International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 4 Issue 3 ǁ Mar. 2016 ǁ PP.101-105

Power Quality Problems Based on Smart Grid and New Energy Generation

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ABSTRACT: *Power energy is the economic lifeline of the country. As more and more non-linear electrical equipment are connected to the power grid, the power quality problem becomes more and more prominent.Atpresent,thecountryisvigorouslybuildingasmartgrid.Onlybysolvingtheproblemofpowerquality,theintelligentconstructionofthegridcanbeguaranteed.Atthesametime,powerqualityproblemsalsoaffectourdaillylifeandproduction,sotheresearchonpower quality detection devices has important practical significance. This paper first puts forward the relationship between the developmentofdomesticsmartgridandpowerquality,andsecondlystudiesthestatusquoandfuturedevelopmenttrend ofpowerqualityanalysisathomeandabroad.Next,severalpowerqualityproblemsandtreatmentmethodsfornewenergy generationarelisted.Finally,thenewsituationofpowerqualityintheeraofsmartgridisclarified.*
Key words: *Power Quality; Smart Grid; New Energy Grid-Connected; Distributed Energy.*

I. INTRODUCTION

Intoday'ssmartgridera,thelargenumberofapplicationsofvariouspowerelectronicdevicesandtheaccessofdistriuted power sources and energy storage devices make power quality problems increasingly prominent and complex.Therefore,intheeraofsmartgrid,high-precisiondetectionofpowerqualityisofgreatsignificance.
Powerqualityreferstothequalityofvariousindicatorsofelectricalenergy.Ideally,thepublicgridsignalshould be a sine wave with constant amplitude and frequency, and when three-phase AC is used, the voltage and current amplitudesofthephasesarerequiredtobethesame,whilethephasesymmetryis120°.Inreality,thisidealstatedoes notexistbecauseoftheeffectsofgenerators,transformers,andvariousnon-linearloads,orotherexternaldisturbances andpowerfailures.Therefore,inthevariousstagesofgridoperation,thereareproblemssuchasdeviationofnormal values from indicators, or sudden changes in power quality[1].
After the 1960s, the grid entered the second generation, and its scale was expanded for large-scale units, ultra-high-voltagetransmissionandlarge-scaleinterconnectedpowergrids.Theemergenceofnonlinear,unbalanced,and impactloadshashadmanyeffectsonthegrid.Alotofinfluenceshavecome,sothepowergridqualityhasbeenadded tothepublicgridharmonics,voltagefluctuationsandflicker,S-phasevoltageimbalanceandotherindicators.Sothe concept of power quality is gradually formed. At this time, many countries and international organizations successively formulated and promulgated relevant standards on power quality. For example, in 1976, the United KingdomformulatedG5/3"RestrictionsonHarmonicsinBritishPowerSupplySystems"[6];theUnitedStatesissued ANSI/ in 1981. IEEE StdF 519-1981 "Harmonic Control and Reactive Compensation for Static Power Converters IEEE Guide" [7], the United Kingdom issued the "voltage imbalance planning limitin1990 [8].
Smartgridmanagementiscomposedofmodulessuchaselectricenergy,powersupply,equipmentanddistribution network. The power management is composed of electricity safety, reliable electricity consumption, power consumption,energyassessment,electricalenergyefficiency,electricityconsumptionstructure,andpowerquality. Power management is a combination of voltage, capacity, power structure, etc.; equipment management isacombinationoffile,operation,powerconsumption,etc.;distributionnetworkmanagementisbyorderlyelectricity,

distributionnetwork,Distributionnetworklossandothercombinations[3].Thecharacteristicsofsmartgridsshoul d be: First, high efficiency: corridors with electricity transmission have better unit transmission level, higher energy utilizationefficiency,andcanreducetransmissionanddistributionconsumption.Second,intelligence:self-analysis method,self-perceptualcapabilitiesandcontrolautomation,constituteahugeintelligentmachineconnectedbywide-areacommunicationnetwork.Third,self-healing:Thethirdisself-healing:youcandetectthefaultonyourown,and then judge and make corresponding control actions to solve the problem yourself before the customer finds the problem.Thefourthisreliable:thegridismorecapableofwithstandingdisturbancesandimpacts,andtheoperation issafer.Thefifthistheeconomy:veryhighutilizationefficiencyofthegridassets,whichcanbalancetheinterestsof thepowerindustryandthepublic.Thiskindofrenewableenergygenerationmethod,thepowertransmissionlossis quitesmall,thepowergenerationratioisquitehigh,andthepowerworkisenvironmentallyfriendly.

