Impact of Smart Grid Components on Distribution System Reliability: A Review

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Abstract: The Smart Grid, regarded as the next generation power grid, uses two way flows of electricity and information to create a widely distributed automated energy delivery network. In this article, survey of the literature regarding effect of smart grid component on distribution system reliability is done. Review of the challenges and barriers to improve the reliability of the distribution system has also been under taken. This paper is divided into different the potential areas that altogether improve the reliability of distribution system. Mainly these areas are communication infrastructure, protection system, advance metering infrastructure, dispersed generation (DGs), and hybrid vehicles. Also, different techniques used to calculate reliability indices are also reviewed. These techniques are Monte Carlo Simulation, Markov Process, Fault Tree Analysis, Genetic Algorithms, SWARM Programming, Routing Algorithm, Numerical Analysis, Qualitative and Quantitative analysis.
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1. Introduction

1.1 Smart Grid

The term smart grid has been in use since 2005, when it appeared in the article "Toward A Smart Grid" by Amin and Wallenberg [1]. The term had been used previously and may date as far back as 1998. Today's electric grid was designed to operate as a vertical structure consisting of generation, transmission, and distribution and supported with controls and devices to maintain reliability, stability and efficiency. However, system operators are now facing new challenges including the penetration of renewable energy resources (RER) in the legacy system, rapid technological change, and different types of market players and end users. The next iteration, the smart grid, will be equipped with communication support schemes and real time measurement techniques to enhance resiliency and forecasting as well as to protect against internal and external threats. The design framework of the smart grid is based upon unbundling and restructuring the power sector and optimizing its assets. The new grid will be capable of;

- Handling uncertainties in schedules and power transfers across regions,
- Accommodating renewable energy resources (RER),
- Optimizing the transfer capability of the transmission and distribution networks and meeting the demand for increased quality and reliable supply,
- Managing and resolving unpredictable events and uncertainties [2].

1.2. History of Reliability

1947, Survey on distribution failure causes and failure rates was been started. Early 1970s Utilities begin to compute indices from paper outage tickets. Late 1970s, some large utilities develop custom outage management systems (OMS). In mid 1980s, regulators start to take an increased interest in distribution reliability. In 1988, first commercial OMS begin to develop. In 1989, IEEE defines commonly used reliability indices. In1998, IEEE P1366 was published including reliability index benchmark data. In 2001, Reliability indices become an IEEE standard. Today, most utilities have robust systems and processes related to reliability data collection and reporting. This typically includes a PC based OMS that is interfaced with the customer call center, customer information system, SCADA system, and geographic information system. Reliability indices are computed from data provided from the OMS system, and this data is generally complete and auditable.

2. Reliability and Smart Grid: Coordination

2.1 Communication Infrastructure

Jaebeom Kim *et al* propose the design and architecture of Hybrid wireless mesh protocol called the HWMP-RE (Reliability enhancement) for IEEE 802.11s. The main contribution of the HWMP-RE is that it resolves the problems of the original HWMP in smart grid net work systems by using different methods. Author uses ns-3 simulation criteria to validate the result [3]. Hushing Li *et al* apply wireless communication to Special protection scheme (SPS).

