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English Translation of New Vocabulary for Text Analysis of New Energy Industry and International Evaluation of Power Quality

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Abstract. With the advancement of global energy transformation, the rapid rise of the new energy industry has become a strategic highland that countries are eager to seize. The inherent instability and unpredictability of renewable energy production pose significant obstacles to the seamless operation of the power system. To address these challenges, this article employs text analysis, data-driven methods, and artificial intelligence technology in neologisms to conduct an in-depth international evaluation and comparative research on the power quality of the new energy industry. Using text mining techniques to conduct an in-depth analysis of new energy policy texts in various countries, revealing their policy characteristics and trends. At the same time, the combination of data-driven and artificial intelligence technology enables more accurate prediction and decision analysis. Based on the findings of this study, the United States has achieved a significant 35% enhancement in the quality of new energy electricity over the past decade, attributed to its consistent monitoring and improvement initiatives. Meanwhile, Germany, owing to its robust monitoring system, has witnessed a 25% improvement in electricity quality in the last five years. However, in developing nations like India and Brazil, approximately 60% of new energy projects encounter challenges related to grid connectivity and scheduling, resulting in a deterioration of electricity quality. In contrast, only 20% of developed countries have issues with grid access and scheduling. This phenomenon reflects that developing countries still need to increase investment and improve the layout of new energy industries and the construction of power grid infrastructure. Developing countries should actively learn from the successful experiences of developed countries in the new energy industry and power grid construction, formulate appropriate policy measures based on their national conditions, improve the quality of new energy electricity, and promote energy transformation and sustainable development.

Key words. New Energy, Power Quality, International Assessment, Sustainable Development.

1. Introduction

With the increasing decline of renewable energy content, people will also face more and more serious environmental problems. The contemporary power grid has undergone profound changes in many aspects. With the coordinated development of the UHV grid as the backbone grid and the power grid of all levels, the construction of a strong smart grid is accelerated, and the factors affecting the power quality of the power grid are increasing, and the disturbance of power quality has begun to show new characteristics [1]. At present, the power system has exposed more and more disadvantages, such as local power failure, slow load adjustment, and high cost, so the safe and efficient smart grid has begun to get more and more attention. One of the important features of smart grid-distributed new energy generation stands out among many power generation modes with its environmental protection, flexibility, low investment and other characteristics.

Compared with the traditional power industry, distributed new energy has a new feature [2], [3]. In the process of distributed generation, the power supply of distributed new energy is near the load, so this construction method can also effectively reduce the consumption of electric energy in the process of power transmission. The nearby power compensation can improve the stability of the power system operation and reduce the expansion of the power grid caused by the increase in the power grid load.

Currently, distributed new energy power generation has undergone rapid development, yet this swift expansion, along with the continual enhancement of voltage levels in user access systems of power quality interference sources, presents novel challenges to the efficient operation of the power grid [4]. In addition, large-scale new energy generation needs to be transported over long distances to the load centre, and the random fluctuation and intermittence of its power make the power quality problems such as system frequency and voltage prominent. In terms of load access, disturbed loads such as high-speed railways and high-power smelting are directly connected to 220kV or 330kV power grid, and the scope of influence on the power quality of the power grid is continuously expanding. China's regional power grid has gradually built a main grid of 500kV or 750kV. UHV AC-DC network makes the power grid structure increasingly complex, and the interaction and influence of AC-DC transmission are enhanced. The power quality problem brought by the high-power power electronic equipment in the distributed power supply has also attracted the great attention of power workers from all over the world. How to improve the power quality has become the research hotspot of the power system in recent years.

2. Related Theories and Techniques

A. Definition and Index of Power Quality

In order to realize the integration of data-driven entrepreneurial enterprises in the green hydrogen economy in the era of big data, we should first classify the data of entrepreneurial enterprises in the era of big data, and use association rules data mining algorithm to extract the sequence analysis and features in the process of data integration of entrepreneurial enterprises [5]. Then, the multiple regression analysis function is used to extract the statistical feature quantity of start-up enterprise data, and the start-up enterprise data in the era of big data is reconstructed. The redundant features in the data of start-up enterprises are deduplicated, and the data information of start-up enterprises is fused by the fuzzy information clustering method [6].

At present, there is no complete consensus on the definition and content of power quality in the world. At present, the power quality is recognized by most people as defined as the degree to which the various indexes of voltage and current related to the normal operation (or operation) of the power supply equipment deviate from the rated value. From an engineering point of view, a broad understanding of the concept of power quality can be decomposed and explained separately [5], [6]. The contents include:

(1) voltage quality. It is usually used to reflect whether the power allocated by the power supply department meets the standard, which mainly refers to the deviation between the actual voltage and the standard voltage.

(2) The current mass, quality, and voltage quality are intricately intertwined. To minimize consumption and enhance the efficiency of power transmission, not only should the current waveform adhere to a sinusoidal single-frequency pattern, but it should also strive to maintain the same phase as the power supply voltage. This synchronization is crucial for optimal performance.

(3) Power consumption quality serves as a complement to the quality of power supply. It represents the responsibility of the power user in the collaborative relationship between the supplier and consumer. This aspect includes the user's prompt and full payment of electricity fees. Figure 1 depicts the step-by-step process of evaluating the power quality of new energy sources.

