

## Power Quality Enhancement Using Renewable Energy Sources and Electric Mobility

Muftah Emtir Ali<sup>1\*</sup>

<sup>1</sup> Department of Electrical and Electronic Engineering, Karabuk University, Karabuk, Turkey.

<sup>1</sup> [muffahali2016@gmail.com](mailto:muffahali2016@gmail.com)



### \*Corresponding Author

#### Article History:

Submitted: 26-11-2023

Accepted: 29-11-2023

Published: 15-12-2023

#### Keywords:

Power Quality

Smart Grid

Renewable Energy Sources

Electric Mobility

**Brilliance: Research of Artificial Intelligence** is licensed under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0).

### ABSTRACT

In the present day, there is a growing emergence of obstacles pertaining to the remuneration of power quality (PQ) issues. In this context, the implementation of renewable energy sources (RES) solutions has a critical significance. The transition from traditional electrical power grids to smart grids necessitates the utilization of a significant quantity of power electronics converters and RES. These converters are essential for the incorporation of crucial technologies like renewable energies, electric mobility, and energy storage systems. Consequently, PQ concerns gain heightened significance in this context. The article focuses on elucidating the primary phenomena related to PQ issues in smart grids, their origins, and consequences across various sectors. Additionally, the paper provides a comprehensive examination and categorization of the primary PQ issues, along with their corresponding alignment with established standards. It also offers an assessment of PQ problems associated with RES and their integration with electric mobility.

### INTRODUCTION

Smart grids are being developed to update traditional power systems by using power electronics and digital technology. These next-generation power systems aim to address several significant challenges and uphold environmentally-friendly ideals. The pathway towards achieving the aforementioned reality is intricate, with several key concerns to be addressed (Khaleel et al., 2021; Yusupov, 2023; Hafez et al., 2019). These concerns include the need for flexibility among systems, efficiency in production and consumption, the implementation of distributed generation (DG) and energy storage, ensuring the reliability of power electronics, the integration of smart metering systems, effective power management, the development of smart homes and cities, the establishment of robust communication infrastructures, the design of battery charging systems for electric mobility, the implementation of microgrids, the use of controllable electrical appliances, and the consideration of PQ from both the power grid and final-user perspectives (Elweddad et al., 2022; Khaleel et al., 2021; Nassar et al., 2022; Aljendy et al., 2022).

Furthermore, within this particular environment, urban areas are transforming smart cities and their associated principles. In relation to the assessment of technologies, the examination of cost-benefit and societal ramifications are expounded upon in reference (Khaleel et al., 2023; Kumar 2020; Elweddad et al., 2022; Abdunnabi et al., 2023; Coldrick et al., 2023). Furthermore, a comprehensive examination of the essential management systems pertaining to the demand for enhanced metering infrastructures in forthcoming grids is outlined in reference. On a global scale, the increasing need for power electronics systems driven by new technologies has led to the emergence of new opportunities in power management.

In this context, the intercommunication among these systems further strengthens the significant role played by information and communication technologies. Nevertheless, the extensive utilization of power electronics converters eventually gives rise to concerns related to power quality. PQ is widely acknowledged as a significant and crucial factor for the effective deployment of smart grids, despite its already established status as a prominent concern in traditional power networks. The growing significance of PQ can be attributed to various variables, such as the escalating utilization of electrical appliances, particularly in the industrial domain, and the prevalence of electrical gadgets exhibiting nonlinear characteristics in the household sector (Khaleel et al., 2023; Wazirali et al., 2023; Nassar et al., 2023; Yusupov et al., 2023).

The primary considerations pertaining to PQ are supplementary expenses, compromises in product integrity, and the malfunctioning of electrical devices, encompassing both premature failures and complete breakdowns. As a result, PQ can have significant detrimental implications across several sectors, particularly in the industrial, commercial, and residential domains, each of which exhibits distinct PQ demands (Das et al., 2023; Rezapour et al., 2024).



## LITERATURE REVIEW

Recently, researchers (Ghayth et al., 2023) have focused on photovoltaic (PV) power generation to lessen the environmental pollution caused by traditional electric generators. PV arrays' lifetime energy output and cell cost determine their economic viability. This study uses the Perturb and Observe (P&O) method to model and simulate solar PV systems interfaced with the distribution network. The article examines how solar radiation changes affect system performance and presents an energy storage solution to address PQ challenges caused by solar power intermittency. The simulation findings suggest that the proposed method improves solar PV system performance by increasing energy capture efficiency and lowering power quality concerns. The suggested technique was evaluated and compared to the fixed perturbation MPPT algorithm under various scenarios. Experimental findings demonstrate the method's viability and benefits. In (Noroozi et al., 2023), Over traditional PWM converters, the transformerless single-phase semi-quasi-Z-source inverter (SqZSI) offers significant benefits. This architecture is useful for PV micro-inverter applications because of its cheap cost, high power density, and low leakage current. DC and second harmonic injection in the output AC port may prohibit this architecture from meeting standards. This work proposes, analyzes, and experimentally verifies four harmonic mitigation methods based on PI and PR controllers for the 90 W SqZSI to improve power quality. Additionally, a redesigned modulation reference waveform technique is provided. Under full power demand, the converter's total harmonic distortion (THDV) is 1.27%.

According to (Khaleel et al., 2023), microgrid (MG) battery energy storage system modeling and stability analysis are essential for optimum reliability, efficiency, and power management. This paper proposes using the hybrid energy storage system (HESS)'s photovoltaic (PV), fuel cell (FC), and battery to support demand load. This contribution integration with PV, FC, and battery via MG. The technique uses sophisticated power system phasor feasible alternatives for design evaluation. To collect electrical power system data, an adaptive neuro-fuzzy inference system (ANFIS) and Genetic Algorithm (GA) control techniques are used. Analyzing these facts yields knowledge, which drives intelligent behavior or action. ANFIS gives the HESS-MG system an injection value of 99.6% in the Single Line-to-Ground Faults Scenario (SLGFS), whereas GA gives it 98.9%. Voltage sag is reduced by 76.2% without HESS-MG.