As the reliability requirement of SPS is high so it is necessary to have highly reliable communication infrastructure. Authors also discusses different factor that effect wireless communication which in turn affect reliability [4]. Dusit Niyato *et al* explain how the reliability of modern grid effected by the communication infrastructure, how communication infrastructure effect the power consumption problem. Deferrable load scheduling method and constrained Markov decision process for power consumption optimization have been discussed [5]. Fei Tang *et al* proposed a method to calculate the reliability from both micro and macro point of view in term of failure rate. Reliability calculation of optical devices in different temperature conditions has been calculated. Author also uses concept of Ethernet passive optical network **(**EPON**)** architecture to improve the reliability [6]. Dusit Niyato *et al* uses the reliability analyses to check the availability of communication network. Authors present redundancy design technique to minimize failure and wireless communication implementation cost in smart grid [7]. Sedat Gormus *et al* proposed an opportunistic communication mechanism called Opportunistic Routing Protocol for Low Power and Lossy Network (OPRL) to improve the reliability of data transport in advance metering infrastructure (AMI) mesh networks. The performance of ORPL through mathematical analysis, implemented it as part of Contiki operating system and its behavior through experiments based on emulation has been performed. In an emulation based experiment, the system under test (SUT) is represented by a combination of one or more substitute systems) [8]. Yichi Zhang *et al* proposed new communication network architecture, the Smart Grid Communication Network (SGCN). This architecture provides a multi level, robust and reliable communication network using a wireless mesh network with high capacity wireless standards. It also supports optimal communication routing by using the primal dual algorithm for smart grid communication [9]. Hushing Li *et al* described secure state estimation and control in smart grid to ensure system reliability [10]. Ji Sun Jung *et al* introduces the possibility of utilizing standard based mesh networks in the smart grid and provides methods to improve the performance of the smart grid network. Author also explains some demanding issues of the IEEE 802.11s WLAN mesh based smart grid networks. According to author proposed scheme does not able to give optimal reliability .Improving the reliability by use of routing algorithm is future work [11]. C. Wietfeld *et al* presents a general technical overview considering demand oriented communication networks in terms of future Smart Grid applications. In this paper author proposed network planning algorithm for neighborhood area network. Author also describe about wireless web service for reliable date transfer. Author uses state of the art technique to represent result [12]. Ruirui Zhang *et al* describe the systematical reliability and security assessment process for the electric power communication network. Author proposed a three-level assessment hierarchical architecture. From bottom to up the three levels are Device Level, Network Level, and Service Level respectively. In the end, an application system design has been presented [13]. Zhao Feng *et al* proposed the communications network architecture which depends on broadband wireless mobile communication technology solution for emergency communication based on LTE technology is designed. The link level simulation is made for the solution. Author also discussed the new feature of communication like 3G, 4G and its impact on reliability [14]. Wei Sun *et al* enhanced the Quality of service (QOS) support of the low cost wireless protocol IEEE802.15.4 at the MAC layer to support reliable networking and communication of the power distribution systems .In this paper, author uses morkov process to model MAC behavior [15]. Vehbi C Gungor *et al* describe a statistical characterization of the wireless channel in different electric power system environments has been presented. Author performed the test on IEEE 802.15.4-compliant sensor nodes (using CC2420 radio chips).The empirical measurements in the field have demonstrated that average link quality indication (LQI) values provided by WSN radio components are closely correlated with PRR and can be used as a reliable metric for wireless link quality assessment during the operation of WSNs [16]. Jean Charles Tournier *et al* work on different prediction scheme method to estimate the clock drift in the case of the loss of the GPS signal in a electric substation. Author implemented this technique to handle the reliability loss issue in IEEE 1588 protocol [17]. Mohamad A. Azram *et al* proposed a microscopic reliability assessment method. This method is quantitative in nature. These method models various fault which occur on grid. More over author describe the communication infrastructure. How it will impact the reliability and protection scheme [18]. Xing Ning zhe *et al* analyzes the factors which affects the reliability in power telecommunication system, proposes some methods from the aspects of reliability and network layers. The reliability index system, evaluation method and reliability management of power telecommunication network are also discussed in the paper [19].