II. CURRENT STATUS AND TRENDS OF POWER QUALITY ANALYSIS IN POWER GRIDS

Status of Domestic Power Quality Analysis

Beforethelarge-scaletransformationofthepowersysteminChina,thegridsofurbanpowergridsandruralpower gridswereveryweak,andthelevelofautomationwasalsoverylow,whichgreatlyaffectedthereliabilityofpower supplyofpowersystems.Untilthelate1990s,afterthestatereformedthegrid,thissituationwasalleviated,butsome indicatorsstillcouldnotmeetthenationalstandards.Inparticular,thehighest380/220Vvoltagelevelofthesupplyis the highest, and this problem has also attracted the attention of the power sector. The state has successively promulgatedtechnicalstandardsrelatedtopowerquality,whichareimplementedandguaranteedbythepowersecto r [10].

Intheaspectofpowerqualityanalysis,itiscommontouseadedicateddevicetocollectgriddataandthenanalyze it, which involves the development of analytical equipment. In this respect, our country is in a backward position. Untilthelarge-scalepowergridtransformationinChinainthe1990s,thepowerqualityanalysisdeviceindependently developedinChinaappeared,butitwasabitstretchedintermsofdetectionperformance.However,withtheprogress ofthetimes,manyengineeringresearchcentershavebeenestablishedinChinasincethebeginningofthenewcentury . They have played an active role in this industry, greatly improving the speed and manufacturing level of related equipment in China[1].

At present, domestic power quality monitoring is in the stage of special measurement and regular or irregular monitoring. The real-time monitoring of power quality is still in the pilot stage. With the rapid development of computer communication technology, network technology and database technology, the power quality monitoring system is developing towards online monitoring, real-time analysis, networking and intelligence. The continuous improvement of power quality monitoring system is conducive to the economic operation of power grid and the development of power information technology [4].

Status of Foreign Power Quality Analysis

Theadvantageofforeignpowerqualitytestingproductsisthattheyhavecomprehensiveindicators,highspeed andhighprecision.IntermsofhandhelddevicesintheUnitedStatesisthemost superior,anditsproductsarealsoverypopularinChina.Thecompany'sanalyticalinstrumentsareabletocontinuous ly monitor the grid signal. In addition to the accurate detection of conventional parameters, the detection of transient indicators can also achieve good accuracy. In addition, this type of analysis device is also designed with a communicationfunction,whichcantransmitthedataobtainedinthefieldtothemonitoringcenterremotely,sothat thestafftherecandeeplyanalyzeandmanagethedata.Althoughforeignequipmentforelectricalenergyanalysisis excellent,theyareexpensiveandnotsuitableforlarge-scaleprocurementofdistributedmonitoring.

Power Quality Analysis Future Development Trend

In the context of the country's vigorous implementation of "Internet +" and "Big Data", the power system as a state-owned large-scale enterprise is also necessary to comply with the requirements of the times. Therefore, the developmentofthepowersystemshouldalsointroducetheconceptofthenetwork,andaggregatethepowerquality

inspectiondataofeachplacethroughthenetworkforbigdataanalysis,sothattheproblemsofvariousplacesinthe power grid and the internal connection between them can be seen from a macro perspective. In this way, when the powergridistransformedandoptimized,itcanstandatanewheightandmakeaccurateandfar-sighteddecisions.

Afterintroducingtheideaofthenetworktomanagethepowerqualityindicators,weshouldalsomakefulluseofthe existing technology and introduce the automation concept. In the past, no matter what went wrong with the power system,technicianshadtodealwithitinthefirsttime,whichwasnotonlytime-consumingandlabor-intensive,but

alsoveryinefficient[9].Ifanautomaticdeviceisused,thepowerqualityofeachkeynodeisautomaticallydetected. Whentheproblemoccurs,itisautomaticallyprocessedaccordingtothepresetprogram,whichcansavealotoflabor costs.

Finally,itshouldbeconsideredthattheeconomyisnowglobalizing.Ifeachcountryimplementsitsownpower quality standards, this will inevitably hinder the exchange and learning of power quality detection technologies.