Due to the integration of distributed generation resources, especially FC, the electrical power grid (EPG) becomes more comprehensive and has PQ issues like voltage/current unbalance, harmonics, voltage sag, etc. Unexpected EPG operation circumstances cause voltage sag. The Advanced Equilibrium Optimizer (AEO) and Particle Swarm Optimization (PSO) are proposed as solutions for EPG disturbance in partially voltage sag issues caused by three fault scenarios: SLGF, DLGF, and TLGF (Khaleel et al., 2023). Both suggested controllers use AEO and PSO, and their advantages are shown by comparing them to a traditional PI controller. This research paper (Choudhury et al., 2023), uses MATLAB/Simulink to compare energy management and PQ improvement options for a Fuel Cell, Battery, and SuperCapacitor integrated Microgrid system. A Modified Water Wave Optimization technique using adaptive population size and wavelength coefficient improves energy management and PQ. The MWWO approach modifies Proportional Integral controller settings robustly and dynamically for optimal performance. The suggested approach was compared to existing techniques for hydrogen usage, load power deliberation, power quality, and system efficiency. The findings and numerical analysis show that the recommended strategy improves dynamic voltage responsiveness, fuel consumption, harmonics, and effectiveness over existing techniques, showing its real-time use.

## POWER QUALITY ISSUES

PQ issues encompass a variety of definitions, ranges, and criteria that necessitate clarification from equipment makers, international code bodies, electric power grid operators, and consumers. The financial implications of inadequate power quality can be attributed to increased energy consumption and concealed costs arising from power interruptions caused by false protection, data loss, and device impairment (Ahmed et al., 2023; Andeef et al., 2023; Pathak et al., 2023; boopathi & indagandhi, 2023; Khaleel 2023). The overall expenses associated with inadequate electricity quality are substantial. According to a study, it has been projected that the yearly expenditure for U.S corporations is anticipated to range from USD 119 to 188 billion, while the European sector is likely to incur a cost of EUR 150 billion (Khaleel et al., 2023; Zhang et al., 2023; Sahoo et al., 2023). The primary goal of PQ standards is to govern the characteristics of electrical energy, ensuring that it meets the specific requirements of a given electrical system. Different organizations have proposed various definitions for power quality. An illustration of this can be seen in the electromagnetic compatibility norm EN61000-4-30, which focuses on testing and measurement procedures specifically related to PQ measuring methods. Additionally, the EN-50160 standard addresses voltage characteristics in public distribution networks (Faghani et al., 2021; Almbrouk & Abulifa, 2023; Khaleel et al., 2023; Xu et al., 2023; Kumar et al., 2023; Deffaf et al., 2023).

Conversely, non-linear loads are extensively employed in industrial settings at present, resulting in the extraction of currents from the power grid that exhibit a significant level of total harmonic distortion (THD). This phenomenon therefore leads to a degradation in power quality. The PQ norms for these specialized loads, which are connected to the three-phase AC power grid at high-voltage (HV) or medium-voltage (MV) levels, are distinct and specific to their



operation. For instance, in electrified railway applications, the standard for the supply voltages of traction systems is EN 50163 (Khaleel et al., 2023; Nassar et al., 2016; Nassar et al., 2023; Chaudhary et al., 2023). Fig. 1, presents the PQ issues classification

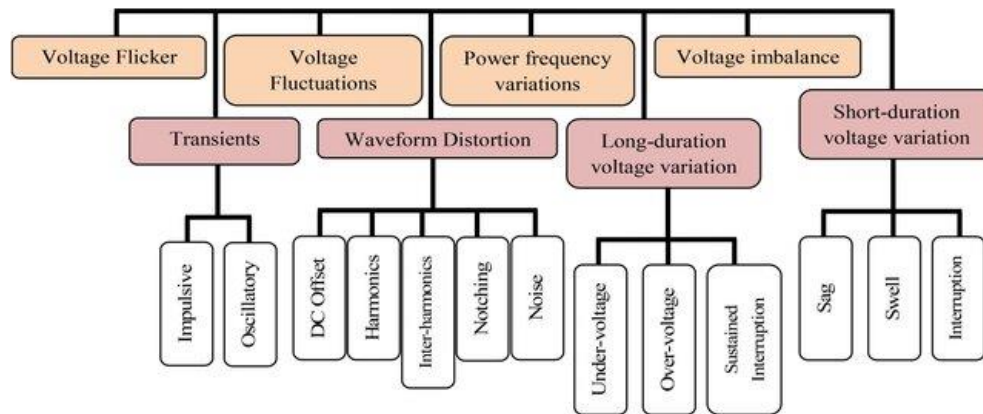


Fig. 1. PQ issues classification

Voltage sags in alternating current (AC) power networks can be characterized as transient reductions in the root mean square (RMS) supply voltage, resulting in a value ranging between 90% and 10% of the declared RMS voltage, persisting for a duration exceeding one fundamental cycle. In the context of voltage sags in direct current (DC) power grids, the direct current voltage value serves as a replacement for the alternating current (AC) root mean square (RMS) value. Following the occurrence of voltage sag, the voltage must be expeditiously reinstated within a brief timeframe. According to the EN-50160 standard, the duration of a voltage sag can range from 10 milliseconds to 1 minute. Voltage sags in alternating current (AC) power grids are occurrences that can be attributed to several factors, such as the initiation of electric motors, the occurrence of short circuits in nearby facilities, and the activation of transformers (El-Khozenadar et al. 2023; Selvakumaran & Kalidasan, 2016; Khan et al., 2022; Khan et al., 2022). Transient overvoltage is a rapid occurrence that can exhibit oscillatory or non-oscillatory behavior, characterized by a rising time ranging from less than 1  $\mu$ s to a few ms. The magnitude, energy, and duration of these phenomena are intricately linked to the events from which they emerge. Transient overvoltage is primarily attributed to various factors, including but not limited to lightning strikes, the activation of fuses, and the energization of capacitors. Conversely, the ramifications of this phenomenon may result in the impairment or cessation of delicate machinery, as well as the intermittent fluctuation of illumination and display devices (Miskeen et al., 2023; Al-Ammar et al., 2020; Velasquez & Ezcurra, 2023; Nassar et al., 2023; Rajesh et al., 2023; Khaleel et al., 2014; Anand & Malik, 2022; Tarraso et al., 2019).

