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A NOVAL APPROACH OF ENHANCING THE SYSTEM RELIABILITY IN WIND-HYDRO MICROGRIDS FOR REMOTE CONTROL AREAS

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Variables such as power quality, wind-hydro, solar, and VSI.

ABSTRACT

For this study, we looked at one renewable energy microgrid (MG). When renewable energy sources like wind and hydro are abundant, wind-hydro MGs may produce power. The primary control device of MG is an inverter for voltage source (VSI), which works on indirect current control. By removing harmonics from nonlinear loads, controlling voltage in the occurrence of events like load imbalance, and compensating reactive power at the connection point based on system demands, this VSI improves energy quality. It may be used to determine the power balance in the event that units of production, storage, and consumption are altered. A method called weighted zero attraction with least square error control is used for VSI switching pulses. A MATLAB/Simulink model was created to describe the MG's performance in both static and dynamic environments, subjected to linear and nonlinear stresses.

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I.INTRODUCTION:

The energy is essential for the development of technology and industry, as well as for maintaining a decent standard of living in industrialised nations such as the United States and Europe. On the other side, it is also true that many Asian and African nations still lack universal access to reliable power. The people living there have not advanced socially or economically, and they lack access to healthcare, schools, and other essential auxiliary services. An alternative to the conventional grid, the isolated microgrid (MG)[1]-[3] for electrifying rural areas might be a worthy way to fulfil the world's growing demand and provide essential ancillary services to remote areas. Powering these MGs might be either diesel generators or renewable energy sources like wind, solar, biomass, etc. [4]-[7] in order to promote the economical use of fossil fuels and the greatest use of renewable energy sources. The global energy consumption for all conventional and renewable resources is documented in [8]. This includes fossil fuels, big hydro, nuclear, and renewable energy sources such as wind, solar, and small hydro. There will reportedly be a total supply of 17,208 MToe by 2020, with renewable energy sources predicted to increase their use by 16% and fossil fuel consumption by 76%. According to this research, renewable energy sources are gradually replacing fossil fuels. Justifications for moving away from fossil fuels

the usage of renewable energy sources has led to a rise in fuel prices [9] and environmental problems including greenhouse gas emissions, global warming, and an increase in health problems like hearing loss, blurred vision, vertigo, and other similar symptoms. References [10], [11]. Applications of renewable energy have grown rapidly and smoothly thanks to advancements in power electronics. Distributed generation sets (DG sets) or renewable energy sources (wind, hydro, solar, etc.) provide the electricity to outlying areas. While renewable resources are very inexpensive to generate, they are highly unstable because to their reliance on the seasons, and DG sets put a strain on distant applications and lifestyle budgets. So, a potential technique to achieve dependability is the combining of renewable resources. Tables [14]–[16]. Several control strategies for solar systems are examined in [14]. Such setups include converters that convert direct current to alternating current and vice versa. The term "hybrid converters" describes an additional configuration that allows for switching between converters. The use of both wind and diesel power is detailed in a hybrid MG in [15]. In this case, the frequency of an ac bus is regulated via MG droop control. The use of two converters—an ac-dc and a dc-dc—in the architecture of a renewable MG for energy management is described in [16] to provide a constant flow of power. Maximum power tracking (MPPT) is implemented in the suggested work using a single dc-dc converter and a single voltage source inverter (VSI) (dc-ac converter) as the control unit. The system's control complexity, cost, and maintenance requirements are all reduced in such a setup. Voltage and frequency control, as well as power management, are crucial components of standalone operations, as mentioned in [17]. Comprehensive research on ac MG designs and control was published by Rezkallah et al. in [18]. Such MGs may provide service to remote or interior areas using hybrid or green resources. Overcharging of batteries may be prevented by using dump loads. When it comes to creating pulses using pulse width modulation (PWM), MPPT and sliding mode controls are the way to go. Also, because of how unpredictable and varied it is, wind is an extremely unreliable resource. Battery storage [19] and hydropower, which is accessible year-round, are used to circumvent this issue. Because of its durability and minimal maintenance requirements, the squirrel cage induction generator is often used to generate hydroelectric power. However, its efficiency is low, and frequency adjustment is necessary. Using a capacitor bank for reactive power support, this study demonstrates how a hydro power generator based on synchronous reluctance generators (SyRGs) can offer supply at rated frequency and voltage. Because these generators don't have rotor windings and slide rings, they are more efficient, need less maintenance, and have lower losses [20], [21]. To generate electricity from wind, one uses a permanent magnet brushless dc generator (PMBLDCG) with variable speed. With its almost