2.1.1. Wide Area Monitoring System (WAMS) and Cyber Network

Yang Wang *et al* proposed FTA technique to break the Wide Area Monitoring System (WAMS) in to hieratically structure. In this paper author applied the Markov modeling and state enumeration for reliability assessment. Author analyses IEEE 14 Bus system [20]. Mark G Lauby *et al* describe the smart transmission and smart distribution. Author also describes their implementation strategy and consideration .In this paper effect of smarter technology on the reliability is also discussed [21]. Farrokh Aminifar *et al* describe the effect of WAMS malfunction on the power system reliability assessment. In this paper author used Monte Carlo reduction technique for computation. Tests are performed on IEEE 57 bus system [22]. Bamdad Falahati *et al* describe the smart grid and see the effect of cyber failure on the power system. In this paper evolutionary algo is proposed. The proposed algorithm can be applied for developing an optimization problem for the design of cyber network to achieve the higher level of reliability for the power network. The proposed approaches can be used to co simulate a cyber power [23]. Chanan Singh *et al* analyze the cyber system and challenges and complexity in this system. Author describes the reliability aspect of cyber physical system. This paper has classified this analysis into three categories: local, degrading and catastrophic type failures [24]. F. Ayman *et al* describe the use of fault injection in identifying failure scenarios for the Smart Grid. Software faults are injected to represent failures in the cyber infrastructure. Physical failures are concurrently represented, creating integrated cyber physical failure scenarios that differentiate this work from related studies. The effect of these failure scenarios on reliability of system is studied in two cases: with and without fault detection in the distributed software [25].

2.2. Hybrid Vehicles

Casey Quinn *et al* proposed models of Vehicle to Grid (V2G) availability, reliability and compensation that are novel in that they incorporate travel survey data, utility reliability survey data, and time series ancillary services pricing. The results of these analyses show that a V2G architecture that aggregates vehicles can improve compatibility of V2G with the current ancillary services system by improving the reliability of V2G ancillary services and meeting the minimum contractible power requirements [26]. Sara Deilami *et al* purposed real time smart load management (RT-SLM) algorithm to improve smart grid performance with high penetration of PEVs (Plug In Electrical Vehicles). In this paper author uses modified IEEE 23KV distribution system to reveal the performance of SLM [27]. Wencong Su *et al* discussed PHEV/PEV charging algorithms. In this paper author proposed two charging scenario to allocate power. Author performs many simulations to reveal the reliability improvement for these scenarios [28]. Casey Quinn *et al* discussed that integration Vehicle to Grid (V2G) impact the reliability of system more over it has negative impact on the economy for both the grid operator and vehicle owner. Author uses Monte Carol method to generating results [29]. Murat Yilmaz *et al* describe the impact of vehicle to grid technology on system performance. The V2G concept can improve the performance of the grid in areas such as efficiency, stability, reliability, and generation dispatch. V2G provide support to reactive power, reduce harmonics in the current, and they also offer possible backup for renewable power sources such as wind and solar power, supporting efficient integration of intermittent power production [30].

2.3. Protection

At present, Kai Jiang *et al* proposed conceptual all digital special protection scheme architecture for modern grid. In this paper author performed test by using network reduction and Markov modeling. The reliability of SPS is closely related to the reliability of its components. If components tend to be less reliable, the SPS reliability will be degraded. However, increasing component repair rates will be helpful to enhance the reliability of SPS [31]. Shahram Kazemi *et al* describe the effect of fault diagnosis scheme on distribution system reliability. In this paper author compare the results of two types FDS and show their effect on reliability of distribution system [32]. Hushing Li *et al* apply wireless communication to Special protection scheme (SPS). As the reliability requirement of SPS is high so it is necessary to have highly reliable communication infrastructure. In this paper author also discussed the different factor that effect wireless communication which in turn affect reliability [33]. A.R. Motavalian *et al* describe a new wide area backup protection system (WABPS). Author describes about phasor measurement units (PMU) and integration of PMU with WABPS. Author performs the test on IEEE 9 bus system. Simulations are performed using Matlab Simulink. Simulation result shows integration of WABPS with PMU increase the system reliability by avoiding mal operation [34]. Yu Jun *et al* proposed a new method based on entropy for the reliability analysis on the black start decision making results ,and an index for quantifying the reliability level of black start decision making and measuring the decision making level of the experts concerned is presented. Based on the results of the reliability analysis, the decision makers could reappraise their black start strategies. As a result, the integrated reliability level could then be improved and the black start decision making results optimized [35].

