Power Quality improvement provide Digital Economy by the Smart Grid

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Abstract. The developing power supply characterises in smart grid networks of the power system with high power quality (PQ) for the digital economy as one of the attributes. Consumers need good power quality to meet the demand. Consumers consider reliable power that is not affected by interruption and clean energy without unstable influence. The focus of this paper is on good power quality for reducing economic impact. As a result of the vital role that sophisticated, intelligent devices accept in today's economy attention to PQ is beneficial. The level of the power quality is transmitted power can change from different "standard" to "premium" by consumer demands. Smart grids provide power grade changes and increase the value of variables in the same way. The evaluation of the power transmitted is mostly dependent on the structure of the electricity transmission that provides services for individual consumers. Unique considerations are specified to control the effects on power quality impact. Smart grids increase the power transmission framework and mitigate the effects of poor PQ starting with regenerative components. The promoted control strategy entire filter and necessary element make quick decisions and accurate solutions on every stage of PQ opportunity. Similarly, the grid structure emphasises the reduction of unstable effects of PQ. The smart grid drive section applies the latest research on superconductivity, materials, energy storage, and reliable modern technology to improve power quality.

1. Introduction
The problem of PQ especially for utilities, consumers and end customers, it must be known by experts or customers because PQ is a terrible effect on financial activities. The industry presented by the PQ problem is real even in the "low technology" industry, which is given in the despair of the actual budget[1]. The global financial crisis is the main factor that reduces the income of Asian countries. Power quality (PQ) is a concern for utilities, end customers, producers, and all other customers. Power quality is to control the characteristics of the power supply. PQ is increasingly vital that it is a matter of concern[2]. The use of a deregulation approach both in the power provider and the consumer framework causes development problems regarding power quality problems. Even though many attempts and allegations were made by electricity companies to avoid electricity disturbance, it was a fully functional framework for damage. Much worse is caused by general activities, such as exchanging loads and capacitors, or eliminating responsibility for defects and opening of circuit breakers. Opportunities Outside Utilities Even though power supply continues to recognize demand, in transmission resources have long experienced a constant decline and has always disrupted the quality of free network voltage fluctuations. Therefore, supply reliability is not consistent between the foundation of a mature electricity network and the attributes of the current load and electricity supply[3]. These results are a severe problem in various industries including those related to money, administration, pharmaceutical services, sophisticated; this brings financial disgrace. In this paper, we have tried to present that smart grid can give the solution to recover the power quality problem for developing economic growth.
2. Poor Power Qualities

This part shows the PQ area and why the problem continues. At this point, it will show how the PQ will be fixed by the smart grid later. Before dealing with PQ issues, it needs first to understand about power quality disturbing [4]. The power provided by the utility starts as a smooth sinusoidal wave.

This is a waveform produced in a power plant by a generator (see Figure 1).

When this power moves from the generator to the customer’s equipment through transmission and distribution frameworks, it tends to be susceptible to four types of interference that can damage its simple sinusoidal envelopes.

**Sags:** The voltage sag is the effect of the most common instability of power quality problem. It occurs at large startup loads [5]. In industrial places, the voltage sag problem is not uncommon at the entrance of management every year. There is more sags effect in the equipment terminal. Costs associated with sag events can range from close to zero costs up to millions of dollars for each event (see Figure 2).

**Harmonics:** Harmonics caused by "nonlinear" loads that combine engine control, office electrical equipment, computer, compact fluorescent lamps, televisions, and most electronic loads [6]. Unusual harmonic quantities increase trouble and reduce electrical apparatus life (see Figure 3) [6].
3. Power Quality Impact

3.1. Technical impacts of poor PQ

Nowadays, consumers use a large number of devices in facilities built with reliable equipment. The consumers use a variety of household appliances such as television, video cassette recorders (VCRs), microwaves, computer, heating ventilation devices (central air), and dishwashers. Business and office type machinery combine workstations, PCs, copiers, printers, lighting, and so on [7]. Moreover, modern consumers use programmable logic controllers, computerised and information processing equipment. Many customers use fluorescent lights to illuminate the facility. A large number of these devices are susceptible to the effects of unstable PQ [8]. Situation surveys and reviews from various countries around the world were conducted to evaluate the impact on poor PQ customers. However, nowadays, consumers are considering some cases to check PQ technical and non-professional loads to system administrators. Fundamental instability about the specific trouble of various segments of the system because of the unstable influence of different PQ, it should be possible to get a possible sign of a poor PQ effect in the system.

Transformer:

The proximity of the harmonic currents extends the central trouble of the transformer, copper losses, trouble from wild movements. This trouble is on load losses. There is a slight expansion of this losses because of harmonics, but the trouble of the offload is largely unaffected by voltage harmonics. These consist of two segments: hysteresis loss and eddy current losses. The trouble of a transformer load varies with the square of the load current is greatly increased at high communication frequencies. The eddy current loss is a major concern if the harmonic flow is available in the system. This trouble increases approximately by the square of recurrence. Apart from eddy currents, current loss is usually around 10% of losses at full load. The equation (1) adds all load losses (ET) from the transformer when harmonics are available in the system.

