DYNAMIC POWER MANAGEMENT AND STUDY OF PV/PEM FUEL CELLS BASED ON AC/DC MICROGRID

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ABSTRACT: *An important alternative energy source, photovoltaic (PV) solar energy systems are used nowadays, which may also be integrated with other power sources in order to overcome the problem of intermittent power generation. Due to high efficiency, modularity and fuel flexibility, the fuel cells are considered to be an attractive option; however, one main week point is their slow dynamics. While on the other side, generally, it is difficult for the current technology batteries, to provide the long-term energy themselves. Hybrid system made of fuel cells and batteries can be integrated with PV power systems to provide uninterrupted high quality power. Under various modes, the power management algorithm accounts for seamless operation of micro grid and state of charge (SoC) limit conditions of hybrid energy storage; this is done at the time when all the sources, storages and loads are linked directly to the dc link. For dc converter current controllers of fuel cell, battery and super capacitor, the power management scheme (PMS) generates current references for them. The average and fluctuating components are separated by the help of moving average filter. Hence, this work describes the different strategies for power management in the AC/DC micro grid with the survey of the dynamic power management.*

Keywords: *AC/DC Microgrid; Current; Energy; Fuel cell; Power Management; Voltage.*

I. INTRODUCTION

The renewable energy resources are attracting more attention owing to the increasing world wide environmental concerns (Global warming, Acid deposition) and diminishing conventional energy resources (Fossil fuels). In small size applications, the photovoltaic (PV) solar energy systems are broadly utilized as a significant option and for research and development for large scale use it is also considered as the most promising candidate due to possibility of the fabrication of less costly photovoltaic cells. The PV energy systems are used for several purposes like household appliances, data communications and telecommunications systems, for the soldiers in the remote missions, for solar cars, etc.[1]-[3]. On the basis of an operational viewpoint, a photovoltaic panel may experience large variation under variable weather conditions which may occur in control problems.

Diesel Generator [4], super conductive magnetic energy storage (SMES) systems [5], battery energy storage systems [6]-[8], and fuel cells systems [9]-[10] are the examples which helps in overcoming the problems associated with integrating the PV power system with other power sources. A continuous 24-hour power supply is possible with the help of diesel backup for PV power systems. Still it has certain limitations like significantly reduced efficiency at low power output and detrimental environment effects of diesel power generation.

Since many years, the SMES technology from commercialization, have significant potential health risks. Fuel cells are regarded as a very attractive option to be used with intermittent sources of generation due to its high efficiency, modularity and fuel flexibility like photovoltaic cells. The main limitation of the fuel cell is its very slow dynamics, which is associated with the slow dynamics in the fuel supply system that involves pumps, valves, or reformers. There can be a significant drop in the fuel cell output voltage, which would deteriorate power quality or even sometimes cause shutdown of the system at low temperature by a rapid increment in the load power. The fuel cell system ought to be oversized, to meet the peak power requirements. In order to increase the response speed and peak power capacity of the fuel power supply, corresponding power conditioning devices and auxiliary energy storage devices are much needed. Current technology batteries by themselves are insufficient to provide the long term power (energy), whether to store energy when the input power is sufficient or the load is light or to provide energy in case of no input power or a heavy load. So secondary batteries are generally used in the renewable energy systems that meet the requirement of increasing loads. Hence, there is no value of combining the hybrid systems which are made up of fuel cells and batteries and combine the high energy density of fuel cells and the high power density of batteries [11], with the PV power systems with the help of suitable power converters and controls to obtain uninterrupted high-quality power. Two ways to incorporate the fuel cells into a PV system are: firstly, using with an independent power source, and secondly as part of a long-term energy storage system for seasonal coordination through being fuelled by hydrogen from a dedicated electrolyser [12]–[13].

II. PHOTOVOLTAIC POWER GENERATION

Various components included in a photovoltaic power generation systems are cells, mechanical and electrical connections and mountings and the means of regulating and/or modifying the electrical output. These systems are rated in peak kilowatts (kWp) and this is the amount of electrical power, which is expected from a system to deliver at the time, when the sun is directly overhead on a clear day.