The potential impact could manifest as a progressive and cumulative effect, ultimately leading to hardware malfunction in the equipment. Moreover, voltage harmonics refer to the presence of many spectral components in a voltage waveform, where these components are integer multiples of the fundamental frequency, such as double, third, fourth, and so on. Furthermore, it is worth noting that there exist other components known as inter-harmonics, which do not correspond to integer multiples of the fundamental frequency. One of the most significant factors to consider is the third-order harmonic components, which possess a frequency value three times that of the fundamental frequency (Nassar et al., 2024; Shende & Hiware, 2021; Khaleel, 2015; Budiman et al., 2024; Khaleel, 2014). The presence of third-order harmonic components arises during the operation of single-phase non-linear loads, such as rectifiers and variable speed drives. The presence of harmonic components is well recognized as a significant contributing factor to the degradation of PQ in industrial settings.

### PQ ISSUES ASSOCIATED WITH RENEWABLE ENERGY SOURCES

There is a common sense that in the near future, RES will replace conventional energy generation through fossil fuels, leading to a new concept of power grids supplied by DG systems. Nevertheless, there are still some bottlenecks that should be overcome, e.g., intermittent energy production. Thus, currently, there are efforts to develop several technologies involving battery energy storage systems (BESS), e.g., reliable power electronics devices and processing and communication systems with lower latency (Mishra et al., 2023; Sarker et al., 2023; Zhang et al., 2023; Khaleel, 2023; Makhazmi et al., 2023; Nassar et al., 2023; saha et al., 20223). Fig. 2, presents the performance characteristics of selecting BESS. Electrical energy has become an indispensable resource for modern human life. With the worldwide population increase and technological progress, it is foreseeable that there will be an intensification of electrical energy consumption. Therefore, traditional electricity generation from fossil fuels is no longer feasible, as these resources are increasingly scarce. Furthermore, the extraction, transport, refining, and use of fossil fuels cause enormous negative environmental effects, namely, air, water, and soil pollution, as well as the emission of carbon dioxide and other

greenhouse gases. It is estimated that 25% of greenhouse emissions are produced by electricity generation (Li et al., 2023; Khaleel et al., 2022; Gao & Chen, 2023; Fazal et al., 2023; Alasali et al., 2023).

To respond to electricity demand and minimize environmental problems, RES emerges as an alternative solution. Among those available, wind and solar energies are growing rapidly, particularly in the last few years (Shayan et al., 2023; Pontes et al., 2023; Alsharif et al., 2023). The added value of these RES leads to an increase in investment in some regions of the world, namely in Europe, which increased the share of electricity generation based on RES from 20.1% in 2005 to 34.2% in 2015. In terms of wind power, as an example, in 2019, a total of 60.4 GW was installed, increasing the global total wind power capacity to 651 GW. China and the US were responsible for more than 60% of the onshore wind power additions performed during this year, with Europe being in the lead in terms of offshore wind power, accounting for about 59% of the total offshore additions. In terms of solar photovoltaics (PV), the global capacity additions in 2019 were 114.9 GW, with China being the biggest contributor with 30.1 GW additions during this year, followed by the United States with 13.3 GW, and Japan with 7.7 GW. A total of 629 GW of cumulative solar PV capacity was achieved at the end of 2019 throughout the world (Gade & Agrawan, 2023; Tabak et al., 2022; Alsadi & Nassar, 2017; Ali, 2023; Rahmani et al., 2023; Khaleel, 2023; Wang et al., 2024).



Fig. 2. Performance characteristics of selecting BESS

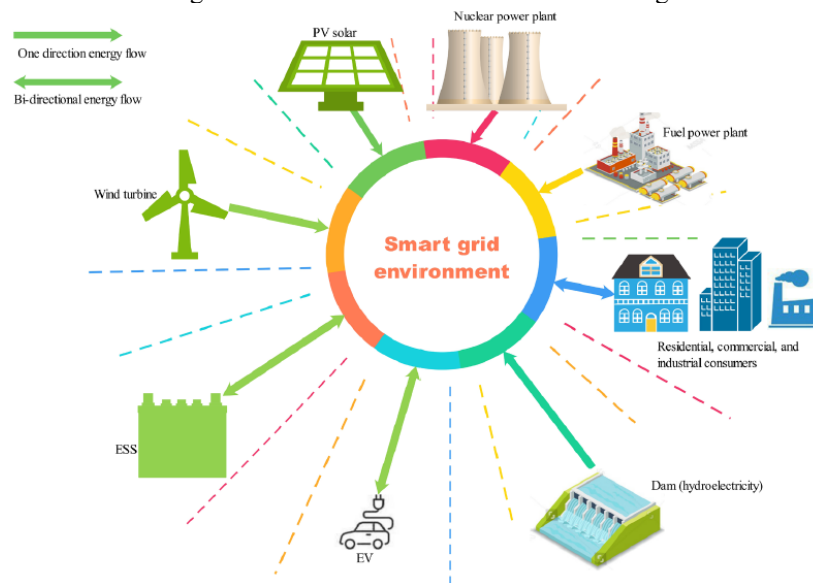


Fig. 3. The diagram of the smart grid environment for the energy management system

### POWER QUALITY IN ELECTRICAL MOBILITY

This section provides a comprehensive analysis of power electronics in the context of electric vehicles (EVs), with a specific focus on on-board and off-board EV battery charging systems, as well as the associated PQ concerns (Alsharif et al., 2023; Khaleel et al., 2023; Belrzaeg et al., 2023). The scientific community has consistently shown significant interest in the advancement of cutting-edge technology for electric mobility. This interest has resulted in



substantial investments in the field of vehicle electrification, including hybrid and fuel-cell cars. Hence, due to the positive shift in the transportation paradigm, prominent companies in the automotive industry have introduced multiple commercially accessible EV models. However, given that EVs are intended to connect with the power grid for charging, the implications of this additional electrical load are of significant concern (Ghayth et al., 2023, Alsharif et al., 2023; Alsharif et al., 2022; Belrzaeg et al., 2021; Gupta et al., 2023).

