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# OVERVIEW ON RELIABILITY ASSESSMENT AND ASSETS MANAGEMENT IN POWER SYSTEM DISTRIBUTION WITH HIGH PENETRATION OF SOLAR ENERGY USING COMPUTATIONAL INTELLIGENCE

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**Abstract:** The Stable and regular supply of electricity is very germane to the economic development of any nation and insufficient generation has affected the regular, constant, reliable supply of electricity and other failures in the system. To reduce and eliminate these issues, reliability assessment and assets management of distribution systems with high penetration of solar energy is proposed using a Monte Carlo–based recurrent neural network. The background of reliability assessment and assets management in power system, review of some past works on reliability and assets management, research gaps, state of art of the research work, reliability worth, reliability of power system network, the procedure for Monte Carlo based recurrent neural network for reliability assessment and conclusion were presented. The network would be modeled with high penetration solar pv, distributed generators (DG) and heavy duty generators and the reliability assessment would be carried out using a recurrent neural network under different scenario with Monte Carlo. The recurrent neural network (RNN) is chosen because it can give a predictive result in sequential data, recurrent neural network will take care of excessive use of the memory by Monte Carlo because it has internal memory itself and it can also learn from any pattern and adapt to it and give result without any functioning equation. The bulkiness of using only probabilistic methods such as Monte Carlo and Markov etc. which required making many simplifying assumptions to reduce to a manageable size is solved by this proposed method and whale optimization algorithm would be carried out.
**Keywords:** Reliability, assessment, penetration, solar energy, and distribution network

## 1. THE GENERAL BACKGROUND OF RELIABILITY ASSESSMENT & ASSETS MANAGEMENT

Any nation that is encountering an inadequate power supply will not develop rapidly in its economy. The power sector in Nigeria has many challenges that have negatively affected the other sectors of the economy [40]. Currently, around 1.3 – 1.6 billion people globally are living are not connected to the electricity [17 and 36]. Due to the rapid development of the economy of the word electricity demand is very high and this will eventually lead to environmental problems and energy disasters [43].

Bulky power may be generated from hydroelectric, thermal and nuclear stations. These generating stations are located in distant places from the consumers. This had made it necessary for the transmission of energy [12].

Presently, power generation, transmission, and distribution are facing many challenges such as increase in the number of customers, sectoral reforms, the need for customers/demand satisfaction, advancing system reliability prerequisites, and some stringent regulatory rules and policies in which many reforms in the sector have not yielded any positive results.

Asset management within an electric power distribution utility" is making decisions about those assets to allow the business to maximize long term profits, while achieving maximum customer satisfaction, manageable risks and acceptable risks". Asset management aims to improve performance and reduce spending. In managing assets, we must put into consideration some issues like asset utilization, automation, maintenance planning, risk management, reliability and aging infrastructure. Asset management (AM) could be categorized into three major areas which are: Information processing, Engineering, and Management [34].

The electrical power supply should be satisfactory and reliable always, a situation in which the supply of power is just for two hours to four hours per day and in some places the supply is been