In most cases, a grid connected system is linked with a large independent grid and mostly the public electricity grid which feeds power into the grid. For residential purpose to solar power stations up to tens of GWp, they are differing in size from a few kWp. They are in decentralized electricity generation. By the methodology of experience curves, the Poponi assessed the prospects for diffusion of photovoltaic (PV) technology for electricity generation in grid-connected systems and which is utilized to foresee the diverse levels of cumulative world PV shipments need to reach the computed break-even prices of PV systems, predicting distinct trends in the relationship among price and in the increment in the cumulative shipments [14]. To study the distribution of radiation and sunshine duration over In Saudi Arabia, the distribution of radiation and sunshine duration was studied by Rehaman et al. using the monthly average daily global solar radiation and sunshine duration data. For electricity generation he also simplified the renewable energy production and economical evaluation of a 5 MW installed capacity photovoltaic based grid connected power plant [15].

The optimization of the electrical load pattern in Kuwait was discussed by the A-Hasan et al, by using grid linked PV systems in the form of electric load demand, which can be satisfied from both the photovoltaic array and the utility grid. During the performance evaluation, it was found that the peak load matches the maximum incident solar radiation in Kuwait, which would highlight the role by means of the PV station to reduce the electrical load demand and a significant decrease in peak load can be achieved with grid connected PV systems [16].

Ito et al., studied a 100 MW large scale photovoltaic power generation (VLS-PV) system which is to be installed in the Gobi desert. He also evaluated its potential from economic and environmental point of view and deduced from energy payback time (EPT), life-cycle CO_2 emission rate and cost generation of the system [17]. In arid/semi-arid locations, the long term aspects of large scale PV generation and its transmission using hydrogen as the energy vector was explored by Muneer et al., across the world [19]. The megawatt plant at the new Munich Trade Fair Centre represents a major advance in large PV plant technology, in terms of system technology as well as the components employed, operational control and costs, was determined by the Cunow et al. [20]. The economics of stand-alone photo- voltaic power system was studied by the Bhuiyan et al., for testing its viability in remote and rural areas of Bangladesh and then compared the renewable generators with non- renewable generators by replicating their life cycle cost as by utilizing the method of net present value analysis. Results suggest that the life cycle cost of PV energy is lower than the cost of energy from diesel or petrol generators in Bangladesh and hence, it is inexpensively possible in remote and rural areas of Bangladesh [21].

The impact of small-scale PV systems was assessed by Alazrakri and Haselip, which are installed in homes, schools and public buildings, since last six years under the PER- MER (Renewable Energy Project for the Rural Electricity Market) co-funded via range of public and private sources and also the structure of financial subsidies which has helped these remote rural communities to accept an electricity supply by replacing it with traditional energy sources [22]. The fitting and exercise of a 3 kWp photo- voltaic (PV) plant at Umbuji village, in Zanzibar, Tanzania was presented by Kivaisi, which was proposed to offer power supply for a village school, health centre, school staff quarters, and mosques [23]. An integration of solar photovoltaic's of 25 kWp capacity in an existing building of the cafeteria on the campus of the Indian Institute of Technology, Delhi was developed by Bansal et al., by creating a solar roof covering with the photovoltaic array inclined at an angle of 15° from the horizontal and faces due south [24]. In a study done by Ubertini and Desideri , a 15 kWp photovoltaic plant and solar air collectors was coupled with a sun breaker structure that was installed on the roof of a scientific high school [25].

III. AC/DC MICROGRID

Fig 1 depicts about an hybrid AC/DC micro grid (HADMG) is a cluster of AC micro grid (ACMG), DC micro grid (DCMG), bidirectional. Converters, control equipment and energy management system. Diesel generators, small hydro turbine with synchronous generator, biomass based power generation etc., AC loads, fly wheel energy storage system with AC/AC interface and utility grid connection through bidirectional power electronic based switch at the point of common coupling (PCC) are included in the ACMG of DGs with AC power output. Photovoltaic panels, fuel cell tracks etc., loads requiring DC power input such as Uninterrupted Power Supply (UPS), fluorescents lighting etc., DC energy storage system (DCESS) such as battery, super-capacitor etc.,, and hybrid electric vehicles are included in the DC power output by the DCMG. These components are able to connect with the DC bus with the help of DC/DC buck or boost converter. To interface ACMG and DCMG, a bidirectional AC-DC/DC converter is required. There is