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square-shaped currents and trapezoidal electromotive force, it produces more average power than the alternator. The use of a P&O method allows for the MPPT of wind power.

LITERATURE SURVEY

2.1 Study and analysis of a small scale micro-grid using renewable energy resources

In Bangladesh utilization of renewable energy sources (RES) is very necessary to meet up the excessive energy demand. With available weather and technical data, aproper simulation tool can be helpful to utilize locally available RES in on-grid and off-grid areas. This paper presents modeling and the analysis of a small scale micro-grid system for community purpose in the rural and remote areas. A simulation tool 'mGrid_2014a' has been developed which can be used to analyze how RES can beeffectively used to meet the community demand. Besides Solar and Wind, Biomass energy has been considered as a useful alternative source. Finally the model has been checked with locally available weather and RES data for the Saint Martin's Island, Bangladesh.

2.2 Microgrid modular design for tribalhealthcare facilities: Kayenta healthcenter PV system case study

This paper describes an experimentalprocess and detailed information related to a100KW PV system case study at the Kayenta Health Center, which is located in the Navajo Nation. Information about thesolar irradiance on site, the PV system performance, the power quality at the facility, and observation of the related equipment is gathered. Experimental data validate the theoretical data available for the zone, the facility, the systems and theequipment. Detailed study of existing PVsystem at the Navajo Nation combined with modeling and simulation will lead to a good industrial pilot project from implementation

and practical perspective of the microgrid in existing tribal health care facilities. A modified configuration of the existing powersystem is presented. The configuration provides guidance for redesign of existing healthcare facilities around the microgrid concept. Since the Kayenta Health Center is representative of the average healthcarefacility in the Navajo Nation, this guidance will be useful for improvement power system of many tribal healthcare facilities. This in turn will improve the quality of the healthcare service and will benefit the living conditions of significant tribal population.

II. PROSED SYSTEM:

This MG functions for power balancing during wind fluctuations and load demand variations. A reweighted zero attractor least mean square (RZALMS) [23], [24] control approach is implemented in the MG VSI, which is the main control unit of the system. RZALMS accelerates theconvergence rate and has lower mean squareerror than the standard LMS [23]. With the help of analytical demonstration, RZALMS is better on the standard LMS in both transient and steady-state performance forsparse and non-sparse systems. It offers harmonics reduction of nonlinear loads,voltage regulation at load variations, reactive power compensation based on system requirement. It also manages balanced power flow among various units, i.e., wind–hydro generators, the battery storage, and loads. The main contribution of the paper is as follows.

1. A single VSI control based MG is developed. Moreover, the wind power of PMBLDCG is converted into dc power using a diode rectifier. Therefore, this topology has reduced the overall cost of the system.

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2. The PMBLDCG does not need sensors such as speed sensor, position sensor, and wind speed sensor for MPPT control, thus further reducing the cost.
3. An RZALMS control approach is implemented in the MG VSI for fast responses during steady-state and dynamic conditions.
4. Generators used are maintenance free andhaving high efficiency.