\[ E_T = E_{CU} + E_{WL} + E_{CL} + E_{SL} + E_{SL} \]

\[ E_{CU} = \text{total copper loss} \]
\[ E_{WL} = \text{Eddy's current loss, 50 Hz (full load)} \]
\[ E_{CL} = \text{Additional eddy current loss, 50 Hz (full load)} \]
\[ E_{SL} = \text{Floating losses of construction parts (full load) 50 Hz} \]
\[ IS = \text{Effective current on harmonics (per unit) n} \]
\[ IL = \text{effective value of total load current (per unit)} \]
\[ IP = \text{The basic component of the load current (per unit) at the frequency 50 Hz} \]
\[ HN = \text{harmonic number} \]

Another concern is the "triple n" harmonic proximity. In the system, especially the LV nonlinear load produces harmonics. In the M / L converter with settings Δ / Y, 'triple-n' circulates in the shutter delta shutter. Only "non-triple" harmonics sent to the upstream system. If providing a non direct load, the transformer is not effective against overheating. To limit the risk of the unexpected disappointment of transformers, use them as "K rated" transformers intended to operate with low power at symphony frequencies or at unknown frequencies [9]. Extended loading can cause excessive transformer pressure and the possibility not to disappoint. This effect has usually communicated until "losing a lifetime". Regional temperature problems are used to evaluate incentives relative to the rate of heating as shown in Fig. Assume the temperature is around 20 °C, and the temperature of the area is problematic, if the temperature of the problem area is 98 °C, increase 78 °C. Condition (2) shows the calculation of the relative maturity level(V) as a component of the problem of environmental \( \theta \) temperature.

\[ V = \frac{Ageingrate(\theta)}{Ageingrate(98)}C = 2^{(\theta-98)\times 6} \]
Figure 4. Increased temperature into the ageing transformer

Cables:
Harmonic current has two fundamental influences on the cable.
- As a result of expanding the estimated RMS of flows for harmonics, a fair conductor of the relationship with the addition of "ohmic loss" (I²R) in the line. This will increase the cables operating temperature.
- Harmonics flow along the framework impedance and the harmonic voltage changes laterally in various parts of the system. This harmonic voltage can expand the dielectric stress on the cable and cut down its useful life.

In addition to the influence of the skin and its surroundings, cable interference also controlled by the DC evaluation. Eddy currents generated because the overall motion of the electromagnetic field and the rotating currents in the conductor are the fundamental drivers of skin influence [10]. The current generally flows to the outer surface of the conductor. This extends the strong interference from the conductor and current disadvantages, for the majority at high frequencies. "Proximity Effect" is a direct result of the overall inductance of a parallel conductor and an exciting field that changes from an adjoining conductor [11]. The impact of both the effect and approach of the skin depends on the recurrence of the power frame, measurement of the conductor, resistance and permeability. Approaching the harmonic cable will affect the failure of the conductor and then increase the operating temperature. This can eventually lead to premature ripening of the cable. Under equation (3), the heat produced in a cable consisting of "conductors and symmetrical parts n" is given.

\[
H(g) = C_N \cdot H_I^2 \cdot C_R \cdot \mathcal{P}
\]

(3)

\nH (g) = heat generated by cables per unit length
CN = number of conductors in a cable
CR = conductor resistance for harmonics n per unit length
HI = RMS value

The thermal deprivation of electrical devices is mainly due to rising temperatures past the evaluation evaluated. When the operating temperature turn from the temperature evaluated, the future of the cable will change and can determine by equation (4).

\[
R_L = R_{Lo} \cdot \left( \frac{E_K}{K} \right) \frac{\Delta \theta}{\phi_L(\phi_L+\Delta \phi)}
\]

(4)

Estimates of research facilities are made to recognise temperature rise of cables under various load conditions using only straight and nonlinear loads. This test uses a 4 x 2.5 mm 2 XVB-F 2 type cable with a copper pipe, PVC shield, and dried polyethylene shield. This is a type of cable established in
Belgium. The estimated flow rate (5 A, 10 A, 15 A, 20 A) is connected to the liner and then connected to a nonlinear load. Brilliant lights are used to load a PC and load directly with a nonlinear load (which adds a current rotation of about 40% of the symphony). Figure 5 shows the correlation between the temperature rise of Cu conductor cables and linear and nonlinear loads for various sets of currents.

Environmental temperature has recorded at 21 ° C at the test location. Extending the setting flow finds that a fair conductor current (as a result of 'triple n' harmonics) is significantly increased for nonlinear loads as shown in Figure 5. This adds warm material from the cable and raises the temperature. In this analysis, it turns out that the temperature of the Cu conductor from the cable exceeds a reasonable temperature limit for high nonlinear loading. As a result, cable life can decrease as shown in equation (4).

![Figure 5. Increase current linear and nonlinear load](image)

**Power factor Correction:**
Power factor correction capacitors are provided to draw flow at the edge of the main stage to compensate for soft flow caused by inductive loads and the induction motor load. In the field of nonlinear loading, the impedance of PFC capacitors decreases when repetition increases, while the source impedance is generally inductive and increases with frequency [12]. The voltage harmonic proximity in the electric frame creates a dielectric failure for capacitors at high operating temperatures and decreases unstable quality. In insensitive conditions, harmonic systems can reduce the lifetime of PFC capacitors. The weakness of the dielectric in the capacitor has determined by equation (5).

\[
P_{\text{loss}} = \sum_{i=5}^{50} C(\tan \theta) \cdot \omega_s \cdot V_s^2
\]

(5)

\(\tan \theta = \frac{R}{1/\omega C}\) is the loss factor
\(\omega_s = 2 f_n\) = harmonic frequency
\(V_s\) = RMS voltage of harmonic

In the electricity network, power factor correction capacitors are used to increase network power factor. However, parallel resonance circuits can make by capacitance and floating inductance from network components. This causes harmonic voltages and huge currents often causing failed capacitor system failures. Customised power factor correction capacitors can be used to filter harmonic content to reduce the possibility of network resonance.