2.4 Advanced Metering Infrastructure (AMI)

Catherine Gamroth *et al* developed a new model to evaluate the Power Reliability Index (PRI) for enterprise level power grid from a practical perspective. This approach utilizes the power quality data recorded with smart meters in the power grid network. Since the new PRI approach looks at the quality of power over all operating conditions, it provides a better view on the current network reliability condition, and it supports more accurate prediction on power failures. This is largely different from the traditional PRI, which uses theoretical metrics such as MTBF (Mean Time between Failures).Author uses Monte Carlo simulation with expectation minimization to assess the reliability of network [36]. Ye yan *et al* investigates cyber security problems of deploying AMI in smart grid. Author proposes a secure and reliable in network collaborative communication scheme for AMI in smart grid. Proposed approach employs mutual authentications with a remote authentication server located in local management and a neighboring smart meter as the authenticator to get the proper cryptography keys for consequent secure data communications. Results have been validated through simulation [37]. Di Wang *et al* proposed a Routing Protocol for Low Power and Lossy Networks (RPL) based routing protocol design for AMI networks in smart grid. Author presented a detailed implementation of RPL with a number of modifications specifically adapted for the AMI. In particular, Author adopted the Expected Transmission Time (ETX) as the link metric and proposed a low cost ETX measurement scheme. Author proposed a novel, ETX-based rank computation method serving as the foundation of the Direct Acyclic Graph (DAG) construction and maintenance mechanisms, which provide high end-to-end reliability for the inward uni-cast traffic in AMI networks [38]. Asif Mahmood *et al* studied about AMR smart grid design and implementation. According to author Automatic meter reading smart grid system provides the features of efficient and smart system with multiple controlling and monitoring features. Wireless communication links makes system quick installation and to synchronize system with new generation. Only single Metering Management System can generate an 'All in one report' detailing correct Generation, transmission and distribution data and subsequent loss of energy at all level and works faster and reliable without recurring integration problems [39]. R. W. Uluski discussed the impact of AMI and distribution management system (DMS) on reliability improvement. The implementation of an AMI system and a DMS are key steps towards the success of this utility's future "smart grid" vision. Combination of AMI and DMS increase the maneuver benefits [40].

2.5 Dispersed Generation

V.Calderaro, *et.al* describe about optimization switching planning problem. The problem has been formulated as a multi objective mixed non integer programming and the solution algorithm has been based on a Genetic Algorithm (GA). Author performed the test on 13 bus IEEE system [41]. Armando M Leite Da Silve *et al* describe the integration of DGs to distribution system. In this paper author proposed new method of minimal cut set and chronological Monte Carlo simulation to access the reliability. In this paper author also describe the load transfer restriction in Distribution energy resource environment [42]. Chen Bo *et al* proposed three requirements to connect the micro and external grid. Author performed the simulation on EMTDC/PSCAD. In this paper author also describe the some action taken to control the frequency, voltage and phase angle of micro grid [43]. A Bracale *et al* proposed hybrid AC/DC smart grid to improve the reliability of system. In this paper it is also describe that presence of DC grid permits direct supply to DC, which avoided the waveform distortion .Due to DC grid there is continuity of supply which increase the reliability of system [44]. Shouxiang Wang *et al* proposed new matrices for reliability assessment of micro grid. Author uses Monte Carlo simulation to simulate new matrices. Tests are performed on IEEE RBTS bus [45]. K. Shenai *et al* proposed DC micro-grid architecture for effective utilization of renewable energy. This proposed architecture is hybrid in nature and is easily scalable to other power levels. Further smart wireless sensors and controls can be incorporated within the proposed DC power system in order to further enhance energy efficiency and improve reliability. This approach is also needed to render the proposed DC power system suitable for high-penetration scenarios [46]. Miao He *et al* discussed the timescale dispatch and scheduling to handle volatile wind generation into the bulk power grid, Author uses Markov method to simulate the results [47]. Zhenjie Li *et al* describe how to improve the reliability of islanded micro grid, which is operating in an emergency mode. The method for assessment is developed based on fault tree analysis. The important features of the method are that the reliability of system can be evaluated in a specific time and system deficiencies can be readily identified, both quantitatively and qualitatively, thereby attention on those sections of micro grid that contribute most to unreliability of power delivery to specific load [48]. Francois Besnard *et al* presented the Reliability Centered Asset Maintenance (RCAM) approach for maintenance optimization for wind power plants, including the need, challenges, and required models for its implementation. The RCAM approach is a structured method originally developed for a combined analysis of reliability, maintenance, and life cycle cost of power systems that can be applied to improve the reliability, availability, and profitability of wind power plants [49]. Werner Friedl *et al* describe the coordinated neutral point treatment to improve the reliability. More over author discussed the high short circuit power and low zero sequence impedance. In the paper reliability of island and micro grid is also discussed [50]. Mark A.Delucchi *et al* evaluating the feasibility of providing all energy for all purposes (electric power, transportation, and heating/cooling), everywhere in the world, from wind, water, and the sun (WWS). Author discuss methods of addressing the variability of WWS energy to ensure that power supply reliably matches demand the economics of WWS generation and transmission, the economics of WWS use in transportation, and policy measures needed to enhance the viability of a WWS system [51]. Lei Zhen *et al* describe the effect of DGs in distribution network. Due to verities of power sources and complexity of operation the reliability of distribution network would be affected. In this paper proposed a calculation model of reliability which is based on different type of failures. Then author applies Monte Carlo simulation to solve this model [52].