Fig. 4.1 depicts the renewable-based MG comprising of hydro and wind sources. The hydro power is generated using SyRG, aconstant power generator and this power is fed to the ac loads. The PMBLDCG is used to generate the electricity from wind power at variable speeds and a diode rectifier is used to convert it into dc power, which is fed to the boost converter for MPPT using the P&O control technique. This extracted power is delivered to the ac loads through a VSI and excess generated power is stored in the battery bank connected parallel to the VSI. This VSI is connected to the hydropower generator (SyRG) and loads at point of common coupling (PCC) through interfacing inductors (Lf). A capacitor bank is connected at SyRG terminals to support reactive power to MG for voltage buildup. The design data of the proposed MG aregiven in Appendix. To operate MG in satisfactory manner, it must provide goodquality power as regulated sinusoidalvoltage and frequency. This work presents MG performance with an RZALMS control approach to underpin a zero attractor fordifferentiating between zero taps andnonzero taps, as shown in Fig. 2. The parameters μ (step size), iLa (phase "a" load current), u pa (in-phase template), uqa(quadrature template), σ and ψ (small constants) are used in the control approach. Phase voltages are computed from line voltages as

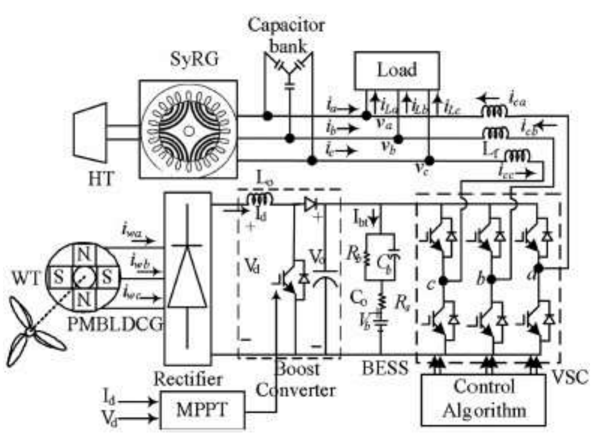

Fig.4.1 Wind-Hydro MG configuration

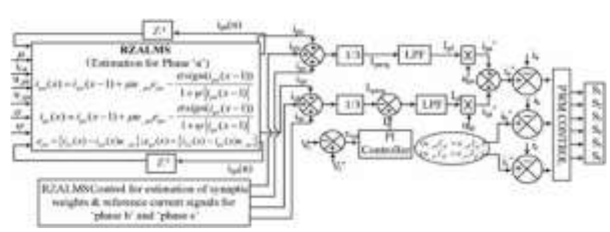

Fig. 4.2 MG Control approach.

$$v_a = 1/3\,(2v_{ab} + v_{bc}) \quad (1)$$

$$v_b = 1/3\,(-v_{ab} + v_{bc}) \quad (2)$$

$$v_c = 1/3\,(-v_{ab} - 2v_{bc})\,. \quad (3)$$

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The terminal voltage Vt is derived fromphase voltages as

$$V_t = \sqrt{\left(2\left(v_a^2 + v_b^2 + v_c^2\right)/3\right)}. \qquad (4)$$

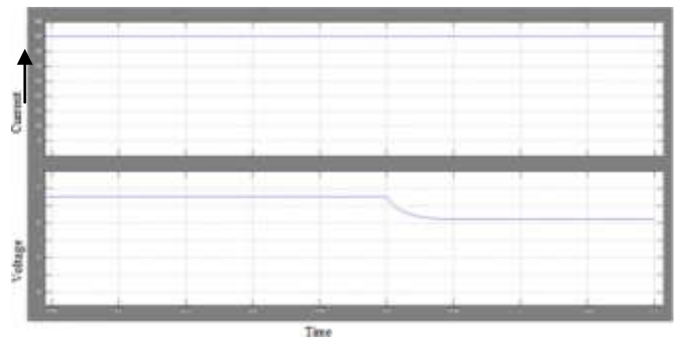
In-phase template of phase “a” voltage as