3.2. The Financial Impact of Poor PQ
The impact of unstable power quality will greatly benefit various customers and system administrators. Evaluating poor PQ rights is very difficult and contains the same number of vulnerabilities. In this way, the context analysis has completed, and poor PQ expenditure signs are
obtained that find many testers with the cost of PQ for various types of customers. Interestingly, minimal data can be accessed by a system operator with the cost of PQ. Since the assessment of poor PQ costs is a complex problem, the collaborative work meeting of CIRED / CIGRE "JWG C4.107" is a form of developing a deliberate methodology to evaluate the various costs identified in the PQ problem. At this meeting, proposed a design for determining the cost of PQ consumers and system operators.

Financial losses caused by process failure:
Degradation in industrial process plants because opportunities for interruption can cause considerable economic impacts for platform owners. Industrial consumer economic losses can express as in Equation (6).

$$LB = EPV - MoC - CoE + AoC$$  \hspace{1cm} (6)

Here,
- LB = Lack of budget
- EPV = Estimate products value that made during the season - Process Outage.
- MoC = material costs that can be spent on manufacturing procedures
- CoE = The cost of energy that can be spent on generation procedures
- AoC = additional costs due to loss of supply

Otherwise, in consideration of PQ opportunities, it is possible to communicate by equation (7) in addition to the unfavourable ones relating to money. Both equations (6) and (7) are identical, and one of them can be connected to confirm the misfortune associated with money because of the interruption.

$$LB = AC + (RL - VC) \cdot (r + s) + ES$$  \hspace{1cm} (7)

Where,
- AC = additional costs obtained for disappointment (per disappointment)
- RL = revenue lost every hour from factory downtime (€ / hour)
- VC = Variable cost per hour factory downtime (€ / hour / hour)
- r = correction time or replacement time (time) after disappointment
- s = plant start time after unemployment (hours)
- ES = every settlement fee (1 euro / disappointment)

Economic Impact due to the unplanned interruption is strongly influenced by the placement and format of consumer compaction at the factory site. Also, in different situation surveys, primary reference is correctly used to speak with information related to interruption (for example, if the drawing criteria are opportunity costs, part of time per kVA or plant boundary introduction, pay costs or total costs each hour each year). Figure 6 shows the level of budget disadvantages due to unplanned interruption opportunities in various companies that can use for large-scale reasons.
Financial impact by harmonics:
Both harmonic voltage and current can cause consumer distress and unusual activity and bring the financial impacts to the consumer. In many cases, the harmonic in the system causes three types of problems.

- Extra energy loss
- The maturity of perceptive devices
- Strange activities or illegal operation of devices.

There are two methods for determining the costs specified in harmonics: deterministic and probabilistic. The deterministic approach is to connect all the data specified in the estimate (e.g. information about the working conditions of the system, the operation conditions of various devices and the level of control consumed, electric unit costs and rebate rates,) that will be connected. This can access without vulnerability. This has shown in Equation (8) that the current values are all the same (definite "(Ew) x, Uw") in the place considered for MT time, for rich harmonic conditions. This can evaluate:

\[
E_w = \sum_{x=1}^{\infty} (E_w)_x, U_w = \sum_{x=1}^{\infty} \frac{(E_w)_x}{(1 + \beta)^x - 1}
\]  

(8)

(Ew) x is the sum of additional work costs of all segments (energy loss) when forming customers all the time, due to consideration of "x" in specific years. 'β' is the current price-discount rate and MT is the number of years to consider. Estimate the misfortune associated harmoniously at the business establishment. In such circumstances, an electronic load (basically computer) of around 80 kW has associated, and I work 10 hours every day for 365 days a year. As a result of the investigation, as a result of losing 222 MWh of surplus each year due to harmonics at the time of client formation, we found that this workplace paid an additional 2,000 dollars of energy each year (around 8 of the total energy cost of%)

Premature maturation due to harmonic contamination includes fixed investment costs (IVC)pw for kth devices in the time frame of perception. This has indicated by equation (9). Where (Pk, ns) pw and (Pk, s) pw is the present estimated value of the total investment cost to purchase the kth device in a life time under that non-sinusoidal and sinusoidal working condition.

\[
(IVC)_{pw} = (P_{x=\infty, s})_{pw} - (P_{x=\infty, s})_{pw}
\]

(9)

In most cases, it is difficult to collect all data that is determined by costs, because harmonics are mainly affected by distance, and are visually fast and less influential. In this way, the probabilistic
strategy for estimating costs can be connected equally when parts of the calculation parameters are uncertain or not accurately known. Equation (10) shows a general equation for evaluating there as on able estimates of the current harmonics (H)pw 'in stochastic investigations. (Hw)pw is intended to introduce the value of other energy misfortune, 'Ha)pw' is a stable investment value nowadays, so this is a measurable possibility of device disappointment Drawing elements, them a turity of old devices.

\[ P(H)_{pw} = P(H_a)_{pw} + P(H_v)_{pw} \]  

(10)

