Comprehensive Study of 3-Level Stabilizer in Hybrid PV and Wind Energy Systems- A Review

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***Abstract*: When variables are bounded so that almost the whole constraints are satisfied, power system stability is typically characterized as an electric power system's ability to restore a situation of functioning equilibrium after being subjected to a physical disturbance.This paper presents a thorough investigation of three-level stabilizers in a hybrid PV Wind Energy system that is integrated with the power system. From a hybrid renewable energy system that is linked to the grid and studied with a stabilizer that uses a variety of control algorithms based on artificial intelligence algorithms developed by several researchers.**

***Keywords**:* Solar photovoltaic system, active power, reactive power, power stability system, grid linked system

I. Introduction

The power system is a network which includes components namely generation, allocation, and propagation. It works by converting the type of energy (such as coal and diesel) into electricity. The synchronous generator, motor, power converter, circuit breaker, conductor, and other devices attached to the network make up the power scheme. The power system's 6 core elements are the power plant, power converter, transmission system, sub - stations, transmission system, and distribution transformer. The power plant creates the power, which would then be step-up or step-down for transmission through the transformer. Power is transferred from the transmission line to the various substations. The power is transferred from the sub - station to the distribution transformer, which steps down the power to the optimum value for the consumers.

Once parameters are constrained so that essentially the entire system remains intact, power system stability is better described as an electricity generation system's capability to regain a state of functioning balance since being exposed to a physical disruption.

Even though traditional forms of energy production, including nuclear and coal, get a large proportion of capital-to-fuel costs, all renewables, with the exception of biomass-initiated electricity (biopower), have no such expenses. The expense of fossil fuels now and in the long term versus the current fixed investment expenses of renewable energy technologies is the trade-off. Renewable and conventional energy production have different scale economics. Larger coal-fired and nuclear-powered generating plants have lower average generation costs than smaller plants, owing to cost savings based on facility size.Renewable electricity accomplishes productivity gains predominantly through equipment manufacturing rather than large-scale facility fabrication at the power station. Large hydroelectric generating units are an exception, as they benefit from on-site economies of scale, although not to the level as coal and nuclear plants.

II. Literature review

Across the globe, HES (hybrid energy systems) are considered as a viable substitute to power production or traditional, dependent on fuel, remote area power supply units. Depending on renewable energy systems, reduced emissions hybrid systems are not expense competitive with conventional fossil-fuel power systems, according to the reviewed literature. The requirement for pure power and advancements in substitute energy mechanisms, on the other hand, point to mass acceptance of these systems. Furthermore, rural residents in both industrialized and developing economies place a high value on a consistent, constrained provision of power [1].Medical centres in villages, education institutions, telecommunications, and water pumping stations are examples of social amenities that can contribute a lot to people's well-being and development in village based area. Although it is acknowledged that innovation can only play a part in community outreach, renewable energy sources have shown the ability to support several of the adequate infrastructural requirements in distant and metropolitan centres for a variety of applications.

A analysis of the literature is conducted on optimization algorithms for sizing and resource utilization of hybrid PV/wind/battery energy systems. As per the latest advancements, the growing body of investigations undertaken for stand-alone implementations far outnumber those undertaken for grid-connected implementations, that also deserve more attention, especially including the micro-grid and smart grid on the horizon [2]. In this frame of reference, an innovative methodology obtained with the proposed discrete cuckoo search algorithm for the optimal design of grid integration hybrid PV/wind energy systems is suggested. A multi-objective minimising function is used to optimise a system that includes PV panels, a wind turbine, and a battery energy storage bank. To evaluate the approach's achievement, two case research has been conducted: initially is a housing , and the next is a livestock farm.

Rnewable Energy systems are a critical component of lowering the negative impacts of change in climatic conditions and global warming brought on by fossil fuels. In light of the foregoing, A comprehend review of controlling the operation and Energy Management Systems strategies used throughout the layout of a standalone PV-WT energy system including fuel cell integration. Because the two characteristics are so directly connected from a system level design point of view introduced in [3], additonally presented a common optimization synthesis system that integrates optimization design parameters, limitations, and decision variables for an improved understanding of the concepts of enhancement. The methodologies for system sizing optimization were then categorized and compared.Computational technique requires fewer function evaluators, although they are not suitable since they are inefficient in a multidimensional explore landscape and are susceptible to encapsulation in local optima. For the best solution, stochastic exploring methodologies are now becoming increasingly popular. A comparison between different EMSs used in standalone PV-WT energy systems with fuel cells was also conducted. The advantages, disadvantages, and constraints of each strategy have also been mentioned. The much more secure and efficient techniques are those that take into account both financial and strategic decision factors.