From a power grid perspective, the primary worry connected with the integration of electric vehicles (EVs) and their charging requirements is the unpredictability of EV use and its impact on PQ. From the standpoint of PQ, the EV can be regarded as a valuable resource for power grids, offering a range of novel capabilities in terms of control. This enhances the ability to implement various management strategies, including frequency regulation, active power operation, and other approaches. In addition to the grid-to-vehicle (G2V) and vehicle-to-grid (V2G) modes, there is ongoing discussion on other new operational modes that are being considered as creative paradigms for the effective integration of electric vehicles (EVs) into power grids. This debate also includes insights from an industrial standpoint. In light of the integration of EVs into power grids, it becomes imperative to regulate the currents at the point of connection to ensure their adherence to sinusoidal waveforms and synchronization with the voltages. The use and supply of energy are now regulated due to the significant economic losses associated with power quality issues (Hajibabai et al., 2023).

As previously stated, the significance of EV charging's influence on the power grid cannot be overstated. Power quality issues and peak demand are closely linked to the operational power of EV battery charging and escalate in tandem with the charging rate. The significance of power quality issues in EV battery charging stations, particularly the high total harmonic distortion (THD) of currents, poor power factor, and current imbalances, cannot be overlooked. This has emerged as a primary worry for power providers. The implementation of more EV battery charging stations in certain regions may need the installation of new power transformers to adequately meet the demand for EV battery charging. Failure to address this requirement might lead to overheating problems, which in turn can diminish the lifespan of the transformers (Pisano et al., 2023; Chidambaram et al., 2023).

### PQ IN ELECTRICAL APPLIANCES

The electrical power grid typically serves as the primary energy source for powering the majority of electrical appliances. Because of this, changing alternating current (AC) to direct current (DC) is common in many places, like switch-mode power supplies, battery charging systems, variable speed drives, electronic ballasts, and many home appliances. Usually, diodes and/or thyristors are used in the power conversion stage to allow the controlled or uncontrolled flow of electricity in one direction or both directions. Many experts agree that the diode full-bridge rectifier, which is also known as a Graetz bridge, is the most common AC-DC topology used in academic literature. This device is very popular because it is easy to understand and use, and the semiconductors used are not expensive. It can also rectify electricity on its own, without any outside help. However, diode full-bridge rectifiers have a large total harmonic distortion (THD) in the amount of current they use. This changes the voltage waveform and causes the power grid's power factor to drop. It's also important to note that the IEC 61000-3-2 standard has strict rules about the harmonic composition of the input current of power electronics converters [103-105].

### METHOD

The investigation of PQ encompasses a wide range of subjects. The primary objective and contribution of this paper are to provide a thorough examination of renewable energy source technologies that are focused on enhancing power quality in various application scenarios. This article addresses power quality phenomena associated with various electrical systems and appliances and offers methods to mitigate PQ issues. Hence, this article presents a comprehensive examination, supported by 105 references, encompassing the compilation and meticulous delineation of the primary technologies reliant on power electronics systems and their corresponding impact on PQ.

### RESULT

The elucidation of PQ phenomena across diverse activity sectors underscores the pivotal role of integrating renewable energy sources (RES) with advanced technologies. The discussion will delve into the key findings related to the efficacy of hybrid configurations employing power electronics converters and energy storage systems (ESS) in addressing the challenges associated with intermittent energy production. The study indicates that hybrid RES configurations could help solve problems caused by the fact that renewable energy generation isn't always available. By combining power electronics converters with ESS in a seamless way, a flexible solution is created that guarantees a more stable and reliable energy supply. The hybrid configuration's ability to extract maximum energy from RES is a noteworthy outcome. The system makes the best use of energy extraction by using smart control mechanisms made possible by power electronics converters. This improves overall efficiency and helps make the energy landscape more sustainable. An essential facet of the discussion revolves around the multifaceted capabilities of power electronics



converters. These components emerge as crucial assets in compensating for PQ problems. They can fix problems like voltage changes, harmonic distortions, and imbalances because they are flexible and can do many things. This makes the power grid strong and reliable.

### DISCUSSION

The primary power quality (PQ) phenomena were discussed concerning various sectors of activity. The study showcased that integrating power electronics converters and energy storage systems (ESS) in a hybrid setup offers a viable approach to address challenges associated with intermittent energy generation from renewable energy sources (RES). This configuration also enables the extraction of maximum energy from RES. Additionally, it is imperative to discuss the efficacy of power electronics converters in mitigating PQ issues through various means, as this is a prerequisite for establishing a dependable power infrastructure. In the context of a smart grid, the use of power transformers is widely acknowledged. While conventional transformers play a crucial role in power grids, there is a growing recognition of the need to address PQ concerns. In this regard, solid-state transformers have emerged as a promising solution to alleviate the issues associated with conventional transformers. The versatility of the Solid-State Transformer stems from its reliance on power electronics converters. This characteristic allows it to be effectively utilized in various application domains, making it a valuable asset for integrating Renewable Energy Sources (RES), Energy Storage Systems (ESS), and electric mobility. Consequently, the Solid-State Transformer plays a crucial role in the envisioned future of smart grids, ensuring optimal PQ for both the power grid and the load sides.

