International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 2, March-April-2021, ISSN (Online): 2395-566X

A Review of Solar Energy Based Heat and Power Generation Systems

M. Tech. Pooja Vaishya, Prof. Barkha Khambra
Department of Electrical & Electronics Engineering,
NRI Institute of Information Science and Technology
Bhopal, M.P.
poojavaishya19@gmail.com, barkhasaxena21@gmail.com

***Abstract*- The microgrid has shown to be a promising solution for the integration and management of intermittent renewable energy generation. This paper looks at critical issues surrounding microgrid control and protection. It proposes an integrated control and protection system with a hierarchical coordination control strategy consisting of a stand-alone operation mode, a grid-connected operation mode, and transitions between these two modes for a microgrid. To enhance the fault ride-through capability of the system, a comprehensive three-layer hierarchical protection system is also proposed, which fully adopts different protection schemes, such as relay protection, a hybrid energy storage system (HESS) regulation, and an emergency control. The effectiveness, feasibility, and practicality of the proposed systems are validated on a practical photovoltaic (PV) microgrid. This study is expected to provide some theoretical guidance and engineering construction experience for microgrids in general. The utilization of solar energy based technologies has attracted increased interest in recent times in order to satisfy the various energy demands of our society. This paper presents a thorough review of the open literature on solar energy based heat and power plants. In order to limit the scope of the review, only fully renewable plants with at least the production of electricity and heat/hot water for end use are considered. These include solar photovoltaic and solar thermal based plants with both concentrating and non-concentrating collectors in both solar-only and solar-hybrid configurations.**

***Keywords*- Solar energy ,solar hybrid, hybrid energy storage system (HESS).**

I. INTRODUCTION

PV technologies years owing have received to their ability to reduce fossil energy use and provide positive impacts to the environment. Photovoltaic generation in the form of distributed photovoltaic microgrids that are integrated into the power system rely on efficient use of solar energy. When compared to traditional distribution networks, photovoltaic microgrids are distinctly different in terms of their control strategies and protection methods. Specifically, when PV microgrids are being operated in isolated mode, improving peer-to-peer control strategies are considered as critical factors for supporting islanded microgrid operations. In the authors have presented a coordinated voltage/frequency (V/F) and active power and reactive power (PQ) control system for both islanded and grid-connected mode in a PV microgrid that shows effective coordination between inverter V/F (or PQ) controls.

Several other strategies have been proposed for seamless transfer between different microgrid operation modes. They include a seamless control methodology for a PV-diesel generator microgrid that can operate both in the grid-connected and islanded modes, and at the same time does not require any islanding detection mechanism. Similarly, in, a control strategy has been proposed that contains the control state/reference compensation algorithm to effectively reduce the impact caused by microgrid operation mode transitions on critical loads and distributed generators (DGs). The control strategies mentioned above provide excellent solutions for microgrid operational control. However, these strategies are relatively independent having poor flexibility and weak expansibility, which may lead to collapse when the microgrid contains multiple distributed generators. Therefore, there is a need to integrate microgrid operational control technologies at steady and transient states in more practical ways.

In addition to advanced control technologies, microgrids also require effective protection systems. The maximum short-circuit current in a microgrid is generally limited to less than two times the rated current because of a large number of DGs configured with power electronic interface devices. Power flow and short-circuit capacity changes are significant under different microgrid operation modes. As a consequence, conventional protection methods in large-scale power grids are not able to effectively meet the needs of an inverter-dominated microgrid. A range of advanced methodologies is available in the literature for microgrid protection. They include a simple three- phase four-wire system with differential current and zero

© 2021 IJSRET

sequence current used to detect faults in a microgrid; a protection scheme that uses both modes of operation for optimally setting direction over current relays; as well as other protection schemes with voltage restraint algorithms or inverse time characteristics. All these systems can be adapted to address the frequent changes in a microgrid.