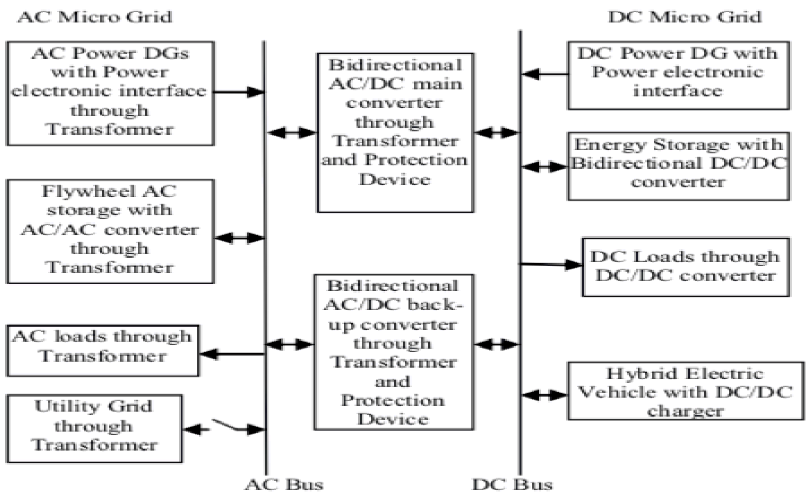

Fig.1 Basic Layout of Hybrid AC/DC Micro Grid.

a need of Back-up converter to avoid any islanding of ACMG and DCMG. Smooth power transfer between ACMG and DCMG and stability in the voltages of AC bus and DC bus under varying generation and load conditions both are the main objective of the bidirectional AC/DC converter. When the power generation in ACMG is more than in the DCMG or vice versa, in grid connected as well as islanding modes of operation, than the power transfer would take place from ACMG to DCMG.

IV. POWER MANAGEMENT STRATEGIES

HRES is regarded as a very significant power management strategy between the assorted energy sources as it is essential for a better result of the ability output from renewable sources, which is irregular and reliant on many unrestrained conditions. There is frequent need of alert in the dynamic interface among many energy sources, energy storage systems and masses in order to study the transient response of the systems. There is guarantee of high system potency and high responsibility with least price by the ability of control strategy. The main objective of the PMS is that it provides high demand in less time. FC is the future energy storage choice in demand having multiple blessings within the hybrid systems [26].

Because of repeated start-up and close up cycles, slow dynamics and dreadful conditions are the two major drawbacks associated with fuel cells. To require care of power deficits, the Thence batteries area unit is used as short term energy storage system in such hybrid systems. Certain uninterrupted power provide to the load can be made, by the mixture of FC and battery together with PV and Wind. The key parameters involved in changing the best power management strategy are as follows: opportunity cost, budget items, time period and days of autonomy of storage devices (such as batteries and FCs), state of charge of storage devices or the force per unit area of chemical element tanks just in case of chemical element energy systems, the quantity of start- ups and close up cycles for banking industry and electrolyzer. Numerous configurations of the hybrid Systems involving PV, wind etc are included in the literature on power management strategy which are intensive.

Power management of ac-linked complete hybrid wind/PV/FC energy system was proposed by the Caisheng Wang et al. [27]. Ipsakis et al. instructed the three power management methods for a hybrid PV/Wind/FC/B Battery (B) system with chemical element production exploitation Electrolyzer [28]. On the time period of assorted subsystems, principally the FC and Electrolyzer, these PMS powerfully have an effect. One dispatch Strategy cannot yield best results below dynamic operational Conditions, as replicated in another study and hence recommends a combined dispatch strategy. In a separate analysis, the authors analyzed a PV/FC/B hybrid system exploitation 3management methods, where by they ascertained the second control strategy to supply best hybrid system potency. In addition to that, a good investigation of PV/FC hybrid systems exploitation battery or super- capacitors has been carried for utility (AC) masses. The authors have delineate power management of HRES either for a strictly AC load or a mixture of AC and DC masses. However, the motive behind the study is to know the intricacies concerned in planning controllers for PV/ FC/B Hybrid systems line remote DC masses. Foreign DC load might be a telecommunication load or a crucial load like Hospital and defense institution.