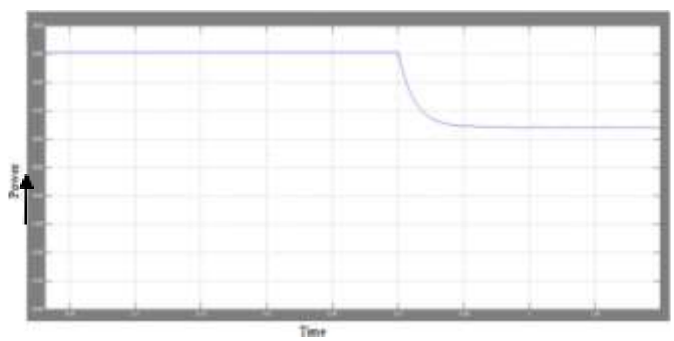
$$u_{pa} = v_a/V_t. \qquad (5)$$

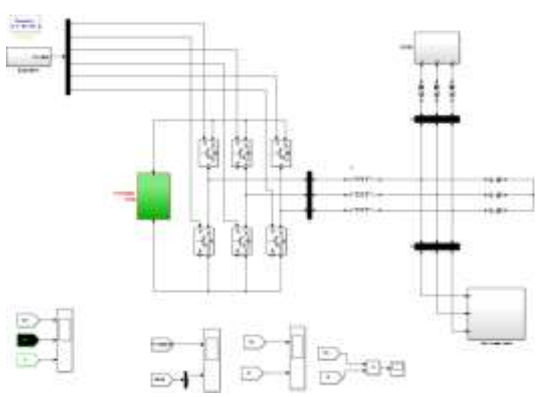
Similarly, other two in-phase templates forphase “b and c” (upb , upc) are also achieved. The quadrature voltage templates of three-phase voltages are as follows:

IV.SIMULATION RESULTS

Simulated results of MG are demonstrated in this section. Steady-state and dynamic responses of a renewable- based MG are shown and the behavior of intermediate signals of control approach at load unbalancing is depicted in detail. The wind MPPT using the P&O approach is also included. The MPPT of wind generation is achieved through applying a P&O approach. It is shown in Fig. 3 that at the wind speed variation, the PMBLDCG current of phase “a” is also reduced.







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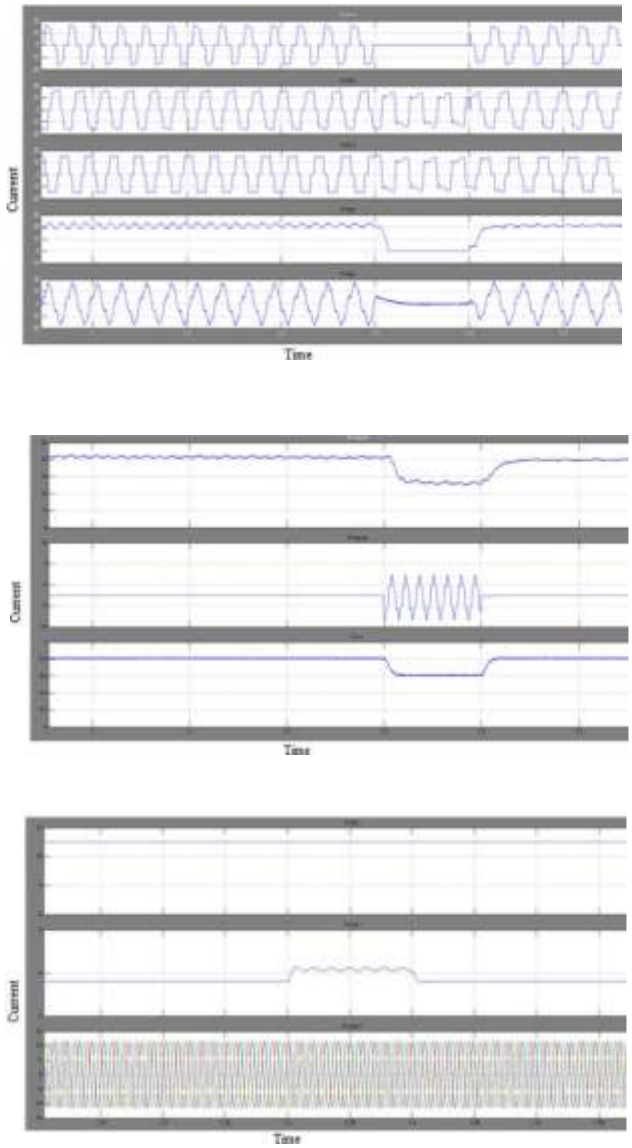

Fig. 5.2 Intermediate signals of RZALMS controlalgorithm at nonlinear load.