However, the main focus of these aforementioned methods is on relay protection, and they tend to neglect regulation resources and means available in the microgrid, e.g., energy storage systems. As a result, there is a need to further explore and develop integrated microgrid protection systems. Also known as a solar park or solar farm is a large-scale photovoltaic system (PV system) designed for the supply of merchant power into the electricity grid. They are differentiated from most building-mounted and other decentralized solar power applications because they supply power at the utility level, rather than to a local user or users.

The generic expression utility-scale solar is sometimes used to describe this type of project. The solar power source is via photovoltaic modules that convert light directly to electricity. However, this differs from, and should not be confused with concentrated solar power, the other large-scale solar generation technology, which uses heat to drive a variety of conventional generator systems. Both approaches have their own advantages and disadvantages, but to date, for a variety of reasons, photovoltaic technology has seen much wider use in the field.

Solar Power and the Environment-As a renewable CO2-free power source, the environmental impact of solar power is significantly smaller than other power generation methods. The impact is mainly related to the production and supply of the special materials and metals that are required to produce solar panels. The location and the water used to clean the solar panels also affect the environment. We are working hard to find alternative ways to clean our solar panels.

Problem Formulation - Power processing systems will be a key factor of future photovoltaic (PV) applications. They will play a central role in transferring, to the load and/or to the grid, the electric power produced by the high-efficiency PV cells of the next generation. In order to come up the expectations related to the use of solar energy for producing electrical energy, such systems must ensure high efficiency, modularity, and, particularly, high reliability. The goal of this paper is to provide an overview of the open problems related to PV power processing systems and to focus the attention of researchers and industries on present and future challenges in this field. In addition, the recent research and emerging PV converter technology are discussed, highlighting their possible advantages compared with the present technology. This phenomenon has been possible because of several factors all working together to push the PV energy to cope with one important position today (and potentially a fundamental position in the near future).

Among these factors are the cost reduction and increase in efficiency of the PV modules, the search for alternative clean energy sources (not based on fossil fuels), increased environmental awareness, and favorable political regulations from local governmentsGrid-connected PV systems account for more than 99% of the PV installed capacity compared to stand-alone systems (which use batteries). In grid-connected PV systems, batteries are not needed since all of the power generated by the PV plant is uploaded to the grid for direct transmission, distribution, and consumption.

Hence, the generated PV power reduces the use of other energy sources feeding the grid, such as hydro or fossil fuels, whose savings act as energy storage in the system, providing the same function of power regulation and backup as a battery would deliver in a stand-alone system. Since grid-connected systems do not need batteries, they are more cost-effective and require less maintenance and reinvestment than stand-alone systems. This concept together with the cost reduction, technology development, environmental awareness, and the right incentives and regulations has unleashed the power of the sun.

II. LITERATURE SURVEY

Photovoltaic power generation A photovoltaic power generation system consists of multiple components like cells, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. These systems are rated in peak kilowatts (kWp) which is an amount of electrical power that a system is expected to deliver when the sun is directly overhead on a clear day. A grid connected system is connected to a large independent grid which in most cases is the public electricity grid and feeds power into the grid. They vary in size from a few kWp for residential purpose to solar power stations up to tens of GWp. This is a form of decentralized electricity generation.

Poponi et al [1]. Assessed the prospects for diffusion of photovoltaic (PV) technology for electricity generation in grid-connected systems by the methodology of experience curves that is used to predict the different levels of cumulative world PV shipments required to reach the calculated break-even prices of PV systems, assuming different trends in the relationship between price and the increase in cumulative shipments

Rehman et al. [2]. Utilized monthly average daily global solar radiation and sunshine duration data to study the distribution of radiation and sunshine duration over Saudi Arabia and also analyzed the renewable energy production and economical evaluation of a 5 MW installed capacity

© 2021 IJSRET

photovoltaic based grid connected power plant for electricity generation

Al-Hasan et al. [3] discussed optimization of the electrical load pattern in Kuwait using grid connected PV systems as the electric load demand can be satisfied from both the photovoltaic array and the utility grid and found during the performance evaluation that the peak load matches the maximum incident solar radiation in Kuwait, which would emphasize the role of using the PV station to minimize the electrical load demand and a significant reduction in peak load can be achieved with grid connected PV systems.

