Performance of Hybrid Energy Systems - A Review

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Abstract: *Hybrid power system technologies will still be in the developmental stages. In the following years, technology is likely to advance, allowing for more application and lower costs. More standard designs will be available, making it very easy to select the systems that is better suited to certain applications. When compared to a systems relying on a personal sources, this systems brings together different producing, storing, and use strategies in an unified system, resulting in improved benefits. As a result, this paper gives an overview of hybrid power systems and how STACOM can be used in them.*

Keywords: *Renewable Energy, HRES, STATCOM, Photovoltaic- Wind Energy Systems,*

I. Introduction

Renewable energy has varied meanings for different groups of people. Because there is minimal debate about just what power is in all of its forms, the term renewable energy conjures up a broader range of characteristics. Power is a physical product's power to act or, potentially, generate electricity in its most basic form. The mechanics of a system are determined by energy. On the other hand, renewable energy relates to the power's sources; as a result, data (or misconception) regarding the source is commonly mixed up with ideas and viewpoints concerning renewable sources. Renewable energy is derived from a perfect replacement that regenerates itself over a short period of time. As a result, any discussion of renewable energy basically comes down to renewable energy sources deduced from geophysical techniques, such as sunlight, winds, tidal currents, maintenance bioenergy, wave movements, tidal currents, and geothermic power.

Renewable energy is defined as power circulating that is continually replenished by natural occurrences. In contrasts, fossil and nuclear fuels, as well as oil, appear to be energy holding with constrained measurement at various points, rather than stream. Because coal and natural gas fuel, along with oil, are energetic resources, they will indeed be depleted at some point. The amount of energy which can still be retrieved, and hence the time until it runs out, is determined by the availability of innovative technology that can extract the fuel at a reasonable cost. Technological advancements will increase the amount of fuel that can be recovered while also enhancing the procedure's principles of economics. Nonetheless, the environmental and long-term effects of this invention and the extraction technique must be examined. Moreover, increasing limited availability may affect fuel retrieving economic systems by significantly escalating the cost where it is deemed commercially possible. Furthermore, technology's ability to enhance the availability of fossil energy, including oil, is limited, so a technological "fix" may not be the answer.

In compared to a single-source system, hybrid energy systems (HESs) combine two or even more producing, handling, and utilization innovations into a single network, resulting in greater benefits. Originally intended to include traditional, extractable generation (e.g., diesel generators) and energy storage devices (BESSs), their definition has since been expanded to include processes that are entirely powered by renewable energy [e.g., solar photovoltaics (PV) and wind], as well as methodologies that combine various energy storage systems (e.g., BESSs, fuel cells, and supercapacitors). HESs have improved in capability, going from small, off-grid operations of a few kilowatts designed for low-voltage DC and AC to larger megawatt devices that can now connect to the grids at medium power. The specific use conditions for HESs, availability, voltage regulation levels, and power system are all major factors that influence the requirement for power electronic devices used during HESs.

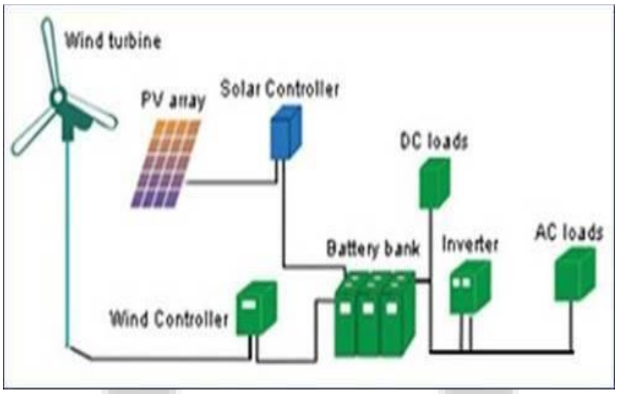

Figure 1: Hybrid Energy Systems

This paper starts with an analysis of hybrid energy systems, followed by chapters on photoelectric wind power generation, STATCOMS utilities in hybrid energy systems, and a survey of the research on hybrid power systems from various perspectives.

II. PHOTOVOLTAIC- WIND ENERGY SYSTEMS

Limited PV-Wind hybrids systems have been found to be the focus of ongoing efforts in rural areas. When both suppliers are used in one hybrid version, a few of the negative effects of the both source are reduced. While wind and solar power technologies have significant upfront prices, repair expenses were always cheaper when compared to the price of power generation using a diesel engine turbines. As a consequence, a PV-Wind hybrid technique eliminates items such as a battery pack and fuel, allowing power generated in this manner to be less expensive than power produced through other methods. The stand-alone hybrid system is made up of a fairly small photovoltaic (pv) system and a wind turbine. Other requirements are essential, such as a battery system, rechargeable battery, and converter.