The performance of wind–hydro based MG depends on its control approach robustness. To demonstrate satisfactory response of the control approach, its various intermediate signals are depicted in Fig.5.2 at nonlinear loads. The load unbalance iscreated at t = 1.3 s, and the load on thatphase is recovered at t = 1.4 s. It is seen that at load unbalance, the load current of phase “a” (iLa) becomes zero and other two phase currents iLb, iLc also change their shape.Simultaneously active and reactive loadpower components (ipa , iqa) also become zero. The equivalent active and reactive loadcurrent components (ipavg , iqavg) are also reduced as the total load demand is reduced due to the absence of load on phase “a.” Thecurrent component coming from a PI controller (Iv) and the reactive source power current components (If q) also change with the load variation. The active source power current component (If p) isconstant as prime mover power is fixed and reference source currents are sinusoidal and balanced. The intermediate signals of the control approach are changing rapidly to achieve the stead ystate condition within couple of cycles.

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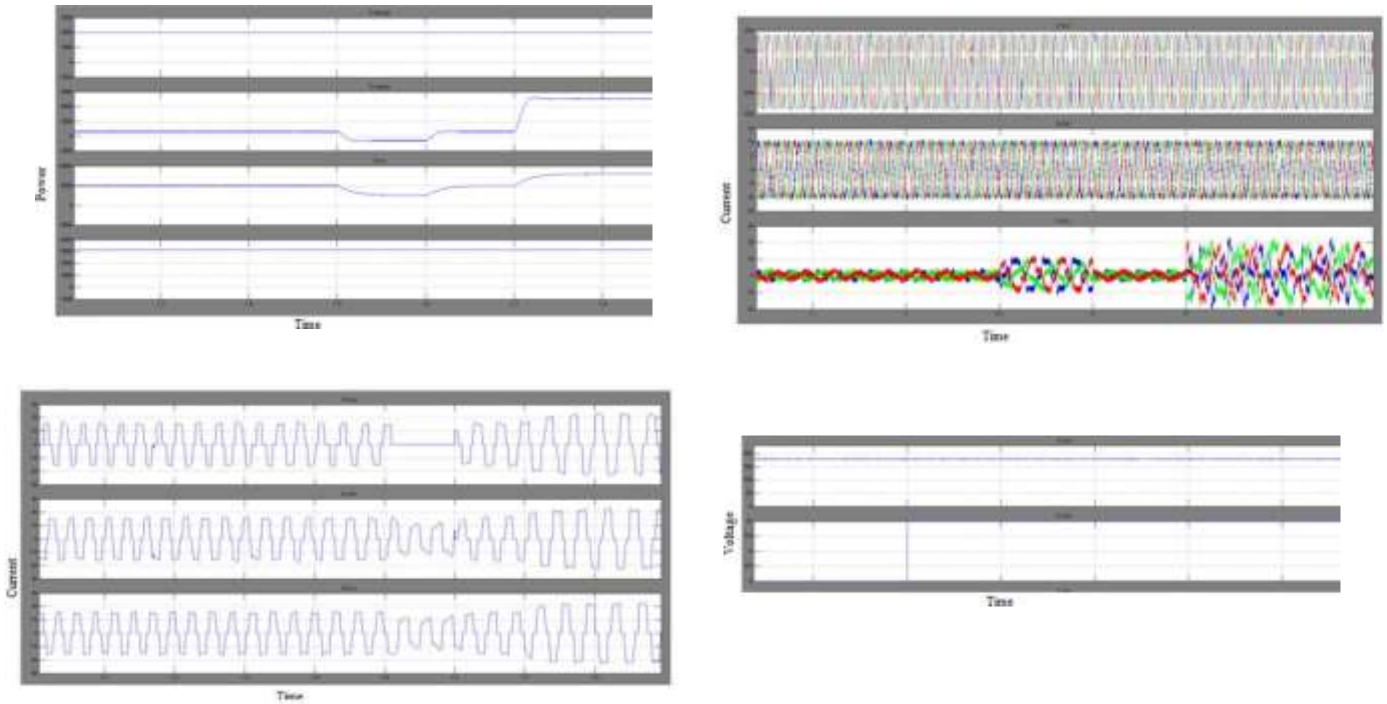