Therefore,inthiseraofglobalvillages,globalpowerqualitystandardsshouldbeunified,anddetectiontechnologies in this field should be unified to lay the foundation for technical exchanges between countries [2]. Therefore, in summary,thefuturedevelopmenttrendofpowerqualityanalysisisdatanetworking,deviceintelligence,andstanda rd globalization.

III. POWER QUALITY PROBLEMS AND TREATMENT METHODS FOR NEW ENERGY POWER GENERATION

Power quality refers to the quality of electrical energy in a power system. The waveform of the most perfectelectricalenergyistheidealsymmetricsinusoidalwaveform.However,duetotheinterferenceofotherfactor s,thewaveformwilldeviate,whichbringspowerqualityproblems.Intheconstructionofsmartgrid,therecannolong er

betheconceptof“firstpollution,thengovernance”.Wemustfullyconsiderthequalityofelectricenergy.Atthesame time,weshouldensurethequalityofpowerconservationasanimportantpartofsmartgridconstruction.

Harmonic Problems

Atpresent,inChina'spowersystem,voltagesag,temporaryriseandshort-terminterruption,thedistortionofthe voltagewaveformgeneratedbyharmonicshavebecomethemostimportantissueaffectingpowerquality.

Generation of Harmonics

Intheprocessofgeneratingelectricitywithnewenergy,themostcriticalreasonsfortheoccurrenceofharmonics are:thelinereactanceandtheharmoniccurrentgeneratedbytheshuntcompensationcapacitorofthegeneratorand thegenerator'sownfacilities.Theharmoniccurrentgreatlydeterminesthequality oftheelectricenergy.Goodorbad ,itseriouslycanleadtoelectricalaccidents.Harmonicsarechangedwiththepowerenvironment,notfixed.Moreove r,thedistributionnetworksystemisquitecomplicated,anditisveryeasytoamplifytheharmoniccurrenttoresonate, which will cause great damage to the powersystem.

Harm and Impact of Harmonic Pollution

The hazards and effects of power harmonics are mainly manifested in four aspects:

(1) It affects the normal operation of the power supply system. The transformer and power lines of the powersupplysystemgenerallyadoptrelayprotectionmeasures,whichcanprovideguaranteeforthesafetyofth esystemandtheequipmentitselfwhenthefaultoccurs.Iftheharmoniccontentexceeds40%,theelectromagneti cappliance and theinductiverelaywillmalfunction.Notonlythat,therectificationsamplingcircuitusedinthetr ansistorrelayisalsoaffectedbyharmonics,andthereisrejectionormalfunction.Thus,itgreatlyaffectsthesafet yandreliabilityof the power supplysystem.

(2) Increasetheadditionallossofthepowersupplysystem.Harmoniccurrentsoftenincreasethelossoftheentire systemasitflowsthroughthesupplyline.Inathree-phasesystem,theoddharmoniccurrentsonthethreephaselines aredirectlyaddedontheneutralline,eventuallymakingthecurrentthroughtheneutrallinegreaterthanthecurre nt through the phase line. When the cross section of the neutral line is too small, it is very prone to a sharp rise in temperatureanddamagetoitsinsulation.Inseverecases,asafetyaccidentmayoccur.

(3) Affect the smooth operation of power supply equipment and electrical equipment. If the harmonics are too large, it is likely to cause the offset of the rated operating point, which will eventually affect the application of the device and sometimes it will bedamaged.
(4) Reduce the accuracy of power measurement and energy metering. Distorted waveforms tend to increase measurementerrors,andsurveydatashowthattheerrorisusuallyhigherthan50%[2].

Harmonic Suppression Strategy
Themostcriticalcauseofharmonicgenerationisthenonlinearityoftheload.Whenthecurrentpassesthrough theload,itisnotlinearwiththevoltageontheload,sothatanon-sinusoidalcurrentisgenerated,soharmonicsare alsogenerated.Theharmofharmonicpollutiontothepowersystemisveryserious.Whenusingalargepowerunit ofapowerelectronicconverterinafactory,itisnecessarytomakeacorrespondingsystemharmoniccurrentcontrol arrangement.Thecurrentaddedbytheharmonicsmustcomplywiththeregulationsoftheharmonicsofthepublic powergrid.Whentheharmoniccurrentisaddedtothedistributionnetworkatthefactory,theharmonicsourcepower generationandtheinstalledcapacityofthepowerplantshouldbetakenasreferenceforthepowersupplycommon connectionpoint,andthetotalcapacityratiooofthepowersupplyfacilityshouldbeconsidered,andthentheharmonic currentshouldbeperformed.Distribution,onlybydoingthis,canbettersuppresstheharmonicproblemsgenerated by power generation. In addition, when generating electricity with new energy, try not to use a single generator, because it will cause some harmonic voltages to become higher, which will damage the system. Therefore, using various types of generators to cooperate with each other, control harmonic currents, and ensure that the operation process of new energy power generation is more secure andreliable.