V. CONTROL STRATEGIES

It is aimed at synchronizing the ACMG with the utility grid, maintaining power balance among the generation and the load, mainly, in island mode of operation. It also aimed to uphold constant voltage and frequency of AC bus in the ACMG, preserve firm voltage of DC bus in the DCMG, preserve quality of power injected into the utility grid, maintain smooth power transfer between the ACMG and the DCMG for the stable system operation under varying operating conditions and to harness maximum power from various renewable energy sources. The control strategy depends on the basis of the mode of operation. In the grid-connected mode of operation, voltage of the DC bus is kept steady by the inverter controller whereas voltage and frequency of the AC bus are controlled by the utility grid controller. Voltage of the DC bus is controlled by the energy storage system in islanded mode of operation whereas, the controllers of the parallel inverters controls the voltage amplitude and frequency of the AC Bus. The control strategy is implemented at two levels viz., system level and component level.

a) Micro Grid Central Controller (MGCC)

The Micro grid central controller (MGCC) is mainly responsible for control and management of microgrids. For maintaining stability in the system, it performs coordinated operation and control of local micro sources in the micro grid. All the local controllers and monitors provide the information and the status of the system. The MGCC functions as follows: 1. For the DG units it give power set points, economic scheduling, supervise demand side bidding; 2. Control peak load; 3. Control non-critical loads during islanding; 4. Reduce the system losses; and remove islanding conditions on the basis of measurements at the PCC; 5. Resynchronization with the local controllers when the grid is restored; 6. Guide power flows via local generating units and the PCC and at last, make islanding decision [29].

b) Micro Source Controller(MC)

AC/AC, AC/DC/DC, DC/DC, DC/AC and AC-DC/DC-AC bidirectional converter are the five distinct types of power electronic computers through which the various micro sources in the HADMG are interfaced. These power electronic converters controls the micro sources in the grid connected as well as in the island mode of operation. Different types of control methods are used to control the micro sources both in the ACMG and DCMG. The micro sources in the ACMG are controlled by active and reactive power (PQ) control, droop control and voltage/frequency control, while the micro sources in the DCMG are controlled using analog and digital control techniques.

c) Energy Storage System (ESS) controller

In order to reduce the influence of fluctuations in generation and load to the utility grid, the energy storage system should be controlled to absorb or release power quickly. The charging and discharging of the storage system is controlled, according to the grid operating conditions and the state of charge of the hybrid storage system [30].

d) Load Controller (LC)

The loads inside the HADMG are usually convenient or programmable. Critical or sensitive or high priority loads and non-critical or common or less priority loads are the types of loads on the basis of priority. The load controller should be designed, to shed the non-critical loads in case of power imbalance, mainly in the islanded mode of operation.

On the basis of the configuration of the individual micro sources utilized and as per their rating, energy storage systems, types of loads and the mode of operation, the choice of control strategy depends. Various types of control strategies reported in various literatures are Centralized control, decentralized control, hierarchical control, distributed control, coordinated control, cooperative control, reference frame control, multi agent control or multi-level (open market access) control, robust multi objective control, wireless control strategy and wide area monitoring and control (WAMC) [31].

VI. LITERATURE REVIEW

E S N Raju P et al. (2013) stated that micro grids are emerging as one of the promising solutions to integrate various types of distributed renewable energy sources with the utility grid [32]. Nowadays, electrical loads comprising of power electronic based equipment's and distributed renewable energy generation make DC micro grids more attractive beside this the existing grids are AC grids. Though, with respect to DC loads and AC loads, an individual AC micro grid and DC micro grid requires multiple conversions of power at the user end, which results in less competent system. Thus hybrid AC/DC micro grid system seems to be the best solution for avoiding the substantial energy losses in multiple conversions. Overview of hybrid AC/DC micro grid is presented and argued the essential key issues and challenges to be overcome intended for its practical implementation.

S.Prakesh and S.Sherine (2017) stated the increasing deployment of distributed generation systems in power systems hybrid AC/DC micro grid [32]. Several micro grids are used for connecting ac/dc converter with proper power management and control strategy The IC is intended to take the role of supplier to one micro grid and also acts as a load to other micro grid and the power management system should be able to share the power demand between the existing ac and dc sources in both micro grids, at the time when the islanding operation of the hybrid AC/DC micro grid take place. Among the multiple sources, the power flow control the management issues which are dispersed throughout both ac and dc micro grids, are considered in this paper. In order to eliminate the need for any communication between distribution generation and micro grids, a new method of the decentralized power sharing method is proposed. In order to decrease the required power conversions stages, this hybrid micro grid allow different ac or dc loads and allow sources to be flexibly located and therefore, maintains the system cost and efficiency. The decentralized control operation and droop method is used for better control strategy. By utilising simulation studies in MATLAB software, the performance of the offered power control strategy is validated for small signal stability analysis and different operating conditions.