Ito et al. [4] studied a 100 MW very large-scale photovoltaic power generation (VLS-PV) system which is to be installed in the Gobi desert and evaluated its potential from economic and environmental viewpoints deduced from energy payback time (EPT), life-cycle CO2 emission rate and generation cost of the system.

Zhou et al. [5]. Performed the economic analysis of power generation from floating solar chimney power plant (FSCPP) by analyzing cash flows during the whole service period of a 100 MW plant.

Muneer et al. [6]. Explored the long term prospects of large scale PV generation in arid/semi-arid locations, around the globe and its transmission using hydrogen as the energy vector.

Cunow et al [7]. Described the megawatt plant at the new Munich Trade Fair Centre that represents a significant advance in large PV plant technology, both in terms of system technology and the components employed, operational control and costs.

Bhuiyan et al. [8]. Studied the economics of stand-alone photovoltaic power system to test its feasibility in remote and rural areas of Bangladesh and compared renewable generators with nonrenewable generators by determining their life cycle cost using the method of net present value analysis and showed that life cycle cost of PV energy is lower than the cost of energy from diesel or petrol generators in Bangladesh and thus is economically feasible in remote and rural areas of Bangladesh.

Alazraki and Haselip [9]. assessed the impact of small-scale PV systems installed in homes, schools and public buildings over the last six years under the PERMER (Renewable Energy Project for the Rural Electricity Market) co-funded by a range of public and private sources and the structure of financial subsidies has enabled these remote rural communities to receive an electricity supply replacing traditional energy sources.

Kivaisi [10].presented the installation and use of a 3 kWp photovoltaic (PV) plant at Umbuji village, in Zanzibar, Tanzania that was intended to provide power supply for a village school, health centre, school staff quarters, and mosques.

Bansal et al. [11] developed an integration of solar photovoltaics of 25 kWp capacity in an existing building of the cafeteria on the campus of the Indian Institute of Technology, Delhi by creating a solar roof covering with the photovoltaic array inclined at an angle of 15◦ from the horizontal and faces due south.

Ubertini and Desideri [12] studied a 15 kWp photovoltaic plant and solar air collectors coupled with a sun breaker structure that was installed on the roof of a scientific high school [13] Hybrid photovolatic power generation Hybrid power generation system combines a renewable energy source (PV in this case) with other forms of generation, usually a conventional generator powered by diesel or even another renewable form of energy like wind. Such hybrid systems serve to reduce the consumption of non renewable fuel. Barton et al. described a novel method of modelling an energy store used to match the power output from a wind turbine and a solar PV array to a varying electrical load and validated the method against time-stepping methods showing good agreement over a wide range of store power ratings, store efficiencies, wind turbine capacities and solar PV capacities.

Katti and Khedkar [13] investigated the application of wind-alone, solar-alone, and integrated wind PV generation for utilization as stand-alone generating systems, to be used at the remote areas which were based on the site matching and an energy flow strategy that satisfies the need with optimum unit sizing.

Deshmukh et al. [14] described methodologies to model hybrid renewable energy system (HRES) components, HRES designs and their evaluation showing that the hybrid PV/wind energy systems are becoming increasingly popular and highlighted the issues related to penetration of these energy systems in the present distribution network as it provides prospects of incorporating in power generation capacity to improve power quality, due to the dispersed generation.

Bitterlin [15]. Attempted to explore the current practicalities of the combination of wind and PV power generation and an energy storage system power generation solution for cellular phone base stations.

Prasad et al [16].presented a procedure for optimizing the size of integrated B. Parida et al. wind, photovoltaic system with battery backup, the design of optimal size of the systems being based on the calculated values of life cycle unit cost (LUC) of power generation or relative excess power generated (REPG) or unutilized energy probability (UEP) for a specified deficiency of power supply probability (DPSP).