2.6 Hardware

Khosrow Moslehi *et al* describe how renewable, demand response and storage affect the reliability of system. In this paper author proposed IT architecture to fulfill the challenges imposed by RER, demand response and storage [53]. Anjan Bose discusses the technique and model for reliability assessment of smart technology. In this paper author describe the distributed data base and real time information infrastructure. Author also discussed substation information architecture [54]. V Calderaro *et al* describe about optimization switching planning problem. The problem has been formulated as a multi objective mixed non integer programming and the solution algorithm has been based on a GA .Author performed the test on 13 bus IEEE system [55]. Hong Yun Liu *et al* describe the cloud theory for qualitative and quantitative conversion. In this paper also describe the reliability improvement methods. It has provided a new way for the research of smart grid reliability [56]. Liu Xiaosheng *et al* propose a new Electric Power Network which is based on the artificial spider web structure. In this paper author compare the proposed structure with the star structure of network. Result analyses show that proposed structure have high reliability [57]. Christian k Hansen *et al* discussed electricity load and demand variations from a time series modeling perspective. Within this framework, historical performance is used to predict future Performance. However, in managing the overall health of the power grid, there is more to it than simply forecasting future demand and deploying energy sources that meet this demand. In this paper statistical forecasting is also discussed. Author describes the reliability impact of fore casting on system [58]. Mark G Lauby *et al* describe the smart distribution and smart transmission. Author discussed the reliability consideration for these smart technologies. More over author also discussed the implementation strategy and consideration for these smart technologies [59]. Rick Kazman *et al* describe two goals, a narrow one and a broad one. The narrow goal was to analyze potential system architectures for residential DR. In doing so we revealed the landscape of architectural decisions that may be considered. Author further showed how this early analysis can discover latent risks in the architectural decisions made that may affect the key quality attributes of such systems: performance, usability, reliability, and resolvability [60]. Raffael La Fauci *et al* describe the concept of the reserve grid .Various possible topologies on the medium and low voltage level has been analyzed considering technical and economic aspects. A reserve grid decreases the outage probability considerably because of the reduced outage duration. The highest reliability is obtained applying a ring shaped topology [61]. Shahram Javadi *et al* this discussed some important point which is necessary for reliable operation of modern power system. Each of these options gives optimal solution [62]. Vijay Venu Vadlamudi *et al* identify some preliminary concerns in reliability prediction/estimation in the Smart Grid environment, and initiate a discussion on the potential challenges that can be anticipated in quantifying the reliability benefits. An architectural composition of SGs with respect to the reliability contribution of various technological constituents has been put forward. A broader outline for a hierarchical level based platform for SG adequacy studies has been proposed [63]. Pieter Venemans *et al* purposed a method for quantitative reliability evaluation of smart grid technologies. In this paper author discussed combine behavior of control, distribution grid and communication infrastructure. Author also purposed fault tree analysis and partial state estimation for reliability improvement [64]. Jia Dongle *et al* discussed self healing feature of smart grid. Author discussed how self healing improve the reliability of smart grid supply and also reduce the outage time [65]. G Alonzo Vera *et al* discussed the terrestrial radiation effect on smart grid reliability. Author also discussed several mitigation approaches as well [66]. Irinel Sorin Llie *et al* discussed the implementation of DMS to LV network. Author show how DMS implementation improve the reliability indices. This is an analogue to LV network reliability [67]. Lalitha Sankar *et al* discussed the conflicting objective of estimation accuracy and competitive privacy. In this paper author discussed the privacy of Regional Transmission Organization and their short coming in sharing data. Author also discussed two RTO model In this Paper [68]. M. Karimzadeh *et al* paper presented an improved method for reliability analysis of different