Fig. 5.3 Performance of MG under dynamiccondition at nonlinear load

The dynamic performance of wind– hydro based MG under different scenarios isillustrated in Fig.5.3 at nonlinear load. At t = 1.4 s, the wind speed is increased, accordingly the wind power (Pwind) is also increased. The load demand (PL) and hydrogeneration (Phy) are fixed, therefore, increased renewable power is stored into the battery bank in terms of battery power (Pbt) and battery charging current (Ibt). During load unbalanced condition, when the load onphase “a” is unavailable at t = 1.5 s, the PCCvoltages (vabc) are kept sinusoidal and constant and source currents (iabc) of MG also remain sinusoidal. The compensatingcurrents of VSI (iCa, iCb,iCc) change their values to compensate reactive power demand to maintain balance in voltages and currents at PCC and to eliminate harmonics. The terminal voltage (Vt) is maintained constant at reference value (V ∗ t) throughout the operation. At t = 1.7 s, the load (i_{Labc} and P_L) is increased suddenly. With constant wind and hydro generation,the battery supports the system anddischarges. This shows that duringcontingencies the MG provides satisfactory response.

Extension with solar power:

In this paper they propose only wind- hydro generating stations, generally both are inconstancy in nature so maintain the constant dc-link voltage is complicated because of variable wind speed so in this proposed method we integrate the solar power at common dc link at battery connection. Here we proposed solar-wind-hydro power generation and enhancing the system reliability.

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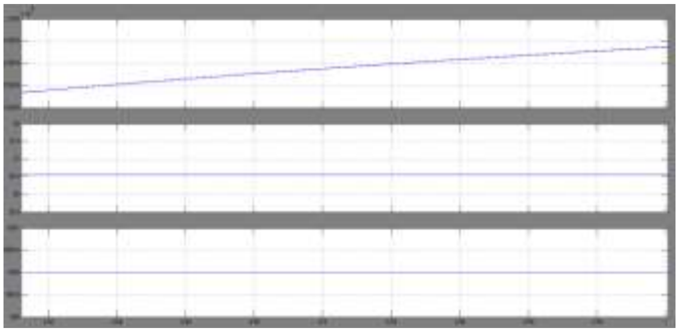

Voltage, current and irradiance of solarpower

From above waveforms our solar array is operating 1000w/m^2 irradiance to generate maximum power first screen of above mentioned waveform is representing voltage of the solar array second one is current and third one is irradiance.

In convention method authors are operating the system with different conditions like steady state and dynamic state to maintain the dc bus voltage is constant with different wind speeds like variable.

ADVANTAGES AND APPLICATIONS

Advantages

- Increase the system reliability
- Reduce the capital cost
- Reduce the size and space
- Reduce the extra inverter requirementApplications
- Rural areas
- Remote control areas

V. CONCLUSION:

The development of a wind-hydro-renewable MG is complete. Utilising the RZALMS control approach, MG demonstrated its ability to provide power quality solutions, such as harmonic reduction, power factor correction, load balancing, and voltage management. It regulates the MG's power balance in many scenarios, including those involving big wind turbines, unbalanced loads, and peak demand. In addition to reducing the negative environmental impact of fossil fuel consumption, an MG like this one provides energy independence to rural areas. Enhanced power quality and balanced power are both provided by a single VSI. The MPPT control speedometer, position sensor, and wind speed sensor are superfluous for the PMBLDCG. Distinct units, such wind, hydro, fuel cell, etc., do not need individual inverters and converters. Consequently, the overall expense of the system and its upkeep is reduced.