© 2021 IJSRET

El-Shatter et al. [17].designed a hybrid photovoltaic(PV)-fuel cell generation system employing an electrolyzer for hydrogen generation and applied a fuzzy regression model (FRM) for maximum power point tracking to extract maximum available solar power from PV arrays under variable insolation conditions.

Maclay et al. [18].developed a model of a solar–hydrogen powered residence, in both stand-alone and grid-parallel configuration using Matlab/Simulink that assesses the viability of employing a regenerative fuel cell (RFC) as an energy storage device to be used with photovoltaic (PV) electrical generation and investigated the design requirements of RFC sizing, battery sizing, charge/ discharge rates, and state of charge limitations.

Zervas et al. [29]. Studied a hybrid power generation system consisting of the following main components: Photovoltaic Array (PV), Electrolyser, Metal Hydride Tanks, and Proton Exchange Membrane Fuel Cells (PEMFC) that can efficiently store solar energy by transforming it to hydrogen, which is the fuel supplied to the fuel cell.

Nelson et al. [20]. Presented unit sizing and an economical evaluation of a hybrid wind/PV/fuel cell (FC) generation system and a cost comparison with a wind/PV/battery system for a typical home in the US Pacific Northwest and the current cost figures as well as the break-even line distance comparison showed a clear economic advantage of the traditional wind/PV/battery system over the wind/PV/FC/electrolyser system, indicating a need for research and technological advances in the FC/electrolyser area.

El Shatter et al. [21]. Proposed an energy system comprising three energy sources, namely PV, wind and fuel cells each of which is controlled so as to deliver energy at optimum efficiency employing fuzzy logic control to achieve maximum power tracking for both PV and wind energies and to deliver the maximum power to a fixed dc voltage bus.

Shaahid et al. [22]. Analysed long-term solar radiation data of Dhahran (East-Coast, K.S.A.) to assess the techno-economic feasibility of utilizing hybrid PV–diesel–battery power systems to meet the load of a typical residential building and exhibited that for a given hybrid PV–diesel configuration, the number of operational hours of diesel generators decreases with increase in PV capacity and the decrease in diesel run time is further enhanced by inclusion of battery storage.

Helal et al. [23].conducted a techno economic study to analyze the economic feasibility of three alternative designs and the design options include a diesel-assisted PV-RO plant, a fully diesel driven RO plant and a fully solar-driven PV-RO plant and performed detailed cost calculations for each one of the suggested configurations to assess their feasibility and cost effectiveness [24].

Schmid and Hoffmann presented simulations showing that PV systems with energy storage connected to existing diesel generators that can be turned off during the day provide the lowest energy costs.

III. CONCLUSION

A review of major solar photovoltaic technologies comprising of PV power generation, Hybrid PV generation, various light absorbing materials, performance and reliability of PV system, sizing, distribution and control is presented.

The different applications of solar PV system such as building integrated system, desalination plant, space, solar home systems and pumps are also presented. This paper would be useful for the solar PV system manufactures, academicians, researchers, generating members and decision makers.

REFERENCES

[1] Poponi D. Analysis of diffusion paths for photovoltaic technology based on experience curves. Solar Energy 2003; 74:331–40.
[2] Rehman S, Bader Maher A, Al-Moallem Said A. Cost of solar energy generated using PV panels. Renewable and Sustainable Energy Reviews 2007; 11:1843–57. [3]
[3] Al-Hasan AY, Ghoneim AA, Abdullah AH. Optimizing electrical load pattern in Kuwait using grid connected photovoltaic systems. Energy Conversion and Management 2004; 45:483–94.
[4] Ito M, Kato K, Sugihara H, Kichimi T, Kichimi J, Kurokawa K. A preliminary study on potential for very largescale photovoltaic power generation (VLSPV) system in the Gobi desert from economic and environmental viewpoints. Solar Energy Materials & Solar Cells 2003; 75:507–17.
[5] Xinping Zhou, Jiakuan Yang, Fen Wang, Bo Xiao. Economic analysis of power generation from floating solar chimney power plant. Renewable and Sustainable Energy Reviews 2009; 13:736–49.
[6] Muneer T, Asif M, Kubie J. Generation and transmission prospects for solar electricity: UK and global markets. Energy Conversion and Management 2003; 44:35–52.
[7] Cunow E, Giesler B. The megawatt solar roof at the new Munich Trade Fair Centre—an advanced and successful new concept for PV plants in the megawatt range. Solar Energy Materials & Solar Cells 2001; 67:459–67.
[8] Bhuiyan MMH, Ali Asgar M, Mazumder RK, Hussain M. Economic evaluation of a stand-alone