The electricity consumption is growing every day, and alternative sources of energy alone cannot meet it. Solar and wind power are examples of renewable energy sources that are prevalent and environmentally sustainable. Renewable energy sources are becoming more popular as a means of meeting energy demands, but they are undependable due to the irregular of their event occurring. The term "hybrid renewable energy system" refers to a system that manages to combine multiple renewable energy sources, such as a wind turbine and a solar system. The purpose is to provide a thorough examination of diverse components of HRES. Detailed feasibility assessment, optimum sizing, modelling, control aspects, and consistency concerns are all discussed [4] also discusses the use of evolutionary techniques and gaming concept in hybrid renewable energy.

Hybrid renewable resources have really been widely lauded across he world as a long-term solution to upcoming energy requirements. With this consciousness, [5] provides a detailed literature review on stand-alone and grid linked PV or wind or battery HRES. To provide the students with a clear overview of the work in the domain of HRES, and over 140 academic journals in the regions of mathematical modelling, designing, converter configuration for grid integration, control strategy, and performance evaluation were taken into account.The significance of meteorological conditions, load profiles, modelling of numerous elements of the system, and expense and serviceability facets have all been discussed in depth when it comes to size optimization. The investigators used a variety of size optimization algorithms, including explanatory, repetitive, and artificial machine learning, which have all been observed and explained in section. Artificial intelligence techniques such as GA, PSO, and ACO have also been expected to lower the computation complexity in achieving the globally optimal solution.

The theories of off-grid HRES for electricity production are discussed in this study [6]. Hybrid Renewable Energy System enabling for a significant increase in power consistency, as well as elevated power quality and a reduction in storage server requirement specification, thanks to high precision and rapid optimization algorithms. Distinctive sizing strategies for off-grid PV–Wind Hybrid Renewable Energy Systems were also described in this section.Precise Hybrid Renewable energy system sizing can aid in determining the initial financial investment whilst also ensuring system stability at a low cost. The PV–Wind HRES techniques were also mentioned [6].The methodologies start comparing the quality and power manufacturing costs of various setups, allowing optimization algorithms to be used to determine the best HRES layout. In many circumstances, hybrid energy systems have been shown to substantially lower the overall life - cycle costs of stand-alone power sources while also supplying a more constant supply of energy by the use of multiple sources of energy. Hybrid power processes, on the other hand, may be the most cost-effective alternative in many cases.

Estimated 1/5th of the globe's people do not have access to electricity. Nearly a third of the population in Asia's improving countries are expected to be without electricity. Renewable energy depending off-grid electric utilities are an option to grid-connected electricity [7].Authors have presented an overview of numerical techniques of numerous renewable power systems, concentrating on the three widely used renewable energy sources. For maximum power point tracking, non-linear features of wind energy and Photovoltaic panels including power, voltage, and current are summarized. Power Point tracking (MPPT) techniques and external storing modelling were discussed.

III. SOLAR PHOTOVOLTAIC SYSTEM

The photovoltaic (PV) inverter converts direct current initiated by the solar panels into alternating current, before it can be used by the electric grid. For both central and distributed power installations, the solar inverters are indispensable for connecting to the electric grid. The integration of solar power into the grid is presumed to have a negative impact on the resiliency and reliability of the electricity system according to the grid operators. This is due to its non-dispatchable and intermittent nature i.e. the sun cannot be controlled and cloudiness as a result of dynamic characteristics of the atmosphere. Considering an instance whereby the solar photovoltaic panel experiences cloudiness, the light intensity which the panel receives reduces, resulting in the output voltage to drop.