Naoki AyAi et al. (2017) introduced a DC micro grid system which offered a power network that helps in the introduction of a large amount of solar energy using distributed photovoltaic generation units [34]. They developed a demonstration facility consisting of silicon photovoltaic (Si-PV) units, copper indium gallium (di)selenide photovoltaic (CIGS-PV) units, concentrator photovoltaic (CPV) units, an aerogenerator, and a redox flow battery to test the feasibility of the system. There is a key component for supply-demand adjustment in the micro grid system, the redox flow battery which productively balanced supply and demand in the grid by its rapid charge-discharge ability even under the fluctuating condition of power generation and consumption.

Chunhui Liu et al (2015) recommended a new DC micro-grid system, which fully utilizes the renewable energy and electric vehicle for smart energy delivery [35]. For executing the energy distribution, the offered DC grid incorporates the AC supply module, standby energy module, renewable energy module, and storage energy module together, to execute the energy distribution. This grid system can offer a high quality power for the three types of loads, namely 110V AC single-phase output, 48V DC output, and 100V DC output. This study described the control strategy of the grid system for performing smart energy delivery. To verify the four operation modes of the grid system, the simulation result will also be given.

A study by Bronson Richard BLASI (2013 argued a brief history of electricity, specifically alternating current (AC) and direct current (DC), and how the current standard of AC distribution has been reached [36]. The shift to AC occurred in the 1880's with the advent of the transformer despite of the fact that DC power was first produced in 1880's. When the power is transmitted by DC at that time the Distributed generation, or on-site generation from photovoltaic panels, wind turbines, fuel cells, or micro turbines, are regarded more efficient. By utilizing DC architecture and eliminating wasteful conversions, DC generation paired with the growing DC load profile. The result of energy saving is the lower grid strain and more efficient utilization of the utility grid.

Due to short transmission distances, high service reliability when paired with on-site generation, and efficient storage, Dc distribution results in a more reliable electrical service. The occupant safety is of great concern with DC micro grids, due to the lack of knowledge and familiarity in regards to these systems. Hence, it is significantly safer than existing 120VAC in the United States with proper regulation and design standards, building occupants never encounter voltage higher than 24VDC. Higher initial cost due, in part, to unfamiliarity of the system as well as a general lack of code recognition and efficiency metric recognition leading to difficult certification and code compliance are the drawbacks of the DC Micro grids.

Dong Chen and Lie Xu (2013) introduced a renewable power generation and the prospect of large-scale energy storage are fundamentally changing the traditional power grid [37]. In terms of energy management, reliability, system control, etc., challenges occur. The concept of micro grid is introduced in this chapter. On the basic issues of control, operation, stability, and protection of DC micro grids are the main concerns.

Peng Wang et al. (2017) stated that three-phase AC power systems have been in dominant position for over hundred years due to invention of transformer and the inherent characteristic from fossil energy-driven rotating machines [38]. Thus, for consideration of adding DC networks, the gradual changes of load types and distributed renewable generation (DRG) in AC local distribution systems provide food. Some AC inherent renewable sources like wind generators also need DC links in their conversion systems to increase efficiency and to mitigate power variation caused by intermittency and uncertainty despite of the fact that renewable sources such as fuel cells and solar photo voltaic are DC inherent and should be connected to AC grid through DC/AC conversion techniques. There can be a significant loss from the reverse conversion because of the disadvantage of AC grids for connection of DC inherent sources and loads as well as AC loads with DC links, additional DC/AC or AC/DC converters are required. DC grids are resurging due to the development and deployment of renewable DC power sources and their inherent advantage for DC loads in commercial, industrial and residential applications. The number of power conversions in a DC micro grid has been significantly reduced for enhancing the system energy efficiency.