### REFERENCES

- Abdunnabi, M., Etiab, N., Nassar, Y. F., El-Khozondar, H. J., & Khargotra, R. (2023). Energy savings strategy for the residential sector in Libya and its impacts on the global environment and the nation economy. *Adv. Build. Energy Res*, 17(4), 379–411.
- Ahmed, A. A., Alsharif, A., & Yasser, N. (2023). Recent advances in energy storage technologies. *International Journal of Electrical Engineering and Sustainability (IJEES)*, 9–17.
- Al-Ammar, E. A., Ul-Haq, A., Iqbal, A., Jalal, M., & Anjum, A. (2020). SRF based versatile control technique for DVR to mitigate voltage sag problem in distribution system. *Ain Shams Engineering Journal*, 11(1), 99–108. doi:10.1016/j.asej.2019.09.001
- Alasali, F., Saidi, A. S., El-Naily, N., Alsmadi, O., Khaleel, M., & Ghirani, I. (2023). Assessment of the impact of a 10-MW grid-tied solar system on the Libyan grid in terms of the power-protection system stability. *Clean Energy*, 7(2), 389–407. doi:10.1093/ce/zkac084
- Ali, M. (2023). A role of mechanical Energy Storage Systems in grid application. *Brilliance: Research of Artificial Intelligence*, 3(1), 1–8. doi:10.47709/brilliance.v3i1.1941
- Aljendy, R., Nasyrov, R. R., Abdelaziz, A. Y., & Diab, A. A. Z. (2019). Enhancement of power quality with hybrid distributed generation and FACTS device. *IETE Journal of Research*, 1–12. doi:10.1080/03772063.2019.1698321
- Almabrouk, A., & Abulifa, S. A. (2023). The technology of renewable energy and its role in achieving sustainable development. *IJEES*, 1–9.
- Alsadi, S. Y., & Nassar, Y. F. (2017). Energy demand based procedure for tilt angle optimization of solar collectors in developing countries. *Journal of Fundamentals of Renewable Energy and Applications*, 07(02). doi:10.4172/2090-4541.1000225
- Alsharif, A., Ahmed, A. A., Khaleel, M. M., Daw Alarga, A. S., Jomah, O. S. M., & Imbayah, I. (n.d.). Comprehensive state-of-the-art of vehicle-to-grid technology. In *2023 IEEE 3rd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering*.
- Alsharif, A. H. (2023). *Mitigation of dust impact on solar photovoltaics performance considering Libyan climate zone: A review*. 22–27.
- Alsharif, A., Tan, C. W., Ayop, R., Ahmed, A. A. A., Alanssari, A., & Khaleel, M. M. (2022). Energy management strategy for Vehicle-to-grid technology integration with energy sources: Mini review. *AJAPAS*, 12–16.
- Alsharif, A., Tan, C. W., Ayop, R., Ahmed, A. A., & Khaleel, M. (2022). Electric vehicle integration with energy sources: Problem and solution review. *AJAPAS*, 17–20.
- Alsharif, Abdulgader, Ahmed, A. A., Khaleel, M. M., & Altayib, M. A. (2023). Ancillary services and energy management for electric Vehicle: Mini-review. *NAJSP*, 9–12. Retrieved from <https://najsp.com/index.php/home/article/view/8>
- Alsharif, Abdulgader, Tan, C. W., Ayop, R., Ali Ahmed, A., Mohamed Khaleel, M., & Abobaker, A. K. (2022). Power management and sizing optimization for hybrid grid-dependent system considering photovoltaic wind battery electric vehicle. *2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA)*. IEEE.

- Alsharif, Abdulgader, Tan, C. W., Ayop, R., Smin, A. A., Ahmed, A. A., Kuwil, F. H., & Khaleel, M. M. (2023). Impact of electric Vehicle on residential power distribution considering energy management strategy and stochastic Monte Carlo algorithm. *Energies*, *16*(3), 1358. doi:10.3390/en16031358
- Anand, V., & Mallik, S. K. (2022). D-FACTS-based power quality enhancement using power balance theory. In *Recent Advances in Power Electronics and Drives* (pp. 335–345). Singapore: Springer Nature Singapore.
- Andeef, M. A. (2023). The role of renewable energies in achieving a more secure and stable future. *IJEES*, 11–20.
- Arias Velásquez, R. M., & Pando Ezcurra, T. T. (2023). Dust analysis in photo-voltaic solar plants with satellite data. *Ain Shams Eng. J.*, (102314).
- Belrzaeg, M., Ahmed, A. A., Khaleel, M. M., Alsharif, A., Rahmah, M. M., & Alarga, A. S. D. (2023). Suspension system control process for Buses with In-Wheel Motors. *Engineering Proceedings*, 29(1).
- Benbouhenni, H., Bizon, N., Mosaad, M. I., Colak, I., Djilali, A. B., & Gasmi, H. (2024). Enhancement of the power quality of DFIG-based dual-rotor wind turbine systems using fractional order fuzzy controller. *Expert Syst. Appl.*, *238*(121695).
- Boopathi, R., & Indragandhi, V. (2023). Comparative analysis of control techniques using a PV-based SAPF integrated grid system to enhance power quality,” e-Prime - Advances in Electrical Engineering. *Advances in Electrical Engineering*, *5*.
- Budiman, F. N., Ramli, M. A. M., Bouchekara, H. R. E. H., & Milyani, A. H. (2024). Optimal scheduling of a microgrid with power quality constraints based on demand side management under grid-connected and islanding operations. *International Journal of Electrical Power & Energy Systems*, *155*(109650), 109650. doi:10.1016/j.ijepes.2023.109650
- Castellanos, J., Correa-Florez, C. A., Garcés, A., Ordóñez-Plata, G., Uribe, C. A., & Patino, D. (2022). An energy management system model with power quality constraints for unbalanced multi-microgrids interacting in a local energy market. Retrieved from <http://arxiv.org/abs/2212.01910>
- Chaudhary, V., Dutt, K., Naresh, M., & Tripathi, R. K. (2020). Power quality enhancement using FACTS device in transmission system with DPFC. In *Lecture Notes in Electrical Engineering* (pp. 63–80). Singapore: Springer Singapore.
- Chidambaram, K., Ashok, B., Vignesh, R., Deepak, C., Ramesh, R., Narendhra, T. M. V., ... Kavitha, C. (2023). Critical analysis on the implementation barriers and consumer perception toward future electric mobility. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *237*(4), 622–654. doi:10.1177/09544070221080349
- Choudhury, S., Varghese, G. T., Mohanty, S., Kolluru, V. R., Bajaj, M., Blazek, V., ... Misak, S. (2023). Energy management and power quality improvement of microgrid system through modified water wave optimization. *Energy Reports*, *9*, 6020–6041. doi:10.1016/j.egy.2023.05.068
- Coldrick, K., Walshe, J., McCormack, S. J., Doran, J., & Amarandei, G. (2023). The role of solar spectral beam splitters in enhancing the solar-energy conversion of existing PV and PVT technologies. *Energies*, *16*(19), 6841. doi:10.3390/en16196841
- Das, S., Ishrak, H. M., Hasan, M. M., & Kabir, M. A. (2023). Empirical analysis of power quality using UPQC with hybrid control techniques. *Results in Engineering*, *20*(101527), 101527. doi:10.1016/j.rineng.2023.101527
- Deffaf, B., Farid, H., Benbouhenni, H., Medjmadj, S., & Debdouche, N. (2023). Synergetic control for three-level voltage source inverter-based shunt active power filter to improve power quality. *Energy Reports*, *10*, 1013–1027. doi:10.1016/j.egy.2023.07.051
- Effect of fuel cells on voltage sag mitigation in power grids using advanced equilibrium optimizer and particle swarm optimization. (2023). *Jordan Journal of Electrical Engineering*, *9*(2), 175–188.
- El-Khozenadar, H. J., Albardawil, M. A., Asfour, M. S., Abu-Khater, I. N., & Nassar, Y. F. (2023). DC off-grid PV system to supply electricity to 50 boats at Gaza seaport. *2023 8th International Engineering Conference on Renewable Energy & Sustainability (ieCRES)*. IEEE.
- Elweddad, M., Gunesser, M. T., & Yusupov, Z. (2022). Energy management and optimization of microgrid system using particle swarm optimization algorithm. *AIP Conference Proceedings*, 2686(1).
- Elweddad, Mohamed, Gunesser, M. T., & Yusupov, Z. (2022). Energy management techniques in off grid energy systems: A review. In *Innovations in Smart Cities Applications Volume 5* (pp. 281–292). Cham: Springer International Publishing.
- Faghani, A., Yaghoubi, E., & Yaghoubi, E. (2021). Triple-channel glasses-shape nanoplasmonic demultiplexer based on multi nanodisk resonators in MIM waveguide. *Optik (Stuttg.)*, *237*(166697).
- Fazal, S., Haque, M., Arif, M., Gargoom, A., & Oo, A. M. T. (2023). Grid integration impacts and control strategies for renewable based microgrid, ” Sustain. *Sustain. Energy Technol. Assessments*, *56*(103069).
- Gade, S., & Agrawal, R. (2023). Optimal utilization of unified power quality conditioner using the JAYA optimization algorithm. *Engineering Optimization*, *55*(1), 1–18. doi:10.1080/0305215x.2021.1978440