FUTURE SCOPE:

Typically, researchers focus on several regions, such as the source side, load side, converter side, or regulating side, when they suggest a solution. We prioritise source-side integration of the solar system with the current system in our suggested strategy. We may use MMCs (Modular multilevel converters) in the future to replace traditional three-phase VSIs, and we may also use digital controllers like as FLCs, ANNs, ANFIS, and wavelet controllers to replace traditional analogue controllers like PI.

VI.REFERENCES

The paper "Study and analysis of a small scale micro-grid using renewable energy resources" was presented at the 2015 International Conference on Electrical Engineering, Information and Communication Technology in Dhaka, Bangladesh. The authors of the paper are A. Rashid, N. Hasan, K. T. Parvez, and M.N. I. Maruf.
In their 2015 article "Review of microgrid architectures - a system of systems perspective," published in the International Journal of Renewable Energy and Power, M.S. Mahmoud, M. Saif Ur Rahman, and F.M.A.L. Sunni

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discuss many aspects of microgrid design.
[3] "Microgrid modular design for tribal healthcare facilities: Kayenta health centre PV system case study" (IEEE Transactions on Industrial Applications, volume 53, issue 6, pages 5121-5129, November/December 2017). W.-J. Lee and S. V. Cotto.
[4] "Control of a hybrid AC/DC microgrid involving energy storage and pulsed loads," IEEE Trans. Ind. Appl., vol. 53, no.1, pp. 567-575, Jan./Feb. 2017, by T. Ma, M. H. Cintuglu, and O.A. Mohammed.
In their 2017 March article titled "Parallel operation of bidirectional interfacing converters in a hybrid AC/DC microgrid under unbalanced grid voltage conditions," K. Sun, X. Wang, Y. W. Li, F. Nejabatkhah, Y. Mei, and X. Lu discuss the use of bidirectional interfacing converters in hybrid AC/DC microgrids.
"Optimised settings of droop parameters using stochastic load modelling for effective DC microgrids operation," published in the IEEE Transactions on Industrial Applications in March/April 2017, was written by F. Cingoz, A. Elrayyah, and Y. Sozer.
A three-phase four-wire winddiesel designed by G. Pathak, B. Singh, and B. K. Panigrahi

pp. 1-6, in 2016 Proc. IEEE 6th International Conference on Power Systems, Microgrid.
[8] Survey of Global Energy Resources 2013, 2013. [On the web]. It may be accessed at this URL: https://www.worldenergy.org/wp-ontent/2013/Complete_WER_2013 _Survey.
Global fossil energy markets and climate change mitigation: An analysis using REMIND, by N. Bauer et al., 2013 (Climatic Change, vol. 136, pp. 69-82).
In 2016, F. P. Perera published an article titled "Multiple threats to child health from fossil fuel combustion: Impacts of air pollution and climate change" in the Environmental Health Perspectives journal. The article can be found on pages 69–82.
"Life cycle environmental impacts of electricity from fossil fuels in Turkey," published in J. Cleaner Prod. in 2015, by B. Atilgan and A. Azapagic, pp. 555-564.
[12] In the proceedings of the 2013 Third International Conference on Electric Power and Energy Conversion Systems, held in Istanbul, Turkey, F. Blaabjerg, Y. Yang, and K. Ma published an article titled "Power electronics—key technology for renewable energy systems—status and future" (pp. 1-6).
Referenced in [13] B. K. Bose's article "Global energy scenario and impact of power electronics in 21st century" published in July 2013 by IEEE Transactions on Industrial Electronics, volume 60, issue 7, pages 2638–2651.
[14] "Microgrid-connected PV-based sources: A novel autonomous control method for maintaining maximum power" (IEEE Industrial Applications Magazine, volume 21, issue 2, pages 19–29, March/April 2015). Written by Y. S. Elrayyah and M. Elbuluk.