**Other impacts of poor PQ**

Another point of being enthusiastic about the share of the benefits of electricity is the record of “customer satisfaction”. It depends on the most common connections between clients and system administrators and shows the nature of the business from the benefits of power distribution. Business quality is the most often identified by a separate statement between the system administrator and the client. If possible, some of these relationships can be estimated and managed by measuring devices and other legitimate means. System administrators can lose client confidence when more clients are dissatisfied with the supply of PQ from the supply[13]. In unfavourable circumstances, national controllers can handle system administrators and handle problems. Directly in many countries, system administrators are obliged to confirm the pleasure of PQ from each client. They must provide voltage to the client terminal that needs to meet the relevant standard prerequisites. If possible, the client's obligations on different PQ needs for the association have not characterized. In this way, the system administrator is a test to maintain professional quality and quality management to meet consumer needs.

When customers buy goods from the market, “Brand Name” acts an important work to buy central leadership. When devices have sold on the market, device manufacturers guarantee their implementation by the standard of important items (IEC or other globally recognised standards) under clean voltage conditions. As a general rule, devices operate in a power distribution where the power supply voltage has run out. Along these lines, the associated device produces unexpected harmonic flow compared to sinusoidal voltage conditions. In certain circumstances, some explicit harmonic current requests can exceed the level cutoff point. Also, it can cause additional losses and function abnormally to promote a reduction in his lifetime. All of this can doubt the spirit of the client about the nature of the device and the quality of the goods provided by the implications for device makers. In line with this, "commercial quality” from manufacturer’s equipment may also be affected.

4. Modern Technologies in Power System

The latest technologies consisted of the smart grid to quickly recognise and reduce the impact of poor power quality within the framework of the power supply and protect the consumer’s inflexible electronic equipment.

4.1. What is the Smart Grid?

Traditionally, the grid is a non-intelligent material that controls power distribution and holds transmission from the power plant unit to end the consumer. The requirement for energy is currently gradually demanding a smart grid. Figure 7 shows the global penetration rate of utilisation of energy. As this growing demand, the current level of failure in the grid framework overall increased at the time of peak load, thus driving the consumption of an additional 25 to 180 million US dollars [14,15]. The current grid framework has based on a state-of-the-art power framework, due to the high demands on energy, non-cooperation with sustainable resources, multifaceted nature of the grid, and various restrictions related to the limitation and generation of electricity. Therefore, reliable and effective automatic network technologies are indeed fundamental. Such a framework will have the ability to coordinate distribution sustainable power plants which ultimately bring direct green eco-friendly and ultimately reduce dependence on petroleum products/fossil fuel.
4.2. Integration of renewable energy source in smart grid
Smart networks can associate a lot of distributed renewable energy sources (DRES). This has a function to connect generators and related grids. Installing and regenerating this generator will enable smart grids to adapt to new energy needs. Smart grids can be fully adjusted to control DG's framework and have the ability to manage very pervasive DRES voltages. The high level of participation in the generation of small and medium scale renewable energy is due to some synchronisation such as synchronisation between sources, significant interaction with the grid, withdrawal far from harmonic destruction, voltage smoothing in generated voltage. Smart networks avoid power outages. The reason is to allow end consumers to handle energy use efficiency. Smart networks have opened some horizons depending on the generation and capacity of the electricity supply in the distribution system. This power can adaptively add to the framework in several levels such as transmission rates and delivery rates.

4.3. Smart grid Technology /Modern Technology
The proper use of renewable energy resources has expanded to prevent the trend of dealing with energy supply problems. Because electric vehicles can charge from intelligent networks, vehicles can store energy with designs from original grid frames. Modular Electric Vehicle (MEV) /plug-in type hybrid electric vehicle module when combining with the framework of renewable energy power plants, is expected to obtain eco-friendly change characteristics, lower vehicle operating costs, Reduce unsafe gas emissions, such as reducing them[17-20]. In general, because of the overall increase in heat and power with related advances such as heat accumulation for cooling, spinning and pinch demand can be reduced as well. On Roque Island, a distributed methodology including tidal, solar and wind power frameworks is being carried out. This framework utilises economically accessible energy stores and is further aware of the controller of the smart home management framework. Figure 8 shows as schematic block diagram. Smart Grid has many technologies and devices that work in every aspect of the generation, transmission, and distribution of electricity. Many things are added to the net power to reach the consumer:

- PQ meter.
- PQ monitoring system.
- Premium electricity programs, combining office parks and environments for premium power use.
- Superconductor attractive energy reserves and Propelled batteries, in order to strengthen PQ and power, or a variable load of gadgets to supply offices that require ultra-clean power.
- A combine of electronic power devices for correct next wave defects.
- Identify to failure which might lead to problems from PQ, monitoring the electrical framework to admit it has resolved.
- New distributed generation devices that can place a load on the power environment (energy units, small-scale turbines, such as small-scale networks).
Implement trending technologies for mitigating PQ problem, support and coordination between equipment makers, electricity supplies, controllers and normative bodies is needed. The basic standards and industrial models must then use in each element of the electrical frame, including the consumer’s loads. This ensures that the power quality provided sure according to the supplier's capabilities and the needs of the consumer.