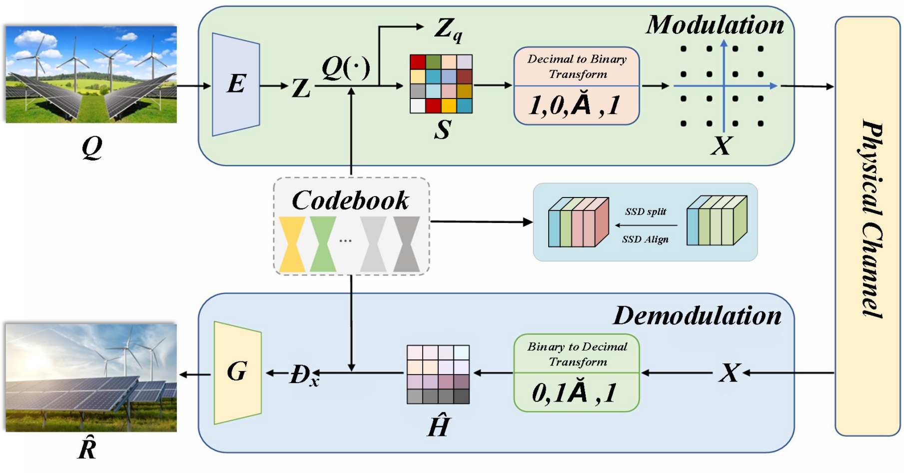

Figure 1. New Energy Power Quality Assessment Flow Chart

To protect the electrical environment, all countries vigorously implement power quality management and supervision, promote power quality control technology, maintain the legitimate rights and interests of both sides, have formulated and issued several power quality indicators, such as the power supply voltage allowed deviation GB12325-1990 [7], "Voltage Fluctuation and Flash" GB 12326-2000, the introduction of these national indicators provides an important basis for the analysis and limitation of power quality indicators. After reviewing the literature, this paper summarizes the meaning and limits of the basic power quality indicators as follows:

1) Voltage Deviation

At present, voltage detection instruments have been put into use on a large scale, which can detect voltage deviation in real time and calculate the pass rate with tools. According to the national standard, in the voltage supply of 35kV and above, the voltage deviation shall not exceed plus or minus 10%; in the power supply of 10kV and below, the voltage deviation shall not exceed plus or minus 7%; the single power supply voltage deviation of 220kV is limited to-10% to + 7%.

2) Grid Harmonics

The parameters of the harmonic mainly include the amplitude, phase, content, distortion rate and so on. At present, there are mainly FFT analysis and wavelet transformation methods for harmonic measurement. In the national standard, harmonic limits have different provisions for different frequencies of different voltage levels [8], [9].

3) Three-Phase Voltage Imbalance Degree

Three-phase imbalance refers to a condition where the phase difference between the three frequencies is 120 degrees, but the amplitudes are not equal. This phenomenon is primarily caused by load imbalance or a malfunction in one of the phases within a three-phase capacitor system. The national standards for voltage requirements about all levels of three-phase imbalance are generally uniform and consistent [10]. The standard stipulates that the allowable value of the normal voltage imbalance of the public connection point in the power system is 2%, a short time, not exceeding 4%. For each user connected to the public connection point, the allowable value of the normal voltage imbalance at this point is generally 1.3%.

B. Power Energy Quality Analysis Method

One of the prominent problems faced by power users and the power sector for a long time is the problem of power quality. In general, power quality is divided into two aspects: steady-state power quality and transient power quality. Voltage deviation, three-phase imbalance, harmonic, frequency and other indicators all belong to the steady state power quality problems [11]. At present, the research on the steady-state power quality problems in the industry has become mature, and certain results have been made. The developed measuring instruments and related national standards have been widely promoted and applied in practical work. But in the study of transient power quality problems, which late, still in exploration, due to the current influence factors on power quality increasing, transient power quality problems both the power system and social aspects, have a more and more profound influence, have more and more by the attention of electric power research institutions.

At present our country has issued several power quality-related national standards and enterprise standards, which are limited to the steady state power quality standards, although transient power quality problems in recent years have caused the relevant departments to attach great importance to them, there is no relevant standards to limit pulse transient, voltage drop, voltage surge [12]. In a word, compared with some developed countries, China's early power quality standards in the formulation of many deficiencies, lack, testing, measurement and other aspects of the standard, related performance indicators are not operational, scientific and other shortcomings, in the whole industry procedures and guidance is still lack of perfect standards. In the aspect of the development of analytical instruments, both at home and abroad are developing towards real-time, modular and network [13]. At present, the implementation of some complex algorithms benefits from the development of microelectronics technology, digital electronic technology, especially digital signal processing technology. The improvement and development of these technologies provide a solid hardware foundation for the realization of complex algorithms [14]. At present, power quality monitoring and analysis is adapting to the trend of international measurement and control technology towards the direction of network and has realized the network information management and remote monitoring of power quality. The development of network information management is conducive to improving the automation level of electric power systems. Many of the existing instruments and systems can use the existing communication interfaces (RS232, RS485, MODEM, LAN) to achieve power quality network monitoring, such as the PQ FIX power quality monitoring device developed by Swiss Lyme (LEM) and the PR Secure online power quality monitoring and analysis system newly developed by The United Power Company of Sweden [15].