The study by Peng WANG et al.(2011) presents a hybrid AC/DC micro grid concept to directly integrate DC/AC renewable sources and loads to DC/AC links respectively [39]. In an individual AC &DC grid, the hybrid grid eliminates multiple DC-AC-DC&AC-DC-AC conversions. The hybrid grid increases the system efficiency and also eliminates the embedded AC/DC and DC/DC converters in various home, office and industry facilities which can reduce size and cost of those facilities. The basic architecture of the hybrid grid is introduced in this paper. Different operation modes of the hybrid grid are discussed to harness the maximum power from various renewable sources, to store energy surplus during low peak loads, to eliminate unbalance problem in AC link. To maintain voltage stability and smooth power transfer between AC and DC links under various generation and load conditions, several control algorithms are investigated. Under construction a hybrid grid is presented and some simulation and test results are also presented.

VII. CHALLENGES AND FUTURE TRENDS

In addition to variations in their dynamic response characteristics as compared with typical synchronous machines, challenge with integrating the renewable generation into an influence system area unit are associated with intermittent power availableness. The issues related to voltage controls area unit poor load sharing and current between converters. If there's a twin within the converters output voltages, then the current issue can arises.

1. The power flow in MG and mitigate the flow of circulating currents between the converters can be balanced by the development of the optimal integrated control strategies.
2. Different control strategies are evaluated and compared.
3. On MG system, the Simulation of the different control strategies.
4. Comparisons are justified via simulation the Active power and reactive power flows, Voltage, current, THD (total harmonic distortions).

The fundamental design of the MG are shown in below fig.2; in low voltage DC grid the picture voltaic cells and wind turbines are connected for assuring the power management and power stability. Renewable and cogeneration are the two objectives which converge the employment of the distributed generation. In terms of distributed generation, the HRES hold promising applications in remote inaccessible sites, they'll be used as another to grid-connected systems. The power may be generated supported the demand at any specific web site looking on the provision of resources.

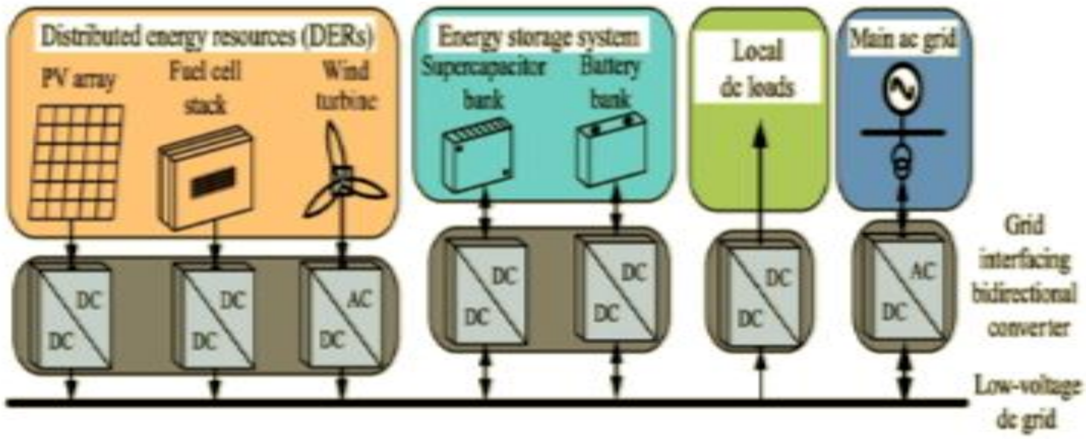

Fig.2 Basic Architecture of MG

AC distribution issues are comparatively different from the operational issues, control, protection and stability of HADMG. Several challenges are depicted below for the practical implementation of the HADMG needs to overcome.

- To build up a new DC grid and upgrading the existing AC grid is a long-term process.
- For the Development of an efficient control strategies and protection schemes for secure and reliable operation of the HADMG in grid connected as well as islanded mode of operation.
- To design a control coordination among several types of power electronic converters for power sharing among several types of DGs under varying operating conditions.
- To re design the home and office products to remove the embedded AC/DC rectifiers.
- The optimal voltage levels are needed to be described for easy connection of several types of DC loads.

VIII. CONCLUSION

To minimize the conversion losses, the Hybrid AC/DC micro grids offer a promising solution with an objective for grid integration of various types of distributed renewable energy sources. This paper has presented an overview of hybrid AC/DC micro grid and has also reviewed the existing techniques used for detecting islanding condition in the hybrid micro grid, control as well as protection strategies and stability analysis. Key issues and challenges for the research and development are highlighted to implement the hybrid micro grids practically. The description about the major strategies and control techniques used in the successful operation of the MG are also detailed in the paper. To understand the basics of the micro grid and fuel cells easily in future researches, the PV/PEM fuel cells are better elaborsated and described in way that it can be better picked up.

