Review of Comprehensive Evaluation Methods for Power Quality and Its Trend in New Generation Energy System

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Abstract. With China's new energy generation grid connected capacity being in the forefront of the world and the uncertainty of new energy sources, such as wind energy and solar energy, it is be of great significance to study scientific and comprehensive assessment of power quality. On the foundation of analyzing the current power quality index systematically and objectively, the new energy grid power quality analysis method and comprehensive evaluation method, this paper tentatively explored the trend of the new generation of energy system power quality comprehensive evaluation.

1. Introduction
It is of ultimate goal of human energy model with clean and power substitution. Compared with traditional energy systems, the new generation of energy systems focus on the future energy centric trends energy development. To build a new generation of energy systems, it is to need focusing on solving a series of important scientific issues, including source, receiver and transmission[1]. With the development of new energy vigorously to the distributed power form and its uncertainty changing the distribution network and affecting the safety and reliability of traditional distribution network, it is both necessary and meaningful to evaluate the power quality comprehensively and Scientifically. On this foundation, this paper analyzed systematically power quality indicators, power quality analysis methods and power quality assessment methods, and discussed tentatively its trend.

2. Research status of power quality evaluation methods at home and abroad

2.1 Power quality indicators
On the basis of the six indexes issued energy quality of the national standard [2], it is of the general selection of voltage deviation, voltage flicker, voltage fluctuation, voltage total harmonic distortion rate, voltage unbalance, frequency deviation as the evaluation index.

2.1.1 Voltage deviation
Voltage is one of the most important indexes of power quality, in which voltage deviation is the main index to evaluate the quality of voltage. Voltage deviation is the percentage of the difference between the actual voltage of a node and the nominal voltage of a system and the nominal voltage ratio when the system is in normal operation.
2.1.2 Voltage fluctuation
Voltage fluctuation is a series of relatively rapid or continuous changes in the root mean square value of a voltage. In distribution systems, voltage fluctuations occur frequently, with variations in two or more random or random ones.

2.1.3 Harmonic distortion rate
The waveform distortion index is usually expressed by the total voltage or current harmonic content and the total harmonic voltage or current.

2.1.4 Voltage flicker
Voltage flicker refers to the reaction of the human eye due to the unstable brightness of the light caused by the fluctuation of the power supply voltage. The essence of flicker is caused by voltage fluctuation, which is subjective and not electromagnetic. The flicker awareness rate is used to reflect voltage flicker.

2.1.5 Three-phase voltage unbalance
Unbalanced three-phase voltage is the ratio of the negative sequence component, the root mean square value and the root mean square of the positive sequence component in the normal operation of the power system.

2.1.6 Power system frequency deviation
Frequency is one of the most important indexes of power quality. The frequency deviation must be controlled within the allowable range to ensure the normal operation of power users and power plants. The frequency deviation of the system is defined as the difference between the actual and nominal values of the system frequency.

2.2 Theoretical basis of power quality analysis
At present, for the new energy grid connected, the power quality analysis methods can be divided into three main categories: time domain, frequency domain and transform domain:

2.2.1 Time domain simulation method:
With the power system mainly being composed of R, L, C and other components, and power system components and the equation being described by differential equations, it is feasible to study various transient phenomena quality problems by solving these differential equations of power. The time domain simulation method of power quality analysis is the most widely used method, being used in time domain simulation program (such as EMTP, PSCAD or SPICE) of various transient phenomena including the new energy power generation power quality problems were analyzed.

2.2.2 Frequency domain analysis method:
Frequency domain analysis is mainly used for harmonic analysis of power quality, and the distribution of harmonics in the system is analyzed. At present, frequency sweep and harmonic flow calculation are the common methods.

2.2.3 Transform domain analysis method:
The commonly used transform domain analysis methods include Fourier transform method, short-time Fourier transform method, the two transform method and wavelet transform method. The core idea is to transform sampled signals and analyze the characteristics of signals based on signal processing methods to detect and analyze the power quality.

2.3 Survey of power quality comprehensive evaluation method for new generation energy system
At present, there are many methods for the comprehensive evaluation of power quality, mainly divided into the following categories:
2.3.1 Traditional method of power quality evaluation

a. The method of power quality assessment based on matter element analysis.

In document [3], an integrated power quality assessment method based on matter element analysis is proposed. Matter-element theory is a method of contradiction, establish the model of complex problems to be abstract, with the correlation function to express things with some properties, can describe the state from two aspects of qualitative and quantitative. The evaluation method based on matter-element method overcomes the problem of difficult choices when approximate membership degree in fuzzy evaluation, establish the model of complex problems to be abstract, using correlation function to describe things with some properties, can describe the state from two aspects of qualitative and quantitative, but will be influenced by the subjective weights factor.

b. Power quality assessment method based on probability statistics and vector algebra

Document [4] based on probability statistics and vector algebra, a power quality evaluation method based on daily cycle is proposed. The method of power quality evaluation based on probability statistics and vector algebra is more convenient to calculate. The method of mathematical calculation is more systematic, the result is clear, and the uncertainty problem can be solved intuitively. The basic idea is in a period of time, using probability distribution probability theory for each index in each level, and then calculate the index standard of expectation and standard deviation, to evaluate the situation of power quality by comparing the expectation and standard deviation. However, the requirement of real-time data monitoring of power quality indicators is higher. It is necessary to monitor the power quality at any time in a period of time, and evaluate the power quality status at that time.