The power quality analysis method, being a pivotal component of power quality monitoring and analysis research, serves as the essence of power quality testing instruments and detection systems. Depending on the varied principles employed, this analysis method can be categorized into three distinct approaches: time domain, frequency domain, and transformation domain. Figure 2 shows the flow chart of international power quality assessment and comparison.

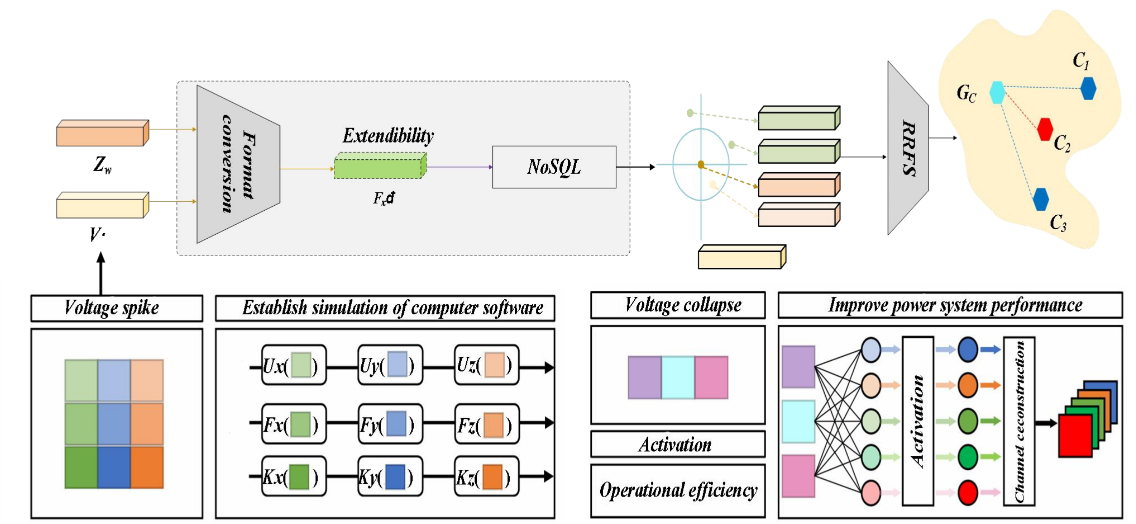

Figure 2. International Power Quality Assessment and Comparison Flow Chart

In practical application, power quality assessment needs to consider a variety of factors, including technology, economy and environment. Technical factors mainly include the basic operation requirements of the power system, technical specifications, performance of equipment, etc. Economic factors involve investment cost, operational efficiency, energy conservation and emission reduction; Environmental factors involve environmental protection requirements, energy renewable utilization and other considerations. Therefore, it is the key to improving the performance of power systems to establish scientific and reasonable power quality evaluation standards and methods and take effective technical and management measures on this basis.

C. Power Quality Assessment Method

The reasonable evaluation of the power quality of the power grid is not only an important basis for clarifying the responsibility of power quality and formulating the power supply contract by both parties but also a reference for the pricing of electric energy as a commodity for sale. Objective and reasonable power quality assessment is the prerequisite for the governance of power quality problems, and a means to check the transmission characteristics of power quality disturbance sources and the interference of user power consumption [16], [17]. Most countries have their power quality control policies or standards, which are formulated or standards according to the actual situation of the power grid of each country, and stipulate the standard scope of power quality indicators in detail. Among these indicators, there exist both negative and positive metrics. When an indicator is negative, a smaller value signifies a better performance, for instance, in the case of voltage deviation, voltage fluctuation, and flicker. Conversely, a positive indicator indicates a better performance with a higher value, such as the reliability of the power supply and voltage drop. In the process of power quality evaluation, to effectively compare the indicators, each index can be treated in one direction, to make the evaluation results more objective and reasonable. For example, for the inverse indicators such as voltage deviation, you can use 100% minus the index value, which can be converted into positive indicators, to be more convenient to do a more effective comparison with other indicators.

The current power quality standard only stipulates the limited value range of a single power quality index, so it can only be suitable for the qualified judgment of a single power quality index, and cannot comprehensively evaluate the advantages and disadvantages of power quality. The evaluation result of power quality is the result of the comprehensive evaluation of many indicators, so the existing power quality standard, which can only judge whether the single indicator is qualified, cannot reflect the quality of power quality [18]. In addition, the power quality problem of the power system is the result of the comprehensive effect of multiple factors. Different power quality problems and different combinations of power quality problems all have different effects on power equipment. Therefore, the simple qualification determination of a single index can no longer meet the needs of the actual production, and the actual work needs a complete and scientific comprehensive evaluation method of power quality. Figure 3 shows the flow chart of power quality index collection and analysis.