- Gao, C., & Chen, H. (2023). Electricity from renewable energy resources: Sustainable energy transition and emissions for developed economies. *Utilities Policy*, 82(101543), 101543. doi:10.1016/j.jup.2023.101543
- Gao, X., Li, R., Chen, S., & Li, Y. (2023). Potential analysis and optimal management of winter electric heating in rural China based on V2H technology. *Sustainability*, 15(15), 11517. doi:10.3390/su151511517
- Ghayth, A., Şimşir, M., Khaleel, M., Ahmed, A., & Alsharif, A. (2023). An investigation of Inverse-Automatic Mechanical Transmission of EV using gear downshift approach. *IJEES*, 1–9.
- Ghayth, A., Yusupov, Z., & Khaleel, M. (2023). Performance Enhancement of PV Array Utilizing Perturb & Observe Algorithm". *IJEES*, 1(2), 29–37.
- Gupta, J., Kushwaha, R., & Singh, B. (2023). Improved power quality charger based on bridgeless canonical switching cell converter for a light electric vehicle. *IEEE Transactions on Industry Applications*, 59(4), 4610–4619. doi:10.1109/tia.2023.3264222
- Hafez, A. A., Nassar, Y. F., Hammdan, M. I., & Alsadi, S. Y. (2020). Technical and economic feasibility of utility-scale solar energy conversion systems in Saudi Arabia," Iran. *J. Sci. Technol. Trans. Electr. Eng.*, 44(1), 213–225.
- Hajibabai, L., Atik, A., & Mirheli, A. (2023). Joint power distribution and charging network design for electrified mobility with user equilibrium decisions. *Computer-Aided Civil and Infrastructure Engineering*, 38(3), 307–324. doi:10.1111/mice.12854
- Intelligent techniques for distribution static compensator using genetic algorithm, and fuzzy logic controller. (2015). *International Journal of Computing Communication and Instrumentation Engineering*, 2(1). doi:10.15242/ijccie.e0915002
- Khaleel, M. (2023). Intelligent Control Techniques for Microgrid Systems. *Brilliance: Research of Artificial Intelligence*, 3(1), 56–67.
- Khaleel, M., Abulifa, S. A., & Abulifa, A. A. (2023). Artificial intelligent techniques for identifying the cause of disturbances in the power grid. *Brilliance: Research of Artificial Intelligence*, 3(1), 19–31.
- Khaleel, M., Ahmed, A. A., & Alsharif, A. (2023). Artificial Intelligence in Engineering. *Brilliance*, 3(1), 32–42.
- Khaleel, M., & Faraj, M. A. (2014). Modeling and control a D-STATCOM with Sugeno fuzzy controller (SFC) and Mamdani fuzzy controller (MFC) for voltage sag mitigation. In *2nd International Conference on Emerging Trends in Engineering and Technology, ICETET* (pp. 114–119).
- Khaleel, M. M. (2014). Enhancement power quality with Sugeno-type Fuzzy Logic and Mamdani-type Fuzzy Logic base on DVR. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, 3(4), 8273–8283.
- Khaleel, M. M., Abduesslam, K., & Nizam, M. (2014). DVR with artificial intelligent controller for voltage sag mitigation. In *International Conference on Advances in Engineering and Technology (ICAET'2014) March* (pp. 29–30).
- Khaleel, M. M., Ahmed, A. A., & Alsharif, A. (2023). Energy Management System Strategies in Microgrids: A Review. *The North African Journal of Scientific Publishing (NAJSP)*, 1(1), 1–8.
- Khaleel, M. M., Alsharif, A., & Imbayah, I. I. K. (2022). Renewable energy technologies: Recent advances and future predictions. *AJAPAS*, 58–64.
- Khaleel, M. M., Yusupov, Z., Güneşer, M. T., Abulifa, A. A., Ahmed, A. A., & Alsharif, A. (n.d.). The effect of PEMFC on power grid using advanced equilibrium optimizer and particle swarm optimisation for voltage sag mitigation. In *2023 IEEE 3rd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering*.
- Khaleel, M., Yaghoubi, E., Yaghoubi, E., & Jahromi, M. Z. (2023). The role of mechanical energy storage systems based on artificial intelligence techniques in future sustainable energy systems. *International Journal of Electrical Engineering and Sustainability (IJEES)*, 1(4), 1–31.
- Khaleel, M., Yusupov, K., Nassar, Y., El-Khozondar, H., Ahmed, A., & Alsharif, A. (2023). Technical challenges and optimization of superconducting magnetic energy storage in electrical power systems," e-Prime - Advances in Electrical Engineering. *Advances in Electrical Engineering*, 5.
- Khaleel, M., Yusupov, Z., Yasser, N., & El-Khozondar, H. J. (2023a). Enhancing Microgrid Performance through Hybrid Energy Storage System Integration: ANFIS and GA Approaches". *IJEES*, 1(2), 38–48.
- Khaleel, M., Yusupov, Z., Yasser, N., & El-Khozondar, H. J. (2023b). Enhancing Microgrid performance through hybrid energy storage system integration: ANFIS and GA approaches. *IJEES*, 38–48.
- Khaleel, Mohamed, Ahmed, A. A., & Alsharif, A. (2023). Technology challenges and trends of electric motor and drive in electric vehicle. *International Journal of Electrical Engineering and Sustainability (IJEES)*, 41–48. Retrieved from <https://ijeess.org/index.php/ijeess/article/view/14>
- Khaleel, Mohamed Mohamed, Abulifa, S. A., Abdaldeam, I. M., Abulifa, A. A., Amer, M., & Ghandoori, T. M. (2022). A current assessment of the renewable energy industry. *African Journal of Advanced Pure and Applied Sciences (AJAPAS)*, 122–127. Retrieved from <https://aaajournals.com/index.php/ajapas/article/view/251>



