Storage System this article displays an automatic balancing based on the switch-panel Switched-Capacitor converter. The advantage of the proposed system is that ultracapacitors and winter packs can simultaneously lead to equilibrium; this recognizes the energy exchange between two types of cells. In addition, the Series-Parallel Switched-Capacitor series is proposed to achieve a high level of compensation, regardless of the number of cells or their places in Hess. Only a symmetric circuit is needed to reduce the size and costs. An experimental prototype of 2 shared lithium batteries and an ultracapacitors series, which has created the test results, checks that the proposed negative adjuster can achieve the balance of ultracapacitors.

V M Sreekala et al. (2020) Battery-powered electric vehicles have several challenges: power density, continuity of supply, and longevity. A separate power source is connected to the battery to solve this problem. This paper proposes a battery ultracapacitors (UC) hybrid energy storage system (HESS). This combination arrangement provides better power and energy density. In this case, the UC supports both the acceleration period and the regeneration period of an electric vehicle (EV). This white paper describes a HESS monitoring controller with a bidirectional 3-port buck-boost converter and a brushless DC (BLDC) motor. The proposed control strategy uses a conventional proportional-integral controller (PI) and a fuzzy logic controller (FLC) to adjust the battery's power level and UC's state of charge (SOC) and evaluate them with MATLAB® simulations. Based on the simulation results, it was confirmed that the controller effectively splits the load demand of the battery and UC.

Jianlin Wang et al. (2020) The varying dynamic characteristics of different vehicle power sources must be taken into consideration while managing the energy of new energy vehicles. An energy management technique for fuel cell/battery/ultracapacitors hybrid energy storage systems in fuel cell electric vehicles is proposed in this research, which is real-time predictive in nature. To anticipate the future speed of the vehicle and compute future power consumption, LSTM Neural Network Speed Prediction was built. It is necessary to use the wavelet transform method to safeguard fuel cells and batteries from transients that change fast and from conditions of high peak power consumption. A rule-based technique for controlling the SOC of the power supply has been implemented. The results of the simulation reveal that the accuracy of LSTM-based forecasts for energy management is satisfactory. Using the proposed energy management method, it is possible to successfully reduce the power frequencies of fuel cells and batteries while maintaining the state-of-charge (SOC) of the Supercapacitor within a suitable range, hence maintaining vehicle performance.

K. Nakul Narayanan et al. (2018) provided a hybrid multiport bidirectional converter system for hybrid electric vehicles (HEVs). The proposed hybrid multiport topology consists of an IC engine coupled to an alternator with a battery bank, a Supercapacitor bank and shares a common DC link. The topology provided uses a high gain converter as the DCDC converter interface. A new control strategy for the closed-loop operation of the proposed topology is also presented. Control strategies are validated in PSCAD / EMTDC using time-domain simulation. A hardware prototype was created to verify the performance of the high gain DCDC converter.

A. A. Khan et al. (2019) Electrical energy storage has been an important element since generating electrical energy. The only option that could be stored for a long time was another electrochemical energy storage device known as a battery. But now, the fusion of electrostatic devices and chemical elements is available for storage known as ultracapacitors (UC). Both products store electrical energy as DC. Batteries are more energy-dense, and UCs are becoming more power-dense. In the case of a smart grid, the energy generated changes according to differences in environmental conditions. A change in the supply of energy from the smart grid to the battery or from the battery to the load reduces the system's reliability. A hybrid energy storage system (HESS) can provide reliability by supplying energy to the battery and the UC load. Electric vehicles (EVs) are a new trend in the automotive sector. HES onboard EVs improve the reliability of the vehicle's energy storage system. The simulation results confirm the above statement by powering a 2kW load, including transients.

V. Vaibhav Krishna et al. (2019) propose hybrid energy source support for electric vehicles to completely reduce the vehicle's burden of one source supply. In general, only the battery is fully supplied during all continuous operations in an electric vehicle. The motor consumes high current during rapid acceleration/deceleration and braking conditions. Low battery SOC creates thermal stress and heat, which shortens battery life. Therefore, in this study, we proposed a Supercapacitor that drives the vehicle to extend the battery's life. The battery supports the car with high energy and supplies high power with the immediate operation of the super capacitor during sudden deceleration of the motor and braking. This will help reduce the burden on one source, and these hybrid sources will help extend the life of the source in the long run. A DCDC boost converter is a BLDC (brushless DC) in which a lithium (Li) battery, a hybrid source, and an ultracapacitors are connected to maintain a power balance between the source and, if necessary, the source is used in an electric vehicle. It can be connected to a motor). The system was developed using MATLAB / Simulink.

Zheng Guan et al. (2019) research on hybrid power supplies with combined batteries and ultracapacitors is a hotspot in the field of electric vehicle research. The battery has a super capacitor with high energy density and power density. Perform a detailed analysis of the operating modes of the hybrid power supply system and propose an energy management strategy based on speed and speed in order to reasonably control the two types of output power and realize a more efficient operation of the electric vehicle. The MATLAB / SIMULINK simulation environment simulates a hybrid power supply for an electric vehicle and the proposed control strategy. The simulation results show that the Supercapacitor current can accurately follow the reference current. The proposed control strategy can reasonably distribute the battery and Supercapacitor outputs to meet the energy output for different power supply requirements. It shows that it is done.

Sharon S. George et al. (2018) this paper introduces a novel energy management system (EMS) for hybrid energy storage in electric vehicles (EVs). The use of ultracapacitors as power pulsation storage in EVs can reduce the inefficiencies associated with the low power dynamics of battery cells. Therefore, since lithium-ion batteries have a high energy density, EVs can supply average power. These hybrid systems lead to managing the energy between each battery and the UC cells. In addition, the EV drive power train should extend the maximum torque per ampere operation to account for the load conditions of the motor. Therefore, modular multi-converters are configured to manage energy between different storage cells for EV applications. And with MMC, you don't need a system-level drive or inverter to power your EV motor. The results are presented to validate the efficiency of the proposed configuration.