![Diagram](image)

**Figure 8.** Schematic block diagram.

### 4.4. Control system of smart grid

Control system and automation are instruments that provide significant authority from the smart grid. With the help of state-of-the-art control methods that can combine the electricity network into a distributed renewable energy generation framework to appreciate the concept of electricity networks. Also, a valid network board framework is needed to use sophisticated controls in all proportions of the smart grid. Some of the fundamental problems identified in the Smart Grid occur in the development and development process which primarily includes prediction, energy accretion, control, power distribution, regulation, and evaluation. Essential features of the smart grid include collaboration with power consumers, adaptation to power needs, support for displaying the power of development, resource economise, self-healing, the anticipation of external hazards and attacks. The practical use of the grid is an element of the highlight below.

- Control from various renewable energy frameworks.
- Correction and synchronisation of the power plant framework with the focus grid and related loads
- Connect between different controls systems.

### 4.5. The operation of the intelligent control system

Based on synchronisation and coordination of smart grid control instructions consist of three levels of control including mandatory, optional and third-dimensional control circles. The instructions for intelligent control systems have shown in Figure 9. In vital control circles, the voltage and current of distributed energy assets are preserved directed control circles appear both indirect and nonlinear loads. The phase control in this aspect provides strength and autonomous power mode[21]. The smart grid works in both island types and primary modes of the main grid. The fundamental role of intelligent grid control structures is as follows:

- Control voltage and frequency
- Distribution of expenses and proper coordination in distributed energy assets
- Synchronise between smart networks and the main grid.
- Control the flow of power between the intelligent network and the main grid.
- Optimising the operation costs of the smart grid.
Voltage and frequency have controlled in the optional dimensional direction. In a smart grid, it is maintaining stability under individual resistance parameters set for primary grid activity that is security controlled voltage and frequency looping estimates, regardless of changes in load and power changes. Optional stage controls are available in centralised and distributed modes [22]. The situation of perception focus control device is a necessary comparison between two methods of use. Focus control is suitable for a collection of comparable types of assets, or collections of small sources that has manually controlled.

Estimated stable voltage and frequency are significant for connecting intelligent networks with the main grid. These characteristics are given as references to control circles. Further, their associations and synchronisation is the operating system of tertiary control.

4.6. Intelligent Control of hybrid generation systems

The implementation of an electric framework increases coordination between network operators by combining smart grid technology that can improve it. Also, smart grid technology permits intelligent control of grid conditions, allowing irregular conditioning of renewable energy assets at ideal costs. If possible, renewable energy assets depend on the land, financial and directorial conditions, and along this line, the promotion of the power framework is required to continue and reliable quality of the grid framework. The Smart grid controls are exposed to asset data to solve smart choices. Wind, solar and tidal energy is a regular and irregular renewable energy asset. Depending on climate change and climate change, the primary energy grid hotspots, and thus a stable non-stop energy supply, will be disabled. This encourages failure regarding the placement of cost-effective energy assets, especially about traditional grids [23]. Then, the framework of a generation and a hybrid generation evolved as a substitute for a conventional energy framework. The hybrid generation framework overcomes this problem by participating in at least two frameworks, thereby reducing the dependence of the general framework on conditional parameters that produce solid and insignificant power quality.

4.7. Demand response in smart grids

Further information about the number of evaluated smart grid consumers has needed for the expectations of direct consumer support needed after management. Demand response (DR), which determines one item or stable load from a structure, is usually made using the Short Term Load Forecasting (STLF). When determining different loads is predicted, that is, when determining one STFL for each load, many STFLs have needed. The problem of versatility in measuring many loads is the tendency towards short Term Load Forecasting (STMLF) by combining temporary placement of a single load into a simplified model and finding different loads depending on the isolated model. There is STMLF accuracy is considered 7% higher by inspection, using individual insight numbers for each load [24].

4.8. Integrate Demand and supply management in smart grid

Electricity in a small zone or network requires a small and low voltage power supply provided by micro grid. On the electricity supply side, a scheme to control demand rates must be set to achieve a commercial use plan and to meet consumer demands. Otherwise, on the demand side of electricity, it
is necessary to rationalise the uncertainty of the generation of renewable energy, which can represent an extraordinary part of the electricity supply at the microgrid. Limitation on load balancing is enough to refer to the relationship between power usage and power generation. Given the vulnerability in renewable generation and load utilisation, a step of the intelligent control method is desirable that can provide the security of frequency control to distribute assets in an ideal method. Demand control systems have classified into cost-based load control strategies which have referred to demand response techniques and direct load control which has connected with Demand Side Management (DSM) [25].

In cost-based load control scheme, consumers are recommended to resolve on energy utilization choices independently as indicated by the energy price data. DSM procedures that are required consumer membership of an economic motivating force program and usually are explicitly connected by the principle controller. In the research, it is dealing with the vulnerability of renewable energy when planning energy generation. However, a Markov model has been accepted to describe the generation of renewable energy. The vital mission in supplying and supplying electricity at a microgrid is to maintain a match between power plants and utilisation with basic costs. Because highly variable reload, energy is a vital asset segment in the microgrid. The microgrid central Controller(MGCC) effectively reduces renewable energy while fulfilling consumer demand. Primarily, a new vulnerability model to capture the randomness of renewable energy generation by knowing the reference distribution that is by past perceptions and experiential learning. This model confines the vulnerability of renewable energy and allows them to be fluctuant the reference distribution of renewable energy. There are possible problems with optimisation to determine typical power usage and electricity generation plans to capacity fuel costs. Finally, two systematic optimisation approaches are proposed to change and address the main problem.