- Khaleel, Mohamed Mohamed, Adzman, M. R., & Zali, S. M. (2021). An integrated of hydrogen fuel cell to distribution network system: Challenging and opportunity for D-STATCOM. *Energies*, 14(21), 7073. doi:10.3390/en14217073
- Khaleel, Mohamed Mohamed, Adzman, M. R., Zali, S. M., Graisa, M. M., & Ahmed, A. A. (2021). A review of fuel cell to distribution network interface using D-FACTS: Technical challenges and interconnection trends. *International Journal of Electrical and Electronic Engineering & Telecommunications*, 319–332. doi:10.18178/ijeetc.10.5.319-332
- Khaleel, Mohamed Mohamed, Mohamed Ghandoori, T., Ali Ahmed, A., Alsharif, A., Ahmed Alnagrat, A. J., & Ali Abulifa, A. (2022). Impact of mechanical storage system technologies: A powerful combination to empowered the electrical grids application. *2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA)*. IEEE.
- Khan, B., Redae, K., Gidey, E., Mahela, O. P., Taha, I. B. M., & Hussien, M. G. (2022). Optimal integration of DSTATCOM using improved bacterial search algorithm for distribution network optimization. *Alexandria Engineering Journal*, 61(7), 5539–5555. doi:10.1016/j.aej.2021.11.012
- Kumar, A., & Indragandhi, V. (2020). Power quality improvement of grid-connected wind energy system using facts devices. *Int. J. Ambient Energy*, 41(6), 631–640.
- Kumar, B. A., Jyothi, B., Rathore, R. S., Singh, A. R., Kumar, B. H., & Bajaj, M. (2023). A novel framework for enhancing the power quality of electrical vehicle battery charging based on a modified Ferdowski Converter. *Energy Reports*, 10, 2394–2416. doi:10.1016/j.egy.2023.09.070
- Lavanya, Navamani, D., Geetha, Ganesh, V., Sathik, M. J., Vijayakumar, & Ravichandran. (2023). Smart energy monitoring and power quality performance based evaluation of 100-kW grid tied PV system. *Heliyon*, 9(6), e17274. doi:10.1016/j.heliyon.2023.e17274
- Makhzom, A. (2023). Carbon dioxide Life Cycle Assessment of the energy industry sector in Libya: A case study. *International Journal of Electrical Engineering and Sustainability (IJEES)*, 1(3), 145–163.
- Mishra, S., Saini, G., Chauhan, A., Upadhyay, S., & Balakrishnan, D. (2023). Optimal sizing and assessment of grid-tied hybrid renewable energy system for electrification of rural site, ” *Renew. Energy Focus*, 44, 259–276.
- Miskeen, A., Elzer, R., Mangir, I., Nassar, Y., J. El-Khozondar, H., M. Khaleel, M., ... I. Alzayani, I. (2023). Electricity from wastewater treatment plants. *Solar Energy and Sustainable Development Journal*, 12(2), 24–37. doi:10.51646/jsesd.v12i2.156
- Nassar, Y. (2023). Solar and wind atlas for Libya. *International Journal of Electrical Engineering and Sustainability (IJEES)*, 1(3), 27–43.
- Nassar, Y., Elzer, R., Alkhazmi, A., El-Khozondar, H., Essid, M., & Baye, A. M. (2023). Thermal analysis of air-heating flat-plate thermal solar collectors. *International Journal of Electrical Engineering and Sustainability (IJEES)*, 1(3), 129–144.
- Nassar, Y. F. (2023). Simulating the energy, economic and environmental performance of concentrating solar power technologies using SAM: Libya as a case study. *Solar Energy and Sustainable Development*, 12(2).
- Nassar, Y. F. (2024). Carbon footprint and energy life cycle assessment of wind energy industry in Libya. *Energy Convers. Manag.*, 300(117846).
- Nassar, Y. F., Amer, K. A., Irhouma, M. A., & Ahmed, S. M. (2016). Economical and environmental assessment of electrical generators: A case study of southern region of Libya. *International Journal of Energy Policy and Management*, 1(4), 64–71.
- Nassar, Yasser F., Alsadi, S. Y., El-Khozondar, H. J., Ismail, M. S., Al-Maghalseh, M., Khatib, T., ... Djerafi, T. (2022). Design of an isolated renewable hybrid energy system: a case study. *Materials for Renewable and Sustainable Energy*, 11(3), 225–240. doi:10.1007/s40243-022-00216-1
- Nassar, Yasser F., Khozondar, H. J. E.-, Abouhmod, N. M., Abubaker, A. A., Ahmed, A. A., Alsharif, A., ... El-Khozondar, R. J. (2023). Regression model for optimum solar collectors’ tilt angles in Libya. *2023 8th International Engineering Conference on Renewable Energy & Sustainability (ieCRES)*. IEEE.
- Noroozi, M., Haghjoo, F., Javadi, H., & Reza Zolghadri, M. (2023). Power quality improvement in single-phase transformerless semi-quasi-Z-source inverters for off-grid photovoltaic systems. *International Journal of Electrical Power & Energy Systems*, 145(108703), 108703. doi:10.1016/j.ijepes.2022.108703
- Pathak, G., Singh, B., & Panigrahi, B. K. (2023). Multi-operational solar photovoltaic microgrid with synchronization, backup and power quality enhancement ability,” *e-Prime - Advances in Electrical Engineering*. *Advances in Electrical Engineering*, 5.
- Pisano, G., Ruggeri, S., Soma, G. G., Falabretti, D., Grillo, S., Gulotta, F., & Pilo, F. (2023). Impact of electrical vehicle private charging stations on the quality of the low voltage network supply. *IEEE Open Access Journal of Power and Energy*, 10, 351–362. doi:10.1109/oajpe.2023.3258254