IX. REFERENCES

[1] B. Lindemark, G. Oberg, “Solar power for radio base station (RBS) sites applications including system dimensioning, cell planning and operation”, Proceedings of 23rd International Telecommunications Energy Conference, 14-18 Oct, 2001, 587 – 590.

[2] L. McCarthy, J. Pieper, A. Rues, C. H. Wu, “Performance monitoring in UMR's solar car”, IEEE Instrumentation & Measurement Magazine, 3(3), 2000, 19-23.

[3] H. J. Wenger, C. Jennings, J. J. Iannucci, “Carrisa Plains PV power plant performance”, Proceedings of IEEE Photovoltaic Specialists Conference, 2, 1990, 844- 849.

[4] T. M., "Autonomous Photovoltaic-Diesel Power System Design", Proceedings of IEEE Photovoltaic Specialists Conference, Las Vegas, Nevada, 1985, 280-284.

[5] K. Tam, P. Kumar and M. Foreman, "Enhancing the Utilization of Photovoltaic Power Generation by Superconductive Magnetic Energy Storage", IEEE Transactions on Energy Conversion, 4(3), 1989, 314-321.

[6] Chaurey and S. Dembi, "Battery Storage for PV Power Systems: An Overview", Renewable Energy, 2(3), 1992, 227-235.

[7] B.H. Chowdhury and S. Rahman, "Analysis of Interrelationships between Photovoltaic Power and Battery Storage for Electric Utility Load Management'', IEEE Transactions on Power Systems, 3(3), 1988, 900-907.

[8] K.C. Kalaitzakis and G.J. Vachtsevanos, "On the Control and Stability of Grid Connected Photovoltaic Sources", IEEE Transactions on Energy Conversion, 2(4), 1987, 556-562.

[9] S. Rahman and K. Tam, "A Feasibility Study of Photovoltaic-Fuel Cell Hybrid Energy System", Transactions on Energy Conversion, 3(1), 1988, 50-55.

[10] K. Tam and S. Rahman, "System Performance Improvement Provided by a Power Conditioning Subsystem for Central Station Photovoltaic Fuel Cell Power Plant", IEEE Transactions on Energy Conversion, 3(1), 1988, 64-70.

[11] Z. Jiang, L. Gao, and R. Dougal, "Flexible Multi objective Control of Power Converter in Active Hybrid Fuel Cell/Battery Power Sources", IEEE Transactions on Power Electronics, 20(1), 2005,244-253.

[12] K. Agbossou, M. Kolhe, J Hamelin, T. K. Bose, "Performance of a stand-alone renewable energy system based on energy storage as hydrogen", IEEE Transactions on Energy Conversion, 19(3), 2004, 633 - 640.

[13] W. Knaupp, E. Mundschau, "Photovoltaic-hydrogen energy systems for stratospheric platforms", Proceedings of 3rd World Conference on PhotovoltaicEnergy Conversion,. 3, 2003, 2143 – 2147.

[14] Poponi D. Analysis of diffusion paths for photovoltaic technology based on experience curves. Solar Energy 2003, 331–40.

[15] Rehman S, Bader Maher A, Al-Moallem Said A. Cost of solar energy generated using PV panels. Renewable and Sustainable Energy Review, 2007, 1843–57.

[16] Al-Hasan AY, Ghoneim AA, Abdullah AH. Optimizing electrical load pattern in Kuwait using grid connected photovoltaic systems. Energy Conversion and Management, 2004, 483–94.

[17] Ito M, Kato K, Sugihara H, Kichimi T, Kichimi J, Kurokawa K. A preliminary study on potential for very largescale photovoltaic power generation (VLS- PV) system in the Gobi desert from economic environmental viewpoints. Solar Energy Materials & Solar Cells, 2003, 507–17.

[18] Xinping Zhou, Jiakuan Yang, Fen Wang, Bo Xiao. Economic analysis of power generation from floating solar chimney power plant. Renewable and Sustain able Energy Reviews, 2009, 736–49.

[19] Muneer T, Asif M, Kubie J. Generation and transmission prospects for solar electricity: UK and global markets. Energy Conversion and Management, 2003, 35–52.

[20] 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, 459–67.