4.9. Cyber safety of the smart grid
The smart grid application has been used practically using several communication protocols; smartgrids have developed AIM and more advanced progress measurement framework and WAMPAC(Werner Territory Checking, Assurance and Control) that are focus the cyber protection to utility and consumers. AMI relies on smart meter operation in the customer area to provide two routes of communication between meters and utilities. This provides the utility with the ability to drive specific information to customers, collect data about current usage and conduct more sophisticated control investigations of the strategy of identifying responsibilities within the distribution framework. Individually, WAMPAC can subdivide into a broad area monitoring framework (WAMF) component, broad zone security framework (WZSF), and comprehensive area control (WAC) conceptually; the WAMPAC control framework model can have three types of attacks: time-based attacks, constant attacks, repeated attacks [26]. Time attacks usually increase communication with packets, which can shut down the system in some cases and even close it. In attacks admiration information, confusing information in the forward or switched direction in the control flow. Repeated attacks such as information sensitive attacks where the attacker controls information on the Phasor Measurement Unit(PMU).

4.10. Optimisation of smart grid
Smart networks are considered a remarkable framework and smart grid sub-networks have differentiated by specific criteria for homogeneous segments, related components, and scheme of intelligent. A single optimisation algorithm can connect to local locations that require particular measurements that have the same quality. The optimum value around is used in the sub-grid of the smart grid to security perception and uncertainty [26]. Therefore, in the focus of this self-orientation, global optimal is specific. Smart grid optimisation is a testing business regardless of whether or not the computer model was used. Traditional and convertible virtual strategies are usually used to achieve optimisation to ensure adaptability and versatility. A sophisticated respond from a smart network framework has taken as follows:

Distributed generation: Optimisation is depending on memory with time. So optimisation is carried out across all levels of the network. Home automation: automation of houses is equally useful as well as
meeting the demands of consumers. In this way, smart devices automated at home reduce energy use in general. Energy supply device: Better equipment will use along with energy supply gadgets in all grid exercises. This will create fruit in managing energy use and reducing the burden on that point. Electric transmission and distribution trouble: Improved environment and global algorithms reduce the loss of transmission and distribution (T and D) and correct steering errors.

The needs of new consumers shift reasonable cost Control: Intelligent cost control regulates unit electricity costs — high unit interest rates at peak-time, and low-interest rates at demand basis. Heuristic optimisation is a state-of-the-art strategy used for complex frameworks. The increase in time is shortened compared to the methodology specified. The missing information data is considered vulnerable, and this optimisation method is too noisier. Heuristic optimisation techniques are used to solve energy requirements, climatic conditions, unit costs, control and placement of frameworks, loss of information, store frameworks, estimates of energy demand response.

5. Transmission Side
At the transmission side, the voltage sags much time after a short circuit effect that may exist between several milliseconds. Nowadays, a high-voltage static VAR comparator (SVC) is fast enough to relax a large number of these opportunities. However, these devices are generally costly, due to current electronic power segment costs. When segment costs decrease, this device will gradually attract the owner of the transmission frame. The future sensible current-limiting appliances also can reduce the severity of voltage sag associated with deficiencies. Also, the transmission lines of loss reduces upper conductors’ will reduce voltage problems.

The use of conventional systems, such as the use of more surge arresters, increased protection and line formation, and controlled exchange edges, too, is stronger for limiting deteriorating PQ problem.

6. Distribution Side
At the distribution side, an assortment of strategies is accessible to enhance the nature of power supplied to the consumer. Since lightning is a noteworthy wellspring of PQ issues, more prominent utilisation of underground services can reduce this commitment. The development of a private PQ park can find consumers load, and it is imperative. These parks can be associated with under ground feeders from distribution substations [27]. Reconstructed feeders can promote this with a fast source change switch allowing different feeders to control when one feeder is blocked quickly. Thus, the capacities of the advantages of reusing closed load capacities including microgrid networks cannot bethe disposition from the main grid network.

Appreciation of the sophisticated measurement of the grid and other metering systems, expanded network monitoring will reveal many PQ problems and enable healing activities. Adjustment of phase discomfort is one of the activities that create additional benefits of reducing electricity losses. By continuing to monitor PQ extensively, that can distinguish and adjust problems before consumers get a significant effect.

7. Consumer Side
Not all consumers are affected by low quality of power. Towards one side of this range, manufacturers of embedded circuits will cause huge losses when opportunities for PQ are blocked or stimulate procedures. On the other side of this range, real estate holders can be a problem when closing DVD players. The PQ configuration does not only combine progress to improve and maintain power quality, not only to combine evolution which gradually creates a tolerant client stack. Inside the client's office, various devices will respond to the influence of PQ [28]. There are various ways that consumers can limit transient service problems. It is best to start by choosing a gear that can hold transients and make training using ordinary cables. However, many spike concealment devices can ensure consumer equipment. To deal with the classification problem of various consumers such as financial problems, industrial and residential problems that need to show the requirements characteristic settings. Commercial and industrial consumers must have the ability to choose an
evaluation of the required power. The PQ grid mitigation method needs to be facilitated with brand sensitive load consumers to overcome PQ opportunities that can cause installation collapse.

8. Key Technologies of Smart grid that Recommend Solutions

If carefully selected and delivered, important innovations from smart grid technologies will provide promising clarifications to mitigate PQ damage through the system:

**Smart and measurement technology:** By transmitting new meter extensively, various data on all power quality properties displayed on the grid. Also, a new detection method filters will the monitor of the equipment properties and predict probable failures that can cause PQ problems.