- Pontes, L. (2023). Operational data analysis of a battery energy storage system to support wind energy generation. *Energies*, 16.
- Rahmani, E., Mohammadi, S., Zadehbagheri, M., & Kiani, M. (2023). Probabilistic reliability management of energy storage systems in connected/islanding microgrids with renewable energy. *Electric Power Systems Research*, 214(108891), 108891. doi:10.1016/j.epsr.2022.108891
- Rajesh, N., Venu Gopala Rao, M., & Srinivasa Rao, R. (2022). Power Quality Improvement using Parallel Connected FACTS Device with Simplified d-q Control. *EAI Endorsed Transactions on Energy Web*, 9(40), e2. doi:10.4108/ew.v9i40.2139
- Rezapour, H., Fathnia, F., Fiuzy, M., Falaghi, H., & Lopes, A. M. (2024). Enhancing power quality and loss optimization in distorted distribution networks utilizing capacitors and active power filters: A simultaneous approach. *International Journal of Electrical Power & Energy Systems*, 155(109590), 109590. doi:10.1016/j.ijepes.2023.109590
- Saha, S., Saleem, M. I., & Roy, T. K. (2023). Impact of high penetration of renewable energy sources on grid frequency behaviour. *International Journal of Electrical Power & Energy Systems*, 145(108701), 108701. doi:10.1016/j.ijepes.2022.108701
- Sahoo, G. K., Choudhury, S., Rathore, R. S., Bajaj, M., & Dutta, A. K. (2023). Scaled Conjugate-Artificial Neural Network-Based novel framework for enhancing the power quality of Grid-Tied Microgrid systems. *Alexandria Engineering Journal*, 80, 520–541. doi:10.1016/j.aej.2023.08.081
- Sarker, A. K., Azad, A. K., Rasul, M. G., & Doppalapudi, A. T. (2023). Prospect of green hydrogen generation from hybrid renewable energy sources: A review. *Energies*, 16(3), 1556. doi:10.3390/en16031556
- Selvakumaran, S., & Kalidasan, S. M. (2016). Power quality improvement in transmission systems using facts devices. *2016 Online International Conference on Green Engineering and Technologies (IC-GET)*. IEEE.
- Shayan, M. E., Najafi, G., Ghobadian, B., Gorjian, S., & Mazlan, M. (2023). A novel approach of synchronization of the sustainable grid with an intelligent local hybrid renewable energy control. *International Journal of Energy and Environmental Engineering*, 14(1), 35–46. doi:10.1007/s40095-022-00503-7
- Shende, D., Jagtap, P., & Hiware, R. (2021). Review of enhanced power quality using unified power flow control system in electrical network. *Journal of Physics. Conference Series*, 2089(1), 012034. doi:10.1088/1742-6596/2089/1/012034
- Tabak, A., Kayabasi, E., Guneser, M. T., & Ozkaymak, M. (2022). Grey wolf optimization for optimum sizing and controlling of a PV/WT/BM hybrid energy system considering TNPC, LPSP, and LCOE concepts. *Energy Sources Part A Recovery Utilization and Environmental Effects*, 44(1), 1508–1528. doi:10.1080/15567036.2019.1668880
- Tarraso, A., Lai, N.-B., Baltas, G. N., & Rodriguez, P. (2019). Power quality services provided by virtually synchronous FACTS. *Energies*, 12(17), 3292. doi:10.3390/en12173292
- Wang, N., Sun, M., & Xi, X. (2024). Identification of power quality disturbance characteristic based on deep learning, ” *Electric Power Syst. Electric Power Syst. Res*, 226(109897).
- Wazirali, R., Yaghoubi, E., Abujazar, M. S. S., Ahmad, R., & Vakili, A. H. (2023). State-of-the-art review on energy and load forecasting in microgrids using artificial neural networks, machine learning, and deep learning techniques. *Electric Power Systems Research*, 225(109792), 109792. doi:10.1016/j.epsr.2023.109792
- Xu, D., Bai, Z., Wang, T., Wu, Z., & Zhang, K. (2023). An energy-based control scheme for optimal power quality management in 12-pulse rectifier integrated distribution systems. *International Journal of Electrical Power & Energy Systems*, 145(108707), 108707. doi:10.1016/j.ijepes.2022.108707
- Yusupov, Z., & Almagrahi, N. (2023). Techno-economic and environmental analysis of microgrid: A case study of Karabuk University. *Sigma: Journal of Engineering & Natural Sciences/Mühendislik ve Fen Bilimleri Dergisi*, 41(4).
- Yusupov, Z., Yaghoubi, E., & Soyibjonov, V. (2023). Reducing the vulnerability in microgrid power systems. *Science and Innovation*, 2(A5), 166–175.
- Zhang, Y., Zhu, Z., Deng, Z., & Wang, M. (2024). A novel cause identification method of voltage sag for auxiliary power quality monitoring. *Electric Power Systems Research*, 226(109937), 109937. doi:10.1016/j.epsr.2023.109937
- Zhang, Z., Wen, K., & Sun, W. (2023). Optimization and sustainability analysis of a hybrid diesel-solar-battery energy storage structure for zero energy buildings at various reliability conditions,” *Sustain. Sustain. Energy Technol. Assessments*, 55(102913).