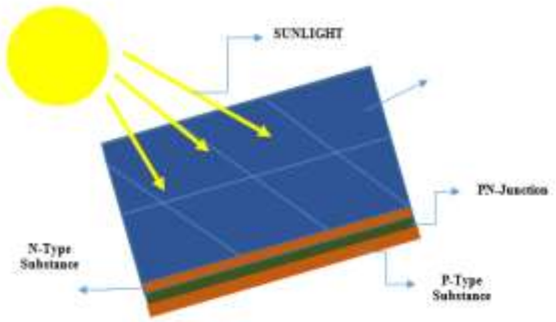

Figure 2 Solar PV System

Solar power involves the conversion of the radiant energy from the sun into electricity by using photovoltaics (PV) or concentrating devices. When sunlight strikes the surface of the PV cell, some of the photons are absorbed and release electrons from the solar cell that are used to produce an electric current circulation, i.e., electricity. A solar cell consists of two layers of materials, one that absorbs the light and the other that controls the direction of current circulation through an external circuit. The absorbing materials can be silicon (Si), which is also used in integrated circuits and computer hardware; thin films of light-absorbing inorganic materials, such as cadmium telluride (CdTe) or gallium arsenide (GaAs), that have absorption properties well matched to capture the solar spectrum; or a variety of organic (plastic) materials, nanostructures, or combinations.

The connectivity, automation and synchronization between the suppliers, consumers and networks that implement a distant transmission or performs local distribution is intensified by the Smart grids. The smart grid theory is the incorporation of digital architecture to distribution and long distance transmission grids to both improve current operations by minimizing the losses, and also to create new markets for the generation of alternative energy.

Grid-tied systems are solar power setups that are linked to the electricity grid — and work without any battery backup equipment. A grid-tied system uses solar panels to generate electricity from sunlight. Excess power is exported to the utility grid, and similarly, when the household requires more power, those needs are met by imports from the grid. A grid tied solar inverter is a special type of power inverter that converts PV output direct current electricity into alternating current electricity so that one can circulation the electricity out into the power grid and actually sell electricity back to the power company. The technical term for a grid-tied Solar inverter (GTSI) is "grid-interactive inverter" which is also known as synchronous inverters because of their capability to synchronize with Grid power.

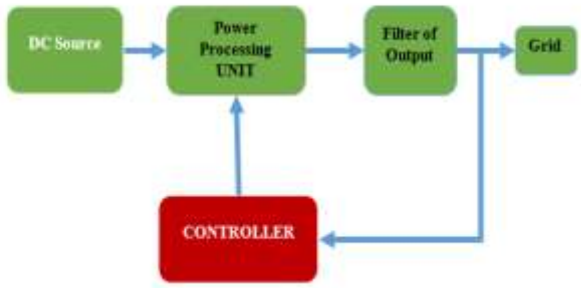

Figure 3 Block diagram of the Smart Grid-Inverter System

Grid-interactive inverters typically cannot be used in standalone applications where utility power is not available. The AC electricity produced by a power inverter is basically the same as the power on the grid – both of them use alternating current, 220 volts, 60 cycles per second. The problem is electricity in the two systems may not be cycling in phase with each other.

IV. REAL POWER AND REACTIVE POWER

In grid-linked mode, MG (or the DGs) is usually controlled as if a controllable power source to exchange the desired power with the utility grid. The voltage reference needed for the functioning of the DGs of the MG is provided by the grid. The active and reactive power references for the DGs of the MG are set by MGCC. The MC usually operates its associated inverter (or DG) as current source inverter (CSI) using active and reactive power (P-Q) control. It is ensured that the quality of power injected to the grid matches the limits set by regulatory bodies or is as per the specified standards.

Real or Active Power - Active power is the power that continuously circulations from source to load in an electric circuit. This power is called as 'Real power' or 'Watt full power' or 'True power 'or Actual power. It is denoted by the capital letter 'P. Real power can be evaluated by using the below formula.

Real Power (P)=[Voltage (V)*Current (I)* cos θ]

$P=VICos\theta$ (1)

It is measured in Watt (W) or Kilowatt (kW) or Mega-Watt (MW). This power circulations in only one direction with respective time. Active power is utilized or dissipated in the circuit through the linked resistive load. It consumes useful power by the load. This power can work both in AC circuits as theyll as in DC Circuits.

Reactive Powers - Reactive power is the power that continuously circulations from source to load and returns back to source in an electric circuit. Reactive power is called as 'Imaginary power' or 'Watt less power' or 'Useless power' or Complex power. It is denoted by the capital letter 'Q '. Evaluate the reactive power (Q) by using the below formula.

Reactive Power (Q)=[Voltage (V)*Current (I)* Sinθ]

$$Q=VISin\theta \qquad (2)$$

It is measured in Volt Ampere Reactive (VAR) or Kilovolt Ampere Reactive (kVAR) or MegaVolt Ampere Reactive (MVAR). This power circulations in both directions with respective time. Reactive power is stored in the circuit through the linked inductive load. It consumes use less power by the load. It works in an AC circuit. It does not convert energy. But, it produces the electrical or magnetic flux. In an electrical circuit, reactive power contributes to the current component which is in out of phase with circuit voltage. Reactive power is used in fan, vacuum cleaner, dishwasher, washing machine, the compressor in the refrigerator, air conditioners, transformer, etc.