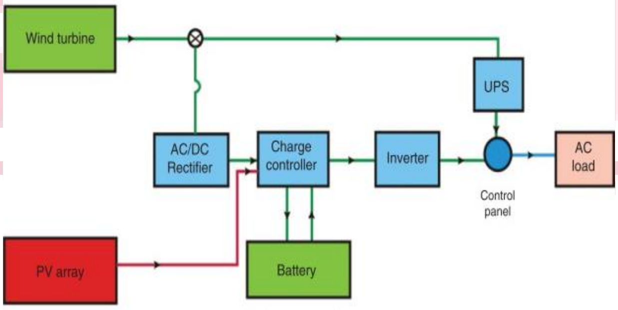

Figure 2: Typical Photovoltaic - Wind Energy System

Wind-driven stand-alone process have already proven to be a viable power source capable of meeting the power generation needs of the full set of mobile customers worldwide, especially in places with medium to high wind power generation. Furthermore, in areas where environmental factors are less favorable, the excessive storage energy needed by the wind generator, as well as the fact that the turbines must be maintained, discourage customers from moving forward with RES implementations.

III. Static Synchronous Compensators

STATCOM enhances the voltage regulation of the wind energy PCC by continuing to fund the required power factor (capacitive mode). The Static Synchronous Compensator (STATCOM) compensates for voltage regulation in a Power converters. Using the Voltage Source Converter, it creates a controllable sinusoidal waveform at the carrier frequency (VSC). When the voltage generated by the STATCOM exceeds that of the AC system, it serves as a capacitors, generating power factor. When the STATCOM's voltage falls below that of the AC system, it serves as a shunted inductance, absorbing power factor. In VSC–HVDC operations, two- or three-level discharge current adapters and multilayer inverters chain link inverters are used.
Overall, the STATCOM is designed to adjust for reactive power, so large power files are not required. Furthermore, there are a few applications where having a small quantity of energy in the dc side could be beneficial, such as accounting for power factor for a brief period of time. In these applications, the dc-side capacitors must always be substituted with an ESS, such as battery packs and double capacitors (super capacitor). To save electricity, another possibility is to use

superconducting magnetostrictive energy storage (SMES) systems. Employing a current source converter (CSC) instead of a VSC to connect to the electrical network would be a viable option using the superconducting materials reactors.

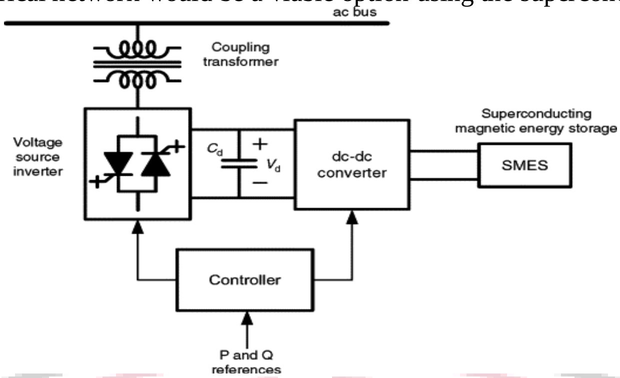

Figure 3: STATCOM with Superconducting Magnetic Energy Systems

When shunt coupled to the system, the static synchronous compensator (STATCOM) is a power electronics conversion that compensates for reactive power. However, various records demonstrate that all these equalizers are utilized to manage voltage regulation aspects in distribution networks, despite the fact that they were created to improve the stabilizing margin and transmission capacities of electrical networks. In these situations, they're known as allocation static synchronous compensators (DSTATCOM). In contradiction to transmission networks, voltage differences in electricity transmission system is typically produced by load fluctuations, short circuit in transformer windings and motors, and differences in conveyors frequency response, among other things.. Even though going to balance one- and dual-phase power stations between many transmission networks can help mitigate this unfavourable impact, the increasing use of grid-connected solitary distributed energy resources, especially those reliant on green tech such as roof-mounted photovoltaic (pv) processes, and the increasing number of required to charge machines for electromobility, could jeopardize the unbalanced voltage indexes of electric powered nodes in the cluster.