Flicker Problem
Atpresent,inChina'spowersystem,voltagesag,temporaryriseandshort-terminterruption,thedistortionofthe voltagewaveformgeneratedbyharmonicshavebecomethemostimportantissueaffectingpowerquality.

Generation of Flicker
Nowadays,manyofthewindpowergenerationequipmentweknowinChinausesoft-connectedgeneratorsets, whichgeneratealotofinrushcurrentduringoperation,thuscausingflickerproblems.Whenthetruewindspeedis greaterthanthemaximumdefinedwindspeed,thegeneratorwillstartitself.Whenallthewindturbinesarerunning together,itwillhavealargeimpactonthedistributionnetwork,causingthegridtohaveflickerproblems.

Measures to Solve the Flicker Problem
When wind power is generated, the biggest damage to the power grid is the flicker problem. The flicker interferencevalueoftheconnectionpointtothewindpowerplantmustcomplywiththeregulationsofpowerquality, voltageregulationandflicker,andthewindpowerplantmusthavealongandshorttimeflickervaluegenerateddurin g thepowergenerationprocess.Itisnecessarytorefertothecapacityoftheharmonicsourceforpowersupplyandthe installed capacity of the power plant, and consider the total capacity ratio of the power supply facility, and then
distributetheharmoniccurrent.Onlybydoingthiscanitbebettersuppressed.Theflickerproblemcausedbypower generation.

IV. NEW SITUATION OF POWER QUALITY IN THE ERA OF SMART GRID

The Impact of the Development of Distributed Energy on Power Quality
Thesmartgridisarevolutioninthecombinationoftheitindustryandtheenergyindustry.Itsessenceisenergy substitutionandcompatibleuse.DistributedEnergy(DG)isanaturalpartnerofsmartgrid.Itnotonlyguaranteesthe securityoflargepowergrids,butalsohasapowerfulpeakshavingfunctionespeciallyinChina'snationalconditions [5].Thedevelopmentofdistributedenergyhascausedabigchangeinthenetworktopology.Fromaradiantnetwork toanetworkthatisinterconnectedbyenergyandusers,thecontrolandmanagementofthepowerdistributionsystem

hasbecomemorecomplicated.Atthesametime,italsocausestheuncertaintyofthepowerdistributionnetworkto increase,whichwillcausedifficultyinfilmcontrolofthedistributionnetwork,causingvoltageflicker.

Influence of the Use of Wind Turbines on Power Quality

As a clean energy source, wind power is the most utilized and most promising DG in various applications ofdistributedpowergeneration.China'swindpowerdevelopmenthasbeenparticularlyrapid.Since2003,China'sw indpowerhasenteredthestageofscaleandlocalization.However,afterthelargecapacitywindpowerisconnectedto thegrid,itwillbringaseriesofadverseeffectstothepowerqualityofthegrid.Thefluctuatingwindspeedmakesthe output power of the wind farm intermittent, which affects the frequency of the system to a certain extent, andmayalsocausethewindturbineoutputtofluctuate,causingthevoltagedeviationtoexceedtheallowablerangean dflicker.

V. CONCLUSION

Powerqualitydetectionandanalysisresearchisoneoftheimportantcontentsofbuildingastrongsmartgridin China.Atthesametime,reasonableandaccuratecomprehensiveevaluationofpowerqualityisanimportantpartof powerqualitymonitoringandanalysis.Thispaperanalyzesandcommentsonthestatusquoofpowerqualityresearc h in the smart grid era, the main problems and solutions of power quality, the impact of distributed energy and

windturbinedevelopmentonpowerquality,etc.Thestudylaidthefoundationfortheintegrationofnewenergyintoth e grid.

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