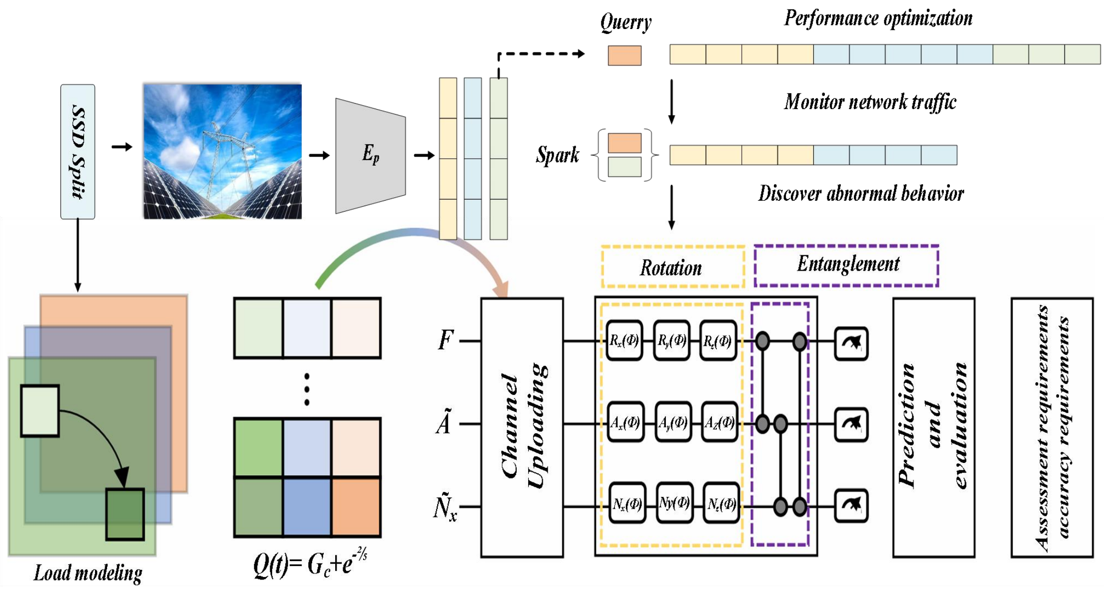

Figure 3. Power Quality Index Collection and Analysis Flow Chart

3. Power Quality Analysis Based on the Characteristic Harmonic Model

A. Power Quality Analysis

The traditional power quality analysis method focuses on power quality problems such as frequency deviation, voltage fluctuation and flash, three-phase imbalance, harmonic, voltage temporary drop, interruption and so on, and the key indicators are voltage, frequency and waveform [19]. The distributed photovoltaic power generation system uses inverters and other components containing power electronic devices to be connected to the grid, which brings problems such as harmonic pollution, voltage and current distortion, and three-phase imbalance to the power grid. In the actual grid-connection process, the change of grid-connection position, grid-connection capacity and other working conditions will reflect different harmonic conditions, and directly affect the base wave current (hereinafter referred to as current), voltage, power, current harmonic total distortion rate, voltage harmonic total distortion rate, three-phase imbalance, the harmonic content of harmonic current (hereinafter referred to as harmonic current) and other indicators. Therefore, this paper will analyze the focus on harmonic, current voltage, power, current harmonic total distortion rate, voltage harmonic total distortion rate, the analysis of the three-phase imbalance index, proposed a distributed photovoltaic grid power quality analysis method, including data pretreatment, overall analysis, classification, condition analysis and characteristic harmonic modelling five steps [20]. Figure 4 shows the power quality assessment flow chart.