**Intelligent component:** This segment applies the latest research on superconductivity, material, energy storage, and reliable devices. All of these segments form the foundation of a device that increases PQ.

**Smart control strategy:** This technology filters primary segments and allows fast analysis and accurate placement that is suitable for all situations. Smart control technology aims to maintain the grid stable in a stable state and to provide extensive condition data. The behaviour of active resistance from PQ event is the development of the substantial new database.

**Integrated communication:** This technology enhances a new security and control system that makes the grid more reliable and reduces interference from events that affect PQ.

**Automatic Voltage Controller (AVC):** AVC detects applications that control, supervise, and connect various system elements to counter the unstable effects of these effects. The generator is more dependent on the AVC and operator’s operations that are smooth, unstable and have no effect. AVC keeps the voltage stable by changing the generated magnetic field and its reactive power.

**Energy Management System (EMS):** EMS is a secure and protected operation focus to achieve supervisory control and data acquisition (SCADA). EMS helps to regulate the use of controls, generation, electricity and vehicle charging. The energy posted as a matter of substantial scale improvement is still being carried out in many fields of business and machinery. There are various vulnerabilities in the field of power, such as customer trends, values, controls produced, and cycle control. Smart grid and equipment systems are secure to run ideal under these vulnerabilities and difficulties.

**Advanced Generator Control (AGC):** AGC uses a closed loop control to reschedule the set of focal points and adjust the preconditions of frequency varieties and connective lines. AGC is consistent with zones that work together between generation and load. That is, it controls the frequency of the system and adjusts the tie-line that has exchanged with the current program. Also, it will change the load allocation among various generators in the smart grid.

**Advanced Metering Infrastructure (AMI):** AMI is driving for bidirectional meter/utility communication. AMI offers various benefits such as lowering the cost of information gathering, customer withdrawal / re-association, control of load control, theft of extra energy, monitoring of power quality and its implement. AMI expands skills and reduces trouble in the power system. The smart Fortum’s system ensures management of electricity use using the AMI devices for information and investigation social incidents. The household electric power usage measurement system *measures information from consumer remotely. All AMI-based strategies and techniques are combined.

**Wide area management system (WAMS):** WAMS is operating with a high voltage control network to ensure accuracy and synchronisation. WAMS makes accurate stamped measurements and time through PMU. This system further provides disturbance analysis, confirms Flexible AC control(FACC) control, and systematic approval of elemental models.
Battery energy storage system (BESS): BESS operates a system of electrical and mechanical capacity, used to increase capacity and implementation. The battery must have a large charge/discharge cycle, and it is vital to secure the required charging time. To propose a better response to the application of smart networks, rapid development with various progressive activities is underway.

9. Specific solutions for PQ problems
The four areas of the PQ issue have own technical improvement in setting up smart grid trends will build up essential parts of this modern technologies. Smart Grid provides PQ that fully complies with basic customer standards, which are characteristic of industrial technical equipment. Measuring instruments, such as SEMI 47, are based on consumer loads behaviour and focus on smart planning for the service provider. Mutually customers and service providers generally need the right standards to make the individual design.

9.1. Voltage Sag
The current limits and FACTS devices help to reduce the voltage sags severity associated with the defective power system. Also, minimising surge in the grid system. The fastest approach to overcoming voltage sags is to provide satisfactory buffering with the load for consumers are using distributed smart grid energy resources that can provide the excellent power quality by the variety of devices, such as storage equipment, small-scale turbines and microgrids.

9.2. Harmonics
The filter is moved very robustly at the end of the harmonic distortion. For instance, by placing a dynamic filter that shows high impedance harmonics that prevent flow harmonic to the consumer's load. Harmonics start with power quality issues for other customers and also affect the power supply framework itself. There are two obligations related to harmonic such as:

- The consumer is responsible for suppressing the flow of harmonics that interfere with the power framework.
- The utility is responsible for maintaining the nature of the voltage waveform.

Since these obligations are exceptionally interrelated, the rules need to build harmonic breakpoints for each group. Technical meetings like the Electrical and Hardware Designers Organization (IEEE) should build these rules and implement by utilities and energy committees.

9.3. Transients (Spikes)
Service providers use various frame structure procedures to limit transients:

- Appropriate installation and protection, participation in the use of free lightning arresters will limit surges associated with lightning.
- Modern controlled switching methods limit the transient from the power system.
- Maintenance procedures promoted by smart grid networks ensure that no errors occur in any case and limit the transients specified in the power framework problem.

Spikes on the grid can reduce by the technique drawn above, but consumers can contribute for solving a problem that can restrain the effects of the transient by selecting equipment and using legitimate cables, grounding, and surge protection to reduce the influence of phenomena while in the grid.

9.4. Voltage Imbalance
In smart grid, recognisable evidence of voltage imbalances occurs quickly, given the fact that modern communication meters report imbalances to service providers. Voltage imbalances cause motor and transformer failure due to overheating, which can also cause damage to electronic equipment. Service providers regularly deal with the problem of critical voltage imbalances as recognised.
10. Challenges

This is a prerequisite for smart grids to provide higher PQ and that have made a note of solutions to meet those requirements. To send solutions that need to deal with problems, such as financial activities, government policies, industry models.