IV. LITERATURE REVIEW

(Gandoman et al., 2018) [1] The growing use of renewable and distributed energy sources in the electricity network has posed new problems for utilities in terms of power consumption, voltages stabilisation, and power efficiency over the previous couple of decades. Power electronics are widely used to connect developing energy systems (both with and without energy storage) and intelligent buildings to transmission and distribution lines. Flexible ac transmission systems (FACTSs) and power supply conversion with clever dynamics controls are gaining traction as voltage stability stabilisation and filtration devices. In smart metering with renewable energy sources, distribution FACTSs also play a key role in optimizing the output power, electricity utilisation, upgrading voltage stability, and assuring effective energy consumption and energy management. This study provides a literature review of FACTS technologies devices and techniques for improving voltage stability and maximizing the use of renewable energy systems.

(2. Sun2017.Pdf, n.d.) [2] Rapid development of renewable energy in China is d In China, the rapid development of renewable energy is causing a dramatic change in the characteristics and controlling required of the power system. Transmission over vast distances is essential because the best renewable energy resources are located in different from transmission network in the east and southeast. There are about 20 high-voltage DC (HVDC) transmission lines in operational or even under development, with a total capacity of over 150 GW. This rapid expansion of digital generation and distribution capacity depending on the power computers begins to alter the grid's characteristic, particularly in places where they are concentrated, posing significant stabilization and operating concerns. To enable the construction and operation of a futuristic network that increasingly relies on electrical machines, new scheme theory and technology are needed. This article describes the characteristics of power electronic goods which is used in renewable energy century and HVDC transmission networks, the effects of the these industrial equipment on electric grid and operating procedures, and possibilities for the implementation of novel system theories and scheme technology to support a national electricity strategy that reinforces its use of renewable energy.

(Subramanian et al., 2018) [3] This paper looks at how STATCOM controls are used in a variety of applications, including voltage management, stability improvement, SSR reduction, utilization of renewable energy networks, energy storage devices, and coordinating with HVDC systems. Different search engine, such as IEEE Xplore, SCOPUS, and others, were used to find journal papers. The papers in this evaluation were published between 2016 and October 2017. (until the submission of this Review paper). Only 75 of the 260 journal papers retrieved in this searches were located using IEEE Xplore, with the remaining 170 discovered through non-IEEE search results.. This Bibliography contains a total of 60 papers due to page constraints. The remaining papers' bibliographical citations will be posted on the IEEE Work Group's website. The goal of this Working Group paper is to distribute information and, as a result, educate the global power and energy networks industry about STATCOM controllers for dataset includes advantages.

(Yap et al., 2019) [4] This research article provides a thorough examination of VI-based inverters in current energy networks. Due to the intermittent nature of wind and photovoltaic (PV) generating, the transition from synchronous generator (SG)-based conventional energy production to conversion tool renewable energy sources (RES) degrades the frequency stability of the power system. The lack of angular momentum, in contrast to the conventional energy production, is becoming the principal issue in connecting RES to the electricity network via power electronic devices. Researchers have addressed this problem in recent years by mathematically simulating the behavior of SG using a pulse width modulation (PWM) control linked to traditional inverter topologies. These devices, which include a virtual synchronous machine (VSM), virtual synchronous generator (VSG), and synchronverter, are referred to as VI-based inverter. This study delves into one of the most recent developments, applications, problems, and future prospects of VI applications, which is critical for the transition to a low-carbon electricity system.

(Sridhar & Umashankar, 2017) [5] uration is not appropriate for extremely high voltage rating, and the size of the AC side filter necessary to ensure grid power quality is large. It is expensive in terms of extracting maximum energy because maximum power point is done for full PV arrays coupled together rather than individual MPPT for each PV array. The utilization factor of a traditional PV inverter is likewise quite low, because the systems will be idle at night and then when the irradiance is weak. As a result, a traditional solar inverter with two or three levels has the following disadvantages: (a) Not appropriate for very high power ratings (b) Large filter size (c) Ineffective in harvest maximum power (d) Low utilization factor. The need for a multilayer inverter (MLI) to mitigate the shortcomings of a traditional inverter is explored in this paper. The Cascaded H-Bridge (CHB) arrangement, which is preferable for solar energy application with isolated input DC sources and for STATCOM applications without the need for DC sources, is explained in depth. Simulation results are used to show the basic working of the CHB inverter, PWM approaches, and fault tolerant processes.