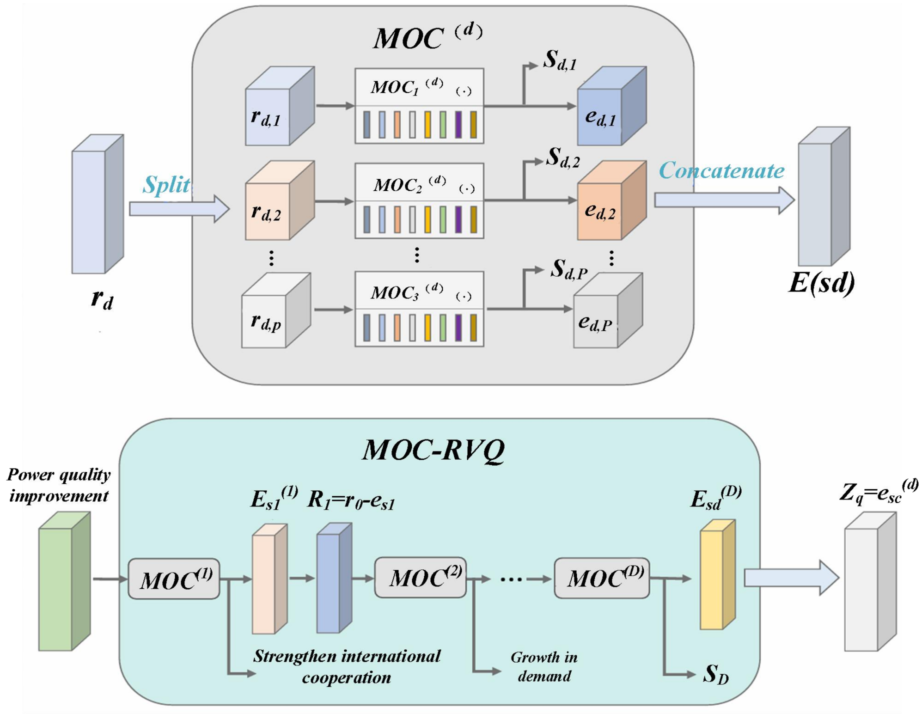

Figure 4. Power Quality Assessment Flow Chart

By undergoing operations such as merging, addition, filling, de-redundancy, and format conversion, the collected data set is refined to yield a comprehensive electric energy data set suitable for the analysis method presented in this paper. This lays the groundwork for the subsequent four steps, with the overall analysis serving as the foundation for classification [21], By mapping and calculating the current and power in the preprocessed dataset, Observe and analyze its value distribution and change law, Determine the indicators and the number of classifications to be classified; The K-means algorithm was used to classify the indicators determined in the overall analysis and mark the acquisition time; After the classification is completed, Other indicators in the full index electric energy data set are classified according to the markers, Draw out the relevant indicators, calculate the statistics, Complete the division of labor condition analysis, Prepare for the next step of the modeling work; last, Mapping the spectrum of 2-50 harmonics, Determine the characteristic harmonic frequency, Combining the results of the analysis in the previous step, Create the characteristic harmonic model by using the higher mathematical functions. Details of the five steps in the overall process are described below. The power loss rate and power factor formulas are shown in (1) and (2).

$$F = \sum_{j=1}^{H\times W}\sum_{c=1}^{C} q_{T_n} \hat{Y}_{T_n}^{(j,c)} \log\left(\hat{Y}_{m_n}\right)^{(j,c)} \odot (1-M) \tag{1}$$

$$E_{T_d} = \sum_{j=1}^{H\times W} \frac{-1}{\log(C)} \sum_{c=1}^{C} P_{T_d}^{(j,c)} \log P_{T_d}^{(j,c)} \tag{2}$$

The power quality detection device, encompassing both online monitoring terminals and portable detectors, is utilized to gather data at designated monitoring points. The data collection is conducted at a second-level density, encompassing indices such as three-phase current voltage, power, three-phase imbalance, total current (voltage) harmonic distortion rate, and harmonic currents ranging from the 1st to 50th order. The initial data set is multiple files in text format. First, the statistical analysis tool is used to add and merge all the text files according to the collection time. Among them, the same files with different acquisition indexes are added, and different variable files with the same acquisition indicators are combined during the collection period, resulting in the whole index data set of the whole acquisition period. In the whole index data set, some places where the effective value is missing, and the filling content is the maximum value of the index [22]. And the mean of the minimum value; again, the filled data is redundancy and sorted by collection time, and the data format conversion; Finally, the full index data set of commas separated value types that can be used for classification.

B. Global Analysis

The overall analysis provides the basis for the classification. The influence of distributed photovoltaic grid connection on the power grid is mainly reflected in the current and electricity Pressure, power, current (voltage) harmonic total distortion rate, three-phase imbalance, harmonic current and other indicators change [23], [24].

The work of photovoltaic power generation modules is directly reflected in the change of current and active power, so the current or active power is selected as the classification index, and the determination of the specific classification index is determined according to the overall analysis and clustering effect. Draw the time trend chart and histogram of the three-phase current effective value, active power and reactive power in the whole index electric energy data set, and calculate the maximum value, minimum value, mean value, variance, 95% probability value and 99% probability value of the above indexes. Combining the figures and statistics of current and power, the value change and distribution rules are analyzed [25]. Figure 5 Comparative study of international new energy power quality.

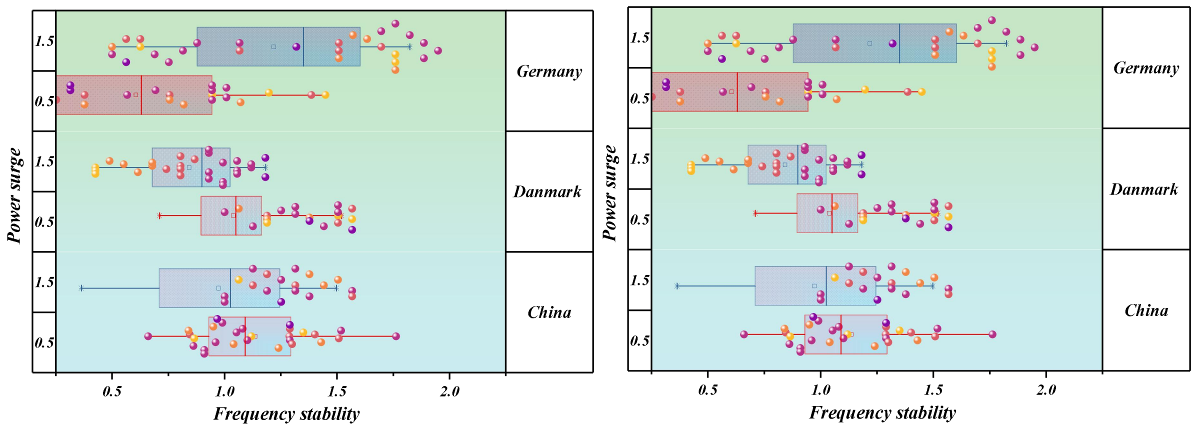

Figure 5. International Comparative Study of New Energy Power Quality

This research validates its methodology based on measured data, necessitating a large data scale and stringent requirements on the speed and practicality of the clustering algorithm. Given the inherent randomness and diverse working conditions in distributed photovoltaic power generation, existing research has not been able to account for all scenarios. Therefore, this paper adopts a model-based approach to condition classification, with less stringent requirements on the accuracy of the clustering algorithm. As one of the earliest classification algorithms, the K-means algorithm has been relatively mature, and the method is simple and fast [26], [27]. After comprehensive consideration, the K-means algorithm was finally selected to classify the data. The specific steps of the K-means algorithm will not be given in this paper. Please refer to the relevant literature for details. At the same time, the K-means algorithm can be implemented with the help of data analysis software, which satisfies the speed of the clustering algorithm Speed, practical requirements. The effective value of the three-phase current using the K-means algorithm on the preprocessed electric energy data.