III Solar PV Stand-alone System

Solar cell systems or solar cell systems are power systems designed to deliver functional solar power through solar cells. It consists of many apparatuses, counting photovoltaic systems that absorb sunlight or convert it into electrical power, photovoltaic systems that convert electricity from direct present to alternating current, or installation, wiring or other electrical accessories to build a functioning classification. It can also use solar cell tracking systems to recover largely performance of classification and include integrated battery solutions as the price of storage devices is predicted to fall. Strictly speaking, a photovoltaic system includes only a synergy of photovoltaic systems, that is, the visible part of the photovoltaic system, excluding all other hardware, and is usually summarized as the balance of the system. In addition, the photovoltaic organization directly convert light into electrical energy or should not be mystified with other technologies, such as concentrated solar energy or solar heating for heating and cooling.

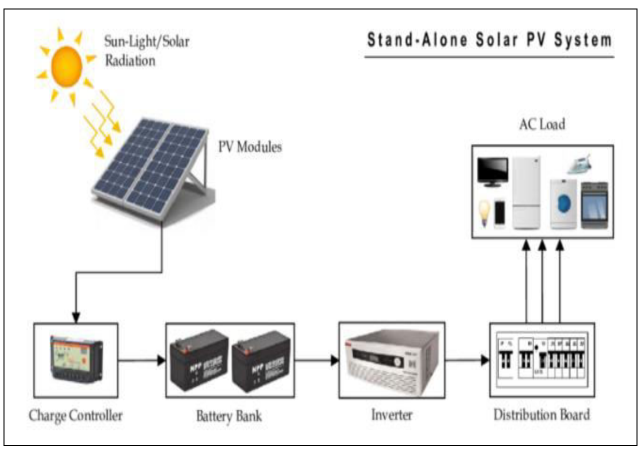

Figure 1.2: Solar PV Stand-alone Power System

The annual solar energy that India receives is equivalent to more than 5,000 trillion kilowatt-hours, far exceeding its total annual consumption. The global daily radiation is approx. 5 kWh / m2 day and most of India's annual sunshine time is between 2300 and 3200 hours. Despite the low energy density and discontinuous availability, this abundantly available energy can now be used very dependably for many purposes by converting it to usable heat or directly generating electricity.

The conversion arrangement is modular or can be used appropriately for decentralized functions. A typical photovoltaic independent system consists of photovoltaic systems and battery connections, as shown in Figure 1.2. The array controls the load or indicts battery during the day. The battery supplies power to load after dark. The inverter converts the direct current of the array or battery to 60 or 50 Hz power.

Ultracapacitors-Conventional capacitors store energy by physically separating unlike charges on two separate electrodes with a dielectric in between. This charge separation causes a potential between two electrodes. Ultracapacitors, on the other hand, do not make use of the electrolyte in the same way. A significant charge separation is achieved by the use of electric double layer technology, resulting in extremely large capacitance. In Figure 1.8, you can see that they are made by two metal electrode foils that have been coated with activated carbon, which are immersed in an electrolyte and separated by a paper separator.

Electrons collect in the electrode that is connected to the negative terminal and attract positive ions from the electrolyte as a result of the electrostatic attraction. Positive charges attract negative electrolyte ions on the other electrode, and current flows via the external load on the other electrode. The separator prevents current from flowing directly between the two electrodes and creates the appearance of two charge layers, which is why ultracapacitors are also referred to as electric double-layer capacitors when they have two charge layers.

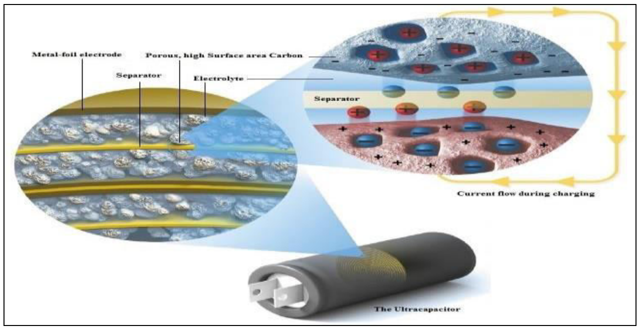

Figure 1.3: An Ultracapacitor's Physical Structure

Since the electrodes are made of a porous material, the charge can be stored in the micro- pores at the electrode and the electrolyte interface. Moreover, the electrode surface is significantly larger than a normal capacitor reaching 2000 $m2/gr$ [1]. This combination of large surface and small separation between electrodes enables capacitances to reach thousands of farads. This structure has major implications on the properties such as cycle life, efficiency, energy and power density, and voltage as a function of SOC.

IV Conclusions

The literature review highlighted two approaches for Microgrid energy management: The centralized and decentralized approaches. The first incorporates optimization using the available information in the absence of a coordination strategy between the actors in a Microgrid. A computer centre transmits the optimal settings to each participant. The second approach implements optimization using partial information and a strategy for coordinating the Microgrid participants; each participant evaluates its own optimal settings. Centralized management is mostly implemented in metaheuristic methods, and decentralized management is frequently implemented in methods based on multi-agents. Many publications have proposed centralized management for microgrids. However, the incursion of distributed energy resources (DER) may cause this type of management to face issues when implemented in a centralized information system because there might be a demand for high computational cost due to the large quantity of data. Distributed energy management may be an alternative solution to this problem. It solves the problem of data processing and reduces processing needs by using distributed controllers that manage the data in real time and require communication equipment that might result in additional costs (for e.g., Bluetooth, Wi-Fi, wireless networks, and IoT)

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