[21] Bhuiyan MMH, Ali Asgar M, Mazumder RK, Hussain M. Economic evaluation of a stand-alone residential photovoltaic power system in Bangladesh. Renewable Energy, 2000, 403–10.

[22] Alazraki R, Haselip J. Assessing the uptake of small-scale photovoltaic elec- tricity production in Argentina: the PERMER project. Journal of Cleaner Production, 2007, 131–42.

[23] Kivaisi RT. Installation and use of a 3 kWp PV plant at Umbuji village in Zanzibar. Renewable Energy 2000, 457–72.

[24] Bansal NK, Sandeep G. Integration of photovoltaic technology in cafeteria building, at Indian Institute of Technology, New Delhi. Renewable Energy, 2000, 65–70.

[25] Ubertini S, Desideri U.Performance estimation and experimental measurements of a photovoltaic roof. Renewable Energy, 2003, 1833–50.

[26] Gupta A, Saini RP, Sharma MP. "Modeling of hybrid energy system – Part II: Combined dispatch strategies and solution algorithm". Renew Energy, 36(2), 466–73.

[27] Ipsakis D, V outetakis S, Seferlis P, Stergiopoulos F, Elma sides C. "Power management strategies for a stand-alone power system using renewable energy sources and hydrogen storage". Int J Hydrogen Energy,34(16), 2009, 7081–95.

[28] Wang C, Nehrir MH. "Power management of a stand-alone wind/ photovoltaic/fuel cell energy system". IEEE Trans Energy Convers, 23(3), 2008, 957–67.

[29] Rasheduzzaman, M.;Bhaskara, S.N.;Chowdhury, B.H. "Implementation of a microgrid central controller in a laboratory microgrid network" North American Power Symposium (NAPS), IEEE Publication Year,2012 , 1 – 6.

[30] Bo Dong ; Yongdong Li ; Zhixue Zheng ; Lie Xu "Control strategies of microgrid with Hybrid DC and AC Buses" Power Electronics and Applications (EPE 2011), Proceedings of the 2011-14thEuropeanConference on Publication Year, 2011 , 1 – 8.

[31] Ahmed Mohamed, Ahmed Ghareeb, Tarek Youssef, and Osama A. Mohammed, "Wide Area Monitoring and Control for Voltage Assessment in Smart Grids with Distributed Generation", IEEEtransactions on innovative smart grid technologies, 2013, 1-6.

[32] E S N Raju P and Trapti Jain "Hybrid AC/DC Micro Grid: An Overview" Fifth International Conference on Power and Energy Systems, Kathmandu, Nepal, 2013.

[33] S.Prakesh and S.Sherine "POWER CONTROL AND MANAGEMENT STRATEGY IN HYBRID AC/DC MICROGRID" International Journal of Pure and Applied Mathematics Volume 116 No. 18 2017, 347-353.

[34] Naoki AyAi, Toshiya HisAdA, Toshikazu sHibATA, HidekazuMiyosHi, Takashi iwAsAki and ken-ichikiTAyAMA "DC Micro Grid System".

[35] Chunhua Liu, K.T. Chau, ChenxiDiao, J. Zhong, Xiaodong Zhang, Shuang Gao, and Diyun Wu "A New DC Micro-grid System Using Renewable Energy and Electric Vehicles for Smart Energy Delivery" The 2010 IEEE Vehicle Power and Propulsion Conference (VPPC), Lille, France, 1-3 September 2010. In Proceedings of VPPC, 2010.

[36] BRONSON RICHARD BLASI "DC MICROGRIDS: REVIEW AND APPLICATIONS" KANSAS STATE UNIVERSITY Manhattan, Kansas.

[37] Dong Chen and Lie Xu "AC and DC Microgrid with Distributed Energy Resources" Springer International Publishing Switzerland 2017.

[38] Peng Wang, Jianfang Xiao, Chi Jin, Xiaoqing Han and Wenping Qin "Hybrid AC/DC Micro-Grids: Solution for High Efficient Future Power Systems" Springer Science+Business Media Singapore 2017.

[39] Peng Wang, Member, IEEE, Xiong Liu, Student member, IEEE, and Chi Jin, Student Member, PohchiangLoh, IEEE Member, IEEE, Fookhoong Choo "A Hybrid AC/DC Micro-Grid Architecture, Operation and Control".