c. Power quality evaluation method based on genetic algorithm

Document [5-6] uses genetic algorithm to evaluate power quality, which makes power quality evaluation more precise and specific. The principle of genetic algorithm in biology, Darwin's survival of the fittest survival of the fittest, based on the basic operation of repeated use of genetics to contain the possible solutions group, continue to generate new population, the population evolves constantly, while global parallel search technique to search the optimal individual in the group, to obtain the optimal solution to meet the requirements. With the gradient descent and simulated annealing search algorithm, genetic algorithm is simple, robust and strong.

d. Power quality evaluation method based on clustering analysis algorithm

Clustering is an unsupervised machine learning and data analysis techniques, search to identify a limited set of data to describe, can objectively reflect the real world, influenced by subjective factors degree is low, and convenient calculation. In recent years, clustering analysis has been widely studied, and has been applied to many fields, including image processing, data analysis, pattern recognition and many other fields. According to the different expression modes of clustering, clustering analysis algorithms can be divided into different types. There are clustering algorithms based on partition, hierarchical clustering algorithm, grid based clustering algorithm, density based clustering algorithm, model-based clustering algorithm and so on. Document [7-9] uses fuzzy synthetic index to evaluate power quality and realize comprehensive evaluation of power quality. In order to make the evaluation process more objective and fair, the method of AHP is used to deal with the weight of each index in document [10-13].Document [14] considering that the power quality evaluation is a multiple evaluation index and a number of influencing factors are determined, a comprehensive evaluation method of power quality is put forward based on the fuzzy multi-objective decision-making theory. Document [15] considering the various evaluation indexes in power quality assessment, a method of power quality assessment based on osculating value method is proposed. This method can carry out comprehensive evaluation and analysis without subjective parameters such as membership function, so the result is more objective and effective. Document [16] short board effect based on the theory, and based on the electromagnetic compatibility of the sensitive special customer demand level, the planning level, the compatibility level and equipment immunity level, put forward the evaluation method of the power quality comprehensive level, conducive to distinguish the power quality and grade of power quality evaluation. Document [17] uses the analytic hierarchy process group decision method to determine the weight of each evaluation index. On this basis, a model and method of power
quality comprehensive evaluation is established by using the model tree. Document[18] put forward the confidence criterion of power quality based on fuzzy comprehensive evaluation method, establishes the comprehensive evaluation of power quality hierarchical model, in the model in steady and transient power quality can be affected by comprehensive consideration.

e. Combined weighting method

Lack of combination weighting method of power quality evaluation method based on the method of how to overcome the single right, taking pressure can improve power quality evaluation accuracy. The [19] is proposed to determine the combination of power quality evaluation indexes weights weighting method (i.e. the subjective weighting method combined with objective weighting method), and using the method of public connection point of the fuzzy synthetic evaluation of power quality, effectively improve the objective and scientific power quality fuzzy comprehensive evaluation.

f. Entropy weight method

A power quality fuzzy comprehensive evaluation method based on entropy weight analytic hierarchy process (AHP) is proposed in document [20]. Entropy weight, as an objective weighting method, belongs to the concept of information theory. Entropy represents a measure of uncertainty in a random event and can be interpreted as the probability of occurrence of a particular information. The smaller the entropy bribe, the greater the amount of information provided, the greater the role in the evaluation, the higher the weight should be. On the contrary, the greater the entropy, the smaller the weight.

2.3.2 New energy grid connected power quality evaluation method

Document [3-20] power quality comprehensive evaluation method for comprehensive evaluation of power quality is the target of power quality ranking analysis, lack of comprehensive evaluation of the discussion of the meaning and power can guide quality management, lack of adequate evaluation and guidance. Document [21-30] puts forward different methods according to the characteristics of distributed power supply quality evaluation. Document [21] proposed using comprehensive evaluation and decision making method of mutation of distributed power supply power quality, although this method avoids the power index weight, but with the traditional power system power quality comprehensive evaluation is no different, just different application scenarios. Using double benchmark method. Document [22-23] can overcome the shortcomings of a single standard. The evaluation results do not reflect the characteristics of the comprehensive evaluation of distributed generation power quality. Document [24] integrates the CO2 emission enhancement into the evaluation index, highlighting the characteristics of the distributed generation power quality assessment. However, only improving the level of clean energy can not guide the solution of power quality problems. Various models proposed in the document [25-27] take into account the uncertainty and subjectivity in the comprehensive evaluation of power quality. In document [28], a new method for evaluating the power quality of microgrid is proposed. According to the influence of distributed power supply on distribution network, [29] establishes the comprehensive evaluation index system of distributed power grid from four aspects of power quality, reliability, economy and environmental impact. The [30] for steady-state power quality comprehensive evaluation of the complexity and limitations of single index in reflecting the comprehensive power quality level, the Fisher classification method was used to evaluate the steady-state power quality of grid connected photovoltaic.

3. New generation energy grid connected power quality assessment method research trends

With the new situation of the energy system revolution and Internet development providing new opportunities for innovative integration of power industry technology, and with the Internet, cloud computing and other ICT technology, new materials and new energy technology, the depth of penetration and integration, the power quality management is also facing new opportunities to leapfrog development, integration between power and other sources of energy, energy user interaction further to promote innovation platform.
Therefore, it is necessary to pay attention to the development trend of power quality assessment methods for the new generation energy system. In the big data platform, the future power quality evaluation method will fully consider the power quality index system, reliability index system, economic index system, the index of environmental impact, will be more precise, comprehensive and systematic evaluation method more effective and scientific.

4. Summary
This paper objectively and systematically analyzes the current research situation and related issues of the comprehensive evaluation method of the new energy grid connected power quality both at home and abroad, and on this basis discusses the development trend of power quality evaluation under the new generation energy system.

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