These three critical problems are as follows.

- Reduce the cost of extraordinary smart technologies.
- Implement policies and controls rules to financial support in the PQ program, including those that provide estimates with the price of different level of power.
- Updated codes and principles.

10.1. Policy regulation

The energy management committee can do many things to support PQ investments and pricing that are determined by the level of power. Not all consumers need premium PQ dimensions, nor wish to payments for it. Only operators are in a position to drive solutions with the lowest overall costs and provide fair proceeds to the financier. Similarly, operators can promote standards for reducing the vulnerability of consumers load. For customers who have suffered severely due to PQ opportunities, the premium power level can be the solution for consumer and seller.

11. Advantages of Smart grid

When organisational problems have overcome, both cost reduction and new open doors for digital financial development will be introduced. Need to take maintain a strategic distance from the misery of the profitability of low-quality power to commercial and industrial consumers can reduce billions of dollars from the economy. Costs associated with PQ in commercial facilities such as banks, data servers, customer profit focus that can be very large and can range from a few thousand dollars to a large number of dollars on one occasion. The cost of assembly facilities may be much higher. The Prime Report in 2017 notes that a reduction in voltage dips less than 100 milliseconds can have an impact on industrial procedures that cannot be distinguished from outages that continue to occur for several minutes or more. Presently maintaining a strategic distance from the efficiency losses of low-quality power to commercial and industrial consumers can shed billions of dollars of waste from the economy. The expenses related with PQ occasions at commercial offices, for example, banks, server farms, and client benefit focuses can be enormous, running from thousands to a considerable number of dollars for a separate occasion. The expenses of manufacturing offices can be much higher. The 2017 Prime report brings up that voltage plunges that last under 100 milliseconds can significantly affect the technical procedure of a power outage that endures a few minutes or more. At present, maintaining a strategic distance from low-quality of power economic losses for commercial and industrial consumers will remove billions of dollars of waste from the economy. For instance, the costs associated with PQ opportunities in commercial offices, such as banking focus, server farm, consumer benefits, will be enormous from hundreds of thousands of dollars to isolated opportunities. Production costs may be much higher. With the Prime report in 2017, voltage sags of less than 100 milliseconds can significantly affect the technical procedure of a power outage that endures a few minutes or more. Reducing PQ problems will result in relative reductions in some categories of economic losses:

- **Waste Materials** - These costs need to consider for industries where the procedures and quality of manufacturing both emphasise power quality and reliability that is unlimited.
- **Customer dissatisfaction** - Although it is difficult to evaluate, this element may have negative observations about losing customers, income, and generosity.
- **Loss of profits** - Indirect costs occur, regardless of whether the business is shut down subs equent revenue losses increase.
- **Consumer welfare** - In some manufacturing procedures, such as crane activity in steel production, electrical disturbances can pose a security threat.
- **Breach of contract** - Damage to litigation caused by failure to observe the specified delivery date can pass.

Dramatically increasing the national PQ power system will provide an opportunity to expand and strengthen the commercial base of the network and regions. Local rural groups can support the high technology-based industries that demand premium power quality with reliable power supply. New jobs and higher tax bases will renovate areas and networks that have devoted to agriculture and a single industry.

12. Recommendations

- Three broad activities will address the problem of deployment to build up PQ and establish routes to understand its advantages.
- The PQ solution needs to adapt to the different requirements of the consumer.
- Considering the full range of benefits provided by improved PQ, cost/benefit investigation must be guided. Public member states, service providers, consumer representatives must work together to develop this study. Solutions with ideal clean social incentives must be widely accepted.
- When energy distributed company is the best coordinator provider, electricity costs must include incremental costs to provide a dominant PQ and a reasonable rate of investment.
- Government authorities are expected to react quickly to the story of people claiming on the PQ problems.
- Government agencies and energy regulators will decide how to allocate the cost of a PQ solution among transmission, distribution and customers because the PQ problem can start in various ways in the electricity path.
- Need to develop a program to provide PQ education and make it available to the public.
- Consumers must need to proper education about PQ issues, and the facilities can be intended to pay for current PQ fault. For plans by the consumer, the developing solution generally must be published by the energy management committee and others.

13. Conclusions

Clean power is significant for modern commercial and industrial equipment, which relies on a computational control system and communication system that continues to focus on industrial productivity. Half of the PQ damage starts with the transmission and distribution components of the power system. The monitoring and control elements promoted by smart grids, coupled with the use of broader conventional surge assistance techniques, enable the determination and regulation of PQ opportunities. Another real source of opportunity for PQ is a load (counting customer devices), which can cause differences in the feedback of the power system. The modern drive devices developed for Smart Grids that will also help overcome this problem of power quality. Industrial, commercial and private consumers have PQ demands. The smart grid provides several levels of power quality from standard to the premium that can assure the ability to assess PQ level — however, premium power quality and customer load that necessary to make it compatible with some PQ defects. At this point, if government efforts, utilities, managers, and standards bodies are coordinated then smart grid standards will reach PQ premium level, and decision making has strengthened in the PQ levels shortly. The advantage of digital economic growth means that billions of dollars have not spent on power quality issues. Equally important is the newly open the door to digital economic development that emerged when industries in the new century responded to calls from a perfect PQ with reliable power supply.

**Acknowledgements**

This work was supported by Hohai University under China Scholarship Council (CSC) No.2017GXZ019296
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