The work power was clustered separately, and the final clustering index was determined in combination with the overall analysis and the clustering effect, and the clustering was completed. In the clustering results, each category corresponds to one working condition, and the collection time corresponding to the clustering index is category-labeled according to the clustering results. Figure 6 shows the distribution of population and electricity consumption in different regions.

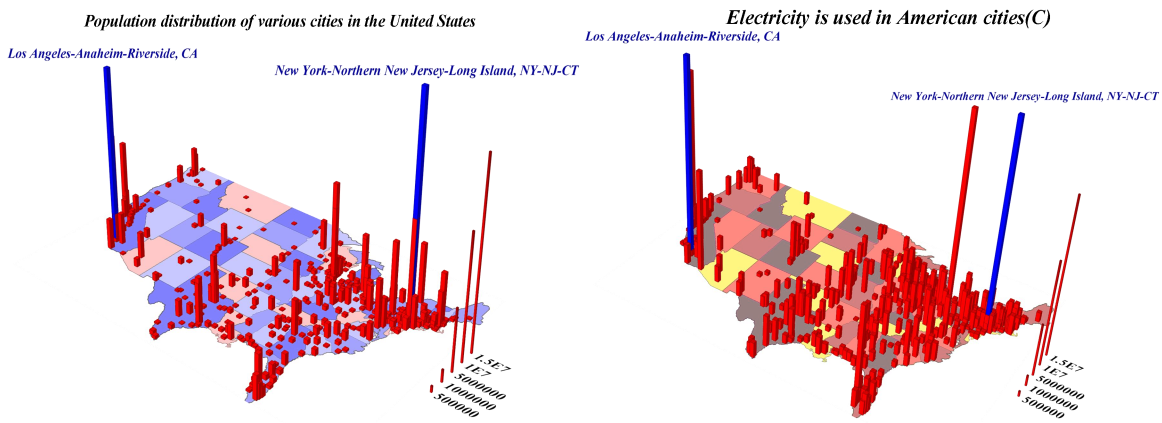

Figure 6. Distribution of Population and Electricity Consumption in Different Regions

According to the data, the installed capacity and power generation of renewable energy in China rank among the top in the world, and the reliability and stability of the power grid have also been significantly improved. India and other developing countries are also making efforts to improve power quality, strengthen grid management and supervision, and improve the reliability and stability of power supply [28], [29].

C. K-means Classify

Since the variation trends and values of the three-phase current's effective values are broadly similar, we opted to illustrate using the effective value of phase A's current as an example. Upon analyzing the time trend chart and histogram for phase A's effective current value and active power, it was observed that the patterns of change in the time trend chart are roughly identical. Due to the large change range of the active power value and the high dispersion degree, the clustering effect is not good, so the three-phase current value is finally selected as the clustering index. The distribution of the effective A-phase current is concentrated between 0-20A, 20-0110A, 110-220A, 220-330A, and 330A-480A. After many attempts, the clustering K-means algorithm is divided into five working conditions; the K-means algorithm classifies the three-phase current in the pretreatment electric energy data, each type corresponds to one working condition, and the collection time corresponding to the effective value of the three-phase current is labelled. The detailed classification effect is as follows: The current range of phase A in condition 1 is OA~20A, the power is 48 kW ~ 660 kW, and 15807 data points, accounting for 55% of the total points; the current range of phase A in condition 2 is 20A~110A, and the power is 619 kW ~ 4036 kW. Energy conversion efficiency and load rate formulas are shown in (3) and (4).

$$L_{orth} = \beta |F| W^T W \odot (1 - I) |A|_F^2 \tag{3}$$

$$L_{cyc,att} = E_{e,att}(y_e) - E_{e,att}(\text{fake}) \tag{4}$$

Of the 4,955 data points, 27% of the total stronghold; The current range of phase A in working condition 3 is 110A~220A, Power is 3922 kW ~ 8129 kW, Of the 3,201 data points, 11% of the total stronghold; The current range of phase A in working condition 4 is 220A~330A, The power is 7799 kW ~ 12470 kW, With 2,487 data points, 8% of the total stronghold; The current range of phase A in working condition 5 is 330A~480A, The power is 12240 kW ~ 18140 kW, With 2,530 data points, For 9% of the total stronghold. The power density and energy efficiency ratio formulas are shown in (5) and (6).

$$蝌 \leq {}_{S} + W(\hat{\mu}_S, \hat{\mu}_T) + \sqrt{\left(2\log\left(\frac{1}{\xi}\right)/\zeta\right)}\left(\sqrt{\frac{1}{N^s}} + \sqrt{\frac{1}{N^t}}\right) + e_C(h^*) \tag{5}$$

$$W(\hat{\mu}_S, \hat{\mu}_T) \leq W(\hat{\mu}_S, \hat{\mu}_Z) + W(\hat{\mu}_Z + \hat{\mu}_T) \tag{6}$$

4. Strategies and Suggestions for Improving Power Quality in the New Energy Industry

A. Analysis of Successful Cases of Power Quality Assurance in the World

Globally, many countries have achieved remarkable success in power quality assurance. These successful cases provide valuable experience and enlightenment for other countries. This paper will analyze the successful cases of power quality assurance in the world, and discuss the successful factors and implementation strategies, to provide reference for improving the global power quality.