© 2021 IJSRET

residential photovoltaic power system in Bangladesh. Renewable Energy 2000; 21:403–10.
[9] Alazraki R, Haselip J. Assessing the uptake of small-scale photovoltaic electricity production in Argentina: the PERMER project. Journal of Cleaner Production 2007; 15:131–42.
[10] Kivaisi RT. Installation and use of a 3 kWp PV plant at Umbuji village in Zanzibar. Renewable Energy 2000; 19:457–72.
[11] Bansal NK, Sandeep G. Integration of photovoltaic technology in cafeteria building, at Indian Institute of Technology, New Delhi. Renewable Energy 2000; 19:65–70.
[12] Ubertini S, Desideri U. Performance estimation and experimental measurements of a photovoltaic roof. Renewable Energy 2003; 28:1833–50.
[13] John PB, David GI. A probabilistic method for calculating the usefulness of a store with finite energy capacity for smoothing electricity generation from wind and solar power. Journal of Power Sources 2006; 162:943–8.
[14] Katti PK, Khedkar MK. Alternative energy facilities based on site matching and generation unit sizing for remote area power supply. Renewable Energy 2007; 32:1346–62.
[15] Deshmukh MK, Deshmukh SS. Modeling of hybrid renewable energy systems. Renewable and Sustainable Energy Reviews 2008; 12:235–49.
[16] Bitterlin IF. Modelling a reliable wind/PV/storage power system for remote radio base station sites without utility power. Journal of Power Sources 2006; 162:906–12.
[17] Rajendra Prasad A, Natarajan E. Optimization of integrated photovoltaic–wind power generation systems with battery storage. Energy 2006; 31:1943–54.
[18] El-Shatter ThF, Eskandar MN, El-Hagry MT. Hybrid PV/fuel cell system design and simulation. Renewable Energy 2002; 27:479–85.
[19] Maclay JD, Brouwer J, Scott Samuelsen G. Dynamic analyses of regenerative fuel cell power for potential use in renewable residential applications. International Journal of Hydrogen Energy 2006; 31:994–1009.
[20] Zervas PL, Sarimveis H, Palyvos JA, Markatos NCG. Model-based optimal control of a hybrid power generation system consisting of photovoltaic arrays and fuel cells. Journal of Power Sources 2008; 181:327–38.
[21] Nelson DB, Nehrir NH, Wang C. Unit sizing and cost analysis of standalone hybrid wind/PV/fuel cell power generation systems. Renewable Energy 2006; 31:1641–56.
[22] El-Shatter TF, Eskander MN, El-Hagry MT. Energy flow and management of a hybrid wind/PV/fuel cell generation system. Energy Conversion and Management 2006; 47:1264–80.
[23] Shaahid SM, Elhadidy MA. Economic analysis of hybrid photovoltaic– diesel–battery power systems for residential loads in hot regions—A step 1634 B. Parida et al. / Renewable and Sustainable Energy Reviews 15 (2011) 1625–1636 to clean future. Renewable and Sustainable Energy Reviews 2008; 12:488– 503.
[24] Helal AM, Al-Malek SA, Al-Katheeri ES. Economic feasibility of alternative designs of a PV-RO desalination unit for remote areas in the United Arab Emirates. Desalination 2008; 221:1–16.
[25] Schmid LA, Hoffmann CAA. Replacing diesel by solar in the Amazon: short-term economic feasibility of PV-diesel hybrid systems. Energy Policy 2004; 32:881–98.

© 2021 IJSRET