(Carunaiselvane & Chelliah, 2017) [6] To meet the aspirations of the majority of the worldwide people and the requirement for environmentally conscious conserving energy, renewable energy systems (RES) have become as necessary as other power systems. Asynchronous machines are commonly employed in windy and hydropower to provide more chances and challenge for power in order to get a stabilized RES. This research examines multiple kinds of asynchronously machines operating at varying speeds, as well as the present control strategies used to achieve stable the RES. In this context, a study of the steady evolution of machinery and the function of electrical machines in enabling them to accept modern technologies has been conducted. There are also extra advantages in regards to energy economy when comparing synchronous and asynchronous machinery in variable speed operation. The paper focuses on the current trends and future prospects in asynchronous devices, which can contribute significantly to the expansion of RES.

(Jing & Maklakov, 2018) [7] The goal of this study is to give a quick overview of voltage source converter (VSC) topologies and operational characteristics for energy storage applications like high voltage dc transmission (HVDC) and flexible ac transmission systems (FACTS), that could be used in the fields of electricity generation, transmitting, and dispersion. The neutral-point-clamped (NPC), flying-capacitor (FC), cascaded H-bridge (CHB), and proposed multilevel converter are among the VSC-based highly energetic consumption topology shown and analyzed in this work (MMC). There is also a list of available industrial VSC-based highly energetic consumer. These conversions' most prevalent and relevant energy application are listed. Finally, the directions for future of their development are as follows. Each conversion topologies and controlling mechanism is directly tied to each unique application, resulting in a wide range of alternatives for diverse energy application, each with its own range of technical parameters such as stability analysis, dynamic response, and total cost.

(Al-shetwi et al., 2019) [8] Various ways have been presented in recent years to meet the FRT requirements set by power system. During grid fault scenarios, this study provides an overview and comparative of numerous FRT capability augmentation options. This study is unique in that it divides FRT capacity augmentation methods into two groups based on control type and connections configurations, including exterior devices-based ways and modified control system methodologies, and then discusses their benefits and drawbacks in depth. In this study, a comparison of different methods is made in terms of network code compliance, controllers complexities, and economic viability. FRT techniques relying on portable drives, according with literature review, may be more efficient. Furthermore, several of these techniques come at a hefty cost premium.

(Telukunta et al., 2017) [9] For reliable planning and operation of renewables integrating energy systems, the designing and selection of the appropriate protective plan is critical. The protective standards vary according to the number of infeed and location of renewables integrated. The present relay settings are immune to any modest changes in the system fault from prospective new renewable for low renewables outfeed at the distribution system. Furthermore, in order to accept the fault conditions variance from the entering renewable, existing security mechanisms must be modified.. The need for modified/additional protective measures is unavoidable for large-scale renewable penetration. In the research, adaptable and non-adaptive relaying systems for protecting power networks with dynamic fault currents and often changed network architectures are studied. This article provides a comprehensive overview of renewables integrative electricity supply protection strategies, including distributing, transportation, and microgrid technologies. The benefits and drawbacks of these insurance products are also discussed in this section for the reader' benefit..

(Salem & Abido, 2018) [10] DC–AC converters with highly efficient, harmonic voltage injection, and small size are preferred for renewable energy system integration. Due to its minimal harmonics injections, albeit at reduced switching resonant frequencies, and ability to take large network voltage levels, the multilevel converter (MLC) is chosen over the two-level conversion. The T-type topology is one of the reduced number of switches technologies countMLCs. In contrast to ordinary neutral position clamping converter, this article provides an overview of the various advance topology of T-type MLC. Each topology's operation, design considerations, and performances in reduced application such as AC drive systems, renewable electricity grid-tie integration, and engine and transmission drive application are reviewed. Furthermore, design issues for enhanced switching devices are discussed. Various MLC-related investigations are demonstrated, including common-mode voltage elimination or reduction, open-switch fault diagnostics, open- and short-circuit fault - tolerant, and Switched capacitor current - voltage characteristics for T-type topology. Finally, suggestions for future study possibilities are discussed.

V. Conclusion

Hybrid energy systems (HESs) are a promising and long-term alternative for electricity production in stand-alone applications. In addition to strictly expense objectives, and it's becoming increasingly important to consider additional factors such as lowering pollutants or improving system stability. In this document, the most typical HES setups are discussed. In addition, a number of researchers have studied Hybrid Energy Systems from various perspectives, which were also found in the literature study.

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