European countries, notably Germany and Denmark, stand as global pioneers in power quality assurance. Germany, for instance, has fortified its power system stability by establishing rigorous power quality and supervisory standards, coupled with investments in grid infrastructure. Additionally, it has made strides in renewable energy sources, further enhancing the overall quality of power supply. Denmark is a global leader in wind power generation, thanks to technological innovations and policy support. To ensure power quality, Denmark has also emphasized intelligent construction and dispatching control of the power grid. This ensures stable grid connection for wind power and efficient power transmission. Carbon emission and reliability assessment formulas are shown in (7) and (8).

$$W_d(P, Q) = \left(\inf_{L \in L(P,Q)} \int \| x - y \|^d \, dL(x, y)\right)^{\frac{1}{d}} \tag{7}$$

$$L_{adapt} = L_{ce}(h(X_Z), Y_Z) + \lambda L_D(f \cdot g(X_T), X_Z) \tag{8}$$

The United States has also made some achievements in power quality assurance. The United States has achieved improved reliability and stability in its power system by establishing a comprehensive power quality and supervision framework, coupled with robust investment in, and maintenance of, power grid infrastructure. Figure 7 shows the comparison of electricity consumption in different countries.

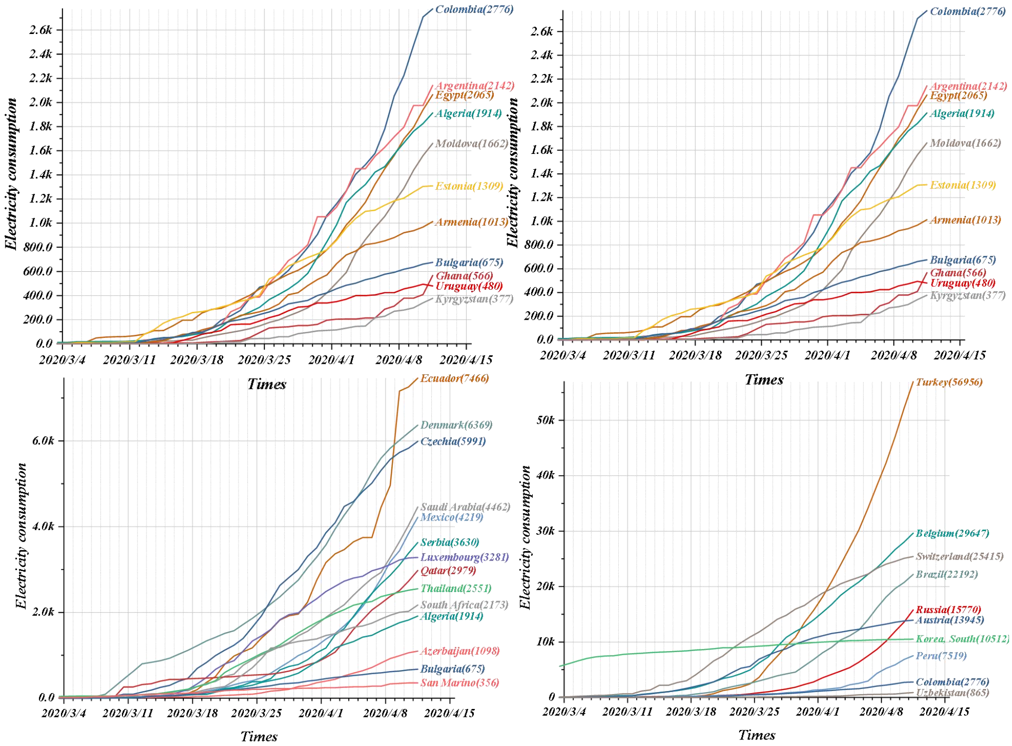

Figure 7. Comparison of Electricity Consumption in Different Countries

Due to the alternation of day and night, the current of this station shows a trend of increasing during the day and decreasing the current to zero at the maximum night at noon. Because the changing trend of the three-phase current reflects the power generation situation of the photovoltaic power station, all the data points collected are divided into several working conditions according to the three-phase current, which just reflects several situations in the process of photovoltaic power generation. The site is divided into five types according to its three-phase current, and the current in these five working conditions is distributed in five ranges: The current range of phase A in working condition 1 is OA~20A, the power is-48 kW ~ 660 kW, 15807 data points, accounting for 55% of the total stronghold; The current range of phase A in working condition 2 is 20A~110A, the power is 619 kW ~ 4036 kW, 4955 data points, accounting for 27% of the total stronghold; The current range of phase A in working 3 is 110A~220A, and the power is 3922 kW ~ 8129 kW, with 3201 data Point, accounting for 11% of the total stronghold; The current range of phase A in working condition 4 is 220A~330A, the power is 7799 kW ~ 12470 kW, 2487 data points, accounting for 8% of the total stronghold;