Amongst various renewable energy sources, photovoltaic (PV) has emerged as one of the most potential energy sources to provide clean energy. The reason for its popularity is the decrease in cost of PV modules and the lucrative feed-in-tariff policies by the governments. The PV provides promising option for grid-linked systems as theyll as for off grid applications as local power supply. The capacity of PV based system has reached the level of 250 MW and above. Thus, it is appearing as a key component in the future energy mix which can solve energy dilemma of human community. Hence, the significant potential of PV based DGs shall be effectively utilized through the concept of MG. However, PV based DGs present certain challenges which must be addressed to realize the benefits from the PV based DGs.

V. CONCLUSION

Once variables are constrained so that pretty much the whole system remains intact, power system stability is generally understood as an electricity generation system's capability to boost a situation of functioning equilibration after being exposed to a physical disruption.

This research investigates the use of a three-level stabiliser in a hybrid PV Wind Energy system that is integrated with the power system. From the hybrid renewable energy system which is integrated with the grid and studied with stabilizer having various control algorithms which mainly work on artificial intelligence algorithm given by several researchers.

REFERENCE

[1] Dhaneria, A. (2020). Grid linked PV system with reactive power compensation for the grid. 2020 IEEE Power and Energy Society Innovative Smart Grid Technologies Conference, ISGT 2020. https://doi.org/10.1109/ISGT45199.2020.9087728

[2] Nadjemi, O., Nacer, T., Hamidat, A., & Salhi, H. (2017). Optimal hybrid PV/wind energy system sizing: Application of cuckoo search algorithm for Algerian dairy farms. *Renewable and Sustainable Energy Reviews*, *70*(December), 1352–1365. https://doi.org/10.1016/j.rser.2016.12.038

[3] Bukar, A. L., & Tan, C. W. (2019). A review on stand-alone photovoltaic-wind energy system with fuel cell: System optimization and energy management strategy. *Journal of Cleaner Production*, *221*, 73–88. https://doi.org/10.1016/j.jclepro.2019.02.228

[4] Khare, V., Nema, S., & Baredar, P. (2016). Solar-wind hybrid renewable energy system: A review. *Renewable and Sustainable Energy Reviews*, *58*, 23–33. https://doi.org/10.1016/j.rser.2015.12.223

[5] Mahesh, A., & Sandhu, K. S. (2015). Hybrid wind/photovoltaic energy system developments: Critical review and findings. *Renewable and Sustainable Energy Reviews*, *52*, 1135–1147. https://doi.org/10.1016/j.rser.2015.08.008

[6] Al Busaidi, A. S., Kazem, H. A., Al-Badi, A. H., & Farooq Khan, M. (2016). A review of optimum sizing of hybrid PV-Wind renewable energy systems in oman. *Renewable and Sustainable Energy Reviews*, *53*, 185–193. https://doi.org/10.1016/j.rser.2015.08.039

[7] Bhandari, B., Poudel, S. R., Lee, K. T., & Ahn, S. H. (2014). Mathematical modeling of hybrid renewable energy system: A review on small hydro-solar-wind power generation. *International Journal of Precision Engineering and Manufacturing - Green Technology*, *1*(2), 157–173. https://doi.org/10.1007/s40684-014-0021-4

[8] Dehghani Tafti, H., Maswood, A. I., Lim, Z., Ooi, G. H. P., & Raj, P. H. (2016). A review of active/reactive power control strategies for PV power plants under unbalanced grid faults. Proceedings of the 2015 IEEE Innovative Smart Grid Technologies - Asia, ISGT ASIA 2015, Mv, 1–6. https://doi.org/10.1109/ISGT-Asia.2015.7387144

[9] Mishra, M. K., & Lal, V. N. (2020). An improved methodology for reactive power management in grid

integrated solar PV system with maximum power point condition. Solar Energy, 199(September 2019), 230–245. https://doi.org/10.1016/j.solener.2020.02.001

[10] Miao, X., & Ilic, M. D. (2021). High Quality of Service in Future Electrical Energy Systems: A New Time-Domain Approach. IEEE Transactions on Sustainable Energy, 12(2), 1196–1205. https://doi.org/10.1109/TSTE.2020.3038884