zones of the distribution network, considering class of costumers and load conditions of the system. In the first stage, reliability zones of the distribution network are defined regarding the place of breakers and disconnect switches and after improving the former methods of the reliability zones segmentations, the reliability assessment of the distribution of interest performs with the emphasis on expected interruption duration index, SAIDI, and for each hour of the day. The main basis for evaluation of these indices is the daily load profile. Therefore, influence of week day, outdoor temperature, season weather and etc. are considered implicitly [69]. A. P. Meliopoulos *et al* describe comprehensive approach for smart grid implementation. The proposed scheme achieves the goals of the smart grid with minimal or no inconvenience to the customer. Implementation of the proposed scheme will require the development of low cost meters that will have the capabilities described in the Universal GPS Synchronized Meter (UGPSSM). Author also discussed reliability enhancement [70]. Amir Hamed Mohsenian Rad *et al* proposed the algorithms that involve huge data centers in order to understand the integration of Cloud computing and Smart Grid. Author focused on one design possibility that can improve load balancing in the grid by carefully distributing the service requests among data centers in a clouding computing system. Simulation is carried on IEEE 24-Bus system. Result of the simulation show that proposed design improves the load balancing and reliability in Smart Grid [71]. Aggelos S. Bouhours *et al* describe selective automation of system to improve the reliability of smart grid. In this paper author describe loss reduction technique through [72]. Shmuel S Oren *et al* describe the concept of priority service. Author also describe about the cost recovery and penalty for poor performances. This article also describe about forecast of price [73]. J. W. Palmour *et al* describe SIC devices. These devices affect the power grid in many ways, such as Reliability and power density improvement, Response time of system and overload capacity [74]. Farrokh Rahimi *et al* studied about demand response in smart grid context. According to author, the smart grid model cuts across several disciplines and impacts different business units in the utility environment. DR is an important ingredient of smart grid, promoting both market efficiency and operational reliability. If implemented correctly, it helps curb supply market power vis-a-vis supply scarcity conditions, and improve operational reliability vis-a-vis profusion of variable generation [75]. Richard E Schuler *et al* describe the concept of smartening up a grid. In this article detail study on smart meter is presented. In this article author describe environmental concern and sustainability beside reliability [76]. Kory W. Hedman *et al* present a co optimization formulation of the generation unit commitment and transmission switching problem while ensuring N-1 reliability. Author performed the test on IEEE 73 bus system. Author performs the simulation on CPLEX software [77]. Peter Kadar *et al* present a model that the present smart approach that putting as many intelligent smart gauges as possible brings advantages compared to the replacement of the old network. The remote controlled line breakers and the self healing auto reconfiguration are also the cheap possibility of the reliability raising. The existing voltage level shouldn't be changed. Low level network duplication a new DC bus beside the existing AC system raises the reliability [78]. Yi Yang *et al* proposed a new method to monitoring the electric power grid. The Power Line Sensor (PLS) module and network using commercially available low power devices, offer the potential to dramatically reduce the cost of power grid monitoring. The PLSN would help utilities improve situational awareness, enhance the system reliability and utilization, and defer construction of new transmission lines. The high reliability, low cost and long life of these devices make them more attractive. Experimental results demonstrate the potential impact of these devices in terms of better grid utilization and improvement in system reliability [79]. James A. Momoh *et al* describe the Dynamic Stochastic Optimal Power Flow (DSOPF) .Author purposed to mature testing ground for DSOPF .More over in this article author describe the facts devices and their coordination. Finally author discussed their effect on reliability of system [80]. D. Divan *et al* developed new to look on the smart grid improvement. In this paper author make comparison between conventional approached and new approach. In proposed new approached current limiting conductor