The current range of phase A in working conditions is 330A~480A, the power is 12240 kW ~ 18140 kW, 2530 data points, accounting for 9% of the total data points. The energy consumption rate and life cycle assessment formulas are shown in (9) and (10).

$$p_k(z) = \sum_{t=1}^{T} \alpha_{k,t} N\left(z \mid \mu_{k,t}, \Sigma_{k,t}\right) \tag{9}$$

$$\hat{\theta} = \operatorname{argmin}_{\theta}\left\{\frac{1}{N}\sum_{i=1}^{N} L_{ce}\left(\phi_{\theta}\left(x_i^s\right),\ y_i^s\right)\right\} \tag{10}$$

B. Power Quality Index Set

Currently, numerous countries have devised standards tailored to their respective national grid development and construction. Nevertheless, the current power quality standards serve primarily as a gauge to determine if certain indicators fall within acceptable ranges. In reality, electrical power professionals prefer a unified, comprehensive evaluation of power quality as a whole [30]. Electric energy is a commodity, which needs high quality to meet the requirements of the masses, to occupy the market to obtain profits. Power users require the electricity provided by the power transmission department to meet the availability and stability. As the consumer of electricity, the demand of power users is the primary factor for the power sector to consider, and also the prerequisite for the relevant power sector to consider the research of power quality. All factors, including voltage, power, frequency and other factors, that cause or may cause user equipment failure or other power problems shall be regarded as power quality problems.

The domestic standards for grid connection of photovoltaic power generation systems were formulated late. At present, there is mainly the enterprise standard of State Grid Corporation Q / GDW617-2011 "Technical Regulations on Photovoltaic Power Station Access to Power Grid" and other national standards related to power quality. In the fuzzy method, the selection of the fuzzy model occupies a pivotal position. Whether the membership function is effective directly affects the credibility of the power quality assessment results. In power quality assessment index concentration, some indicators of membership attribute are similar, such as frequency deviation and voltage deviation, most of them are distributed in a certain interval and often have a trend towards zero, points, the probability of zero value is random, the farther the probability from zero is the smaller, this fit the characteristics of distribution, so frequency deviation and voltage deviation can adopt a normal distribution of Gaussian function as a membership function.

The comprehensive evaluation of the power quality of the power grid should start from the data collection, collect the operation parameters of the power grid, and then evaluate the power quality of the index set and compare the advantages and disadvantages. Therefore, it is crucial to select the power quality evaluation index set objectively. The membership function of each index is as (11) and (12).

$$L_{cls}\left(f_c;M\right)=\sum_{i=1}^{C}\hat{p}^i\log\hat{p}^i \tag{11}$$

$$L_{cert}\left(f_c;M\right)=-E_{m\in M}\sum_{i=1}^{C}\hat{p}_m^i\log\hat{p}_m^i \tag{12}$$

To enhance power quality, a multifaceted approach is essential. This entails fortifying monitoring and evaluation mechanisms, optimizing dispatching and control strategies, reinforcing infrastructure development, fostering the growth of renewable energy sources, establishing robust emergency management systems, and intensifying international collaborations and technical exchanges.

5. Conclusion

The study focuses on the power quality problems exposed by large-scale distributed new energy access and explores new power quality analysis and comprehensive evaluation methods. Through the research, for a large-scale distributed photovoltaic power generation system, a power quality analysis method based on a characteristic harmonic model is proposed, the method verification is completed and the characteristic harmonic probability density model is established. Then, based on the connection model, the power quality and evaluation method are proposed, the connection model of power quality assessment is established, and the method verification is completed by using the measured data of four distributed photovoltaic power stations.

Utilizing text analysis, data-driven methods, and artificial intelligence technology, this study conducts an in-depth international evaluation and comparative analysis of power quality in the new energy industry. The findings reveal notable disparities in the quality of new energy power among countries, with key influencing factors encompassing technical proficiency, policy support, and market environment. On this basis, text mining technology can further analyze the new energy policy text of various countries and reveal its policy characteristics and trends. At the same time, data-driven and artificial intelligence technology are combined for more accurate prediction and decision analysis. Through the data analysis, the data shows that the technical level of different countries varies significantly, with the American technical score of 7.5, the Chinese technical score of 5.3, and the Japanese technical score of 4.8. The market environment score was 7.8 in America, 6.3 in China and 5.1 in Japan. Developing countries still need to increase investment and improve the layout of new energy industry and power grid infrastructure construction, and actively learn from the successful experience of developed countries in new energy industry and power grid construction. In addition, strengthening technology research and development and application, using advanced data-driven and artificial intelligence technology to improve the evaluation and prediction accuracy of power quality, and providing strong support for decision-making is also an important development direction in the future. These measures will help improve the quality of new energy power and promote the energy transition and sustainable development. Although this paper has done related research on the power quality of distributed photovoltaic grid connections and put forward the analysis and evaluation method of transient power quality, further research and improvement are still needed in the fuzzy quantitative processing of data and steady-state power quality.

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