is used due to this reliability of system increases [81]. Ye Yuang *et al* purposed distributed grid scheduling to handle the resource allocation problem. Author uses SWARM optimization algorithm for monitoring of recourses. Author also describes standard protocol. Proposed method increases the reliability of system [82]. Jean Charles Tournier *et al* work on different prediction scheme method to estimate the clock drift in the case of the loss of the GPS signal in a electric substation. Author implemented this technique to handle the reliability loss issue in IEEE 1588 protocol [83]. R. W. Uluski discussed the impact of AMI and DMS on reliability improvement. The implementation of an AMI system and a DMS are key steps towards the triumph of this utility's future "smart grid" vision. Combination of AMI and DMS increase the maneuver benefits [84]. Deepak Divan *et al* propose the controllable network transformer. More over author describe the Ac converters. In the design of Ac convertor author uses IGBTs .This could be used to increase the reliability [85]. Yuan Shun Dai *et al* first introduced a grid service reliability model and evaluation algorithms, then presented an optimization model in order to maximize the grid service reliability after allocation, and developed a GA to effectively solve such an optimization problem as well. In the end, a numerical example was illustrated to show the modeling procedures and the effectiveness of GA [86]. M. Tanrioven *et al* describe the operating benefits from demand side load management are evaluated for a Proton Exchange Membrane (PEM) Fuel Cell Power Plant (FCPP). Author proposed a state space generation model for reliability modeling and evaluation of the PEM FCPP .The simulation are performed using the MATLAB software for a 5 kW stand-alone PEM fuel cell that supplies a typical residential house [87]. Peng Zhang *et al* proposed a new reliability oriented reconfiguration (ROR) method for improving distribution reliability and energy efficiency Based on interval analysis. The proposed method has ability to deal with uncertain parameters and to maximize the possibility of reliability improvement. Numerical results show that the proposed ROR method is an efficient tool for finding an optimal or near optimal configuration with enhanced distribution system performance. Developments of smart grid infrastructures will make the ROR a viable and cost effective means of reliability improvement [88]. S. Gudzius *et al* give concept of smart grid model for reliability evaluation .The smart electric power distribution grids are easier to manage; they are more reliable and more For the evaluation of the insulation reliability dependency from environmental factors and over voltages level it is necessary to determine the change of the insulation electrical strength and the distribution of over voltage values [89]. J.C.P. Kester *et al* proposed a smart MV/LV station .A prototype of this station will be built and tested. Simulation results show a considerable reduction of harmonic voltages and resonances, as well as peak load reduction of 30%.Rseult also show considerable system reliability improvement [90]. M. Farman *et al* presents a practical issue of blackout & brownouts which normally occurs in T&D lines under chemically polluted environment and adversely effects power quality of line. Chemical factors which regulate the magnitude of leakage current (flashover voltage) and methods of measurement of degree of contamination are discussed. Chemical analysis of various salts (soluble as well as insoluble) and ions on the flashover voltage under dry and wet condition is done to see the effectiveness of salts & ions on performance of line. In this paper a new technique for improving grid reliability and maintenance work for T&D lines is proposed. Effect of pH on the surface conductivity is also analyzed [91].

3. Conclusion

In this paper, the different aspects of system reliability in the context of smart components are comprehensively discussed. The different techniques for assessment of system reliability are extensively reviewed. It revealed from the literature review that Communication infrastructure using routing algorithm and its integration with SPS (Special Protection Scheme) improve the reliability of system. Deployment of Cyber security system and Integration of DGs and renewable in Smart Grid also improve the system reliability. Advance metering infrastructure increase the reliability of system by providing real time information about the load and generation to the utility and customer. Hybrid vehicle using real time load management and charging algorithms improve the reliability and performance of system.

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