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

rationed, this problem may be caused by a failure at the part of the power facilities or insufficient power generation capacity and when this is happening always it is not good for the system, because power should be available 24 hours per day and we can say the system is not reliable and not satisfactory and reliability is the capability of a system to carry out a desired and essential function under state conditions at a stipulated period. The major aim of reliability assessment is to answer questions like "Which scheme will fail less?", "is the system reliable enough?" and "where can the next resources (Naira) be best spent to enhance system reliability" [38]?
Okorie et. al, 2015 [38], said the investigation of the purchasers' failure statistics showed that the distribution network is contributing highly to the unavailability of supply to the customers.
In this research, the network would be modeled with high penetration solar PV, distributed generators and the reliability assessment would be carried under different scenario with Monte Carlo. Optimization of distribution assets, solar PV resources and distributed generators would be carried out using whale optimization algorithm and the economic analysis of connecting under different scenario and would be carried out using whale algorithm. The temperature rise in cable /wire of the distribution network would be monitored using the algorithm that would be developed to prevent cable or wire burnt or melting and carbon emission to the surrounding would be evaluated with the algorithm and the strategies that will improve power reliability (outages prevention) would be recommended.
There have been many advancements in the past years that permit asset management (AM) systems to run more effectively by employing technical alternatives that would reduce the time to finish a task (initiation of action, report interpretation/generation time, and user wait time). For us to create some of these reductions, artificial intelligence would be incorporated with Matlab in achieving the objectives of this work. The adoption of artificial intelligence would how a decision–maker is making the final decision and develop an algorithm that a computer–based system could make useful decisions without the involvement of an "implicit knowledge" user. This allows seamless interfaces between decisions and assets like maintenance planning [9]. "Artificial intelligence is the simulation of human intelligence processes, especially computer systems". "Artificial Intelligence (AI) has the capability of taking big data, boiling it down and making sense out of it". The chief misperception issues are many diverse names that are used sometimes as substitutes for artificial Intelligence (AI) like as machine learning, deep learning, cognitive computing, etc. These are increasing every day, knowing that these words are not interchangeable, nevertheless, and they are always used like that (https://www.tdworld.com/grid–innovations/article).Incorporating artificial intelligence (AI) could help the vigorous management of electrical power networks by ensuring that the demand for electricity is equivalent to the supply of electricity. And while, "computational intelligence is described as the study of adaptive mechanisms to facilitate or enable intelligent behavior in uncertain, complex, and varying environments". The adaptive mechanisms include artificial intelligence paradigms that display the capacity to adapt to new situations or to learn, to generalize, discover, associate, and abstract. The several kinds of computational intelligence paradigms are Artificial Neural Networks (ANN), Artificial Immune System (AIS), Fuzzy System (FS), Evolutionary Computing (EC) and Swarm Intelligence (SI) [43].
Olajuyin and Olubakinde, 2019 [41] said, an artificial neural network (ANN) is one of artificial intelligence. It is forming machine that functions the way human brains function by creating these machines using apparatus that perform in similar to biological neurons. Neural networks are interconnected neural computing basics that can reply to input stimuli, to adapt and to learn the environment. It can be trained to solve problems that are not easy to solve with human brains. After the neural networks have been trained, they can make forecasting and prediction. Recurrent Neural Networks are types of Neural Networks that the previous outputs are fed as inputs to the present step. Traditionally, the inputs of neural networks and outputs of neural networks are


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

independent of each other, but when it is needed to forecast the next term of a sentence, the earlier words are needed and therefore, there is a need to remember the earlier words. RNNs have internal memories which caused Recurrent Neural Networks to remember the information that had been estimated [3], [18]. Recurrent neural networks will produce predictive results with sequential data that other algorithms cannot predict. Again, most recorded activities of failure, maintenance activities are probabilistic in nature. To analyze them, there is need to use a probabilistic approach to simulate the distribution of the situation which is better than the deterministic approach in term of accuracy, wide coverage of data, avoidance of assumption, and presumption. One of the methods for the probabilistic assessment is Monte Carlo. The chief advantages of the Monte Carlo Simulation method are angular distributions as a function of energy, direct use of data no need for approximations [51]. But the disadvantages of the Monte Carlo Simulation method are the enormous use of memory: angular distributions and the cross–sections must be accessible for all energies of interest, all nuclides and elongated calculation times, which quickly diverge with the yearning accurateness [51].

Integrating high penetration solar energies or DGs to power systems become cost–effective remedy to compliment the rising energy demand due to increase load in the traditional or conventional energy system will improve the reliability performance of the electrical system network by offering a supplementary source during power disturbance or uproar [4]. The surplus electrical energy from the solar PV at the distribution end of the consumers is fed to the grid. Renewable energy resources are in the different form such as micro–grid, distributed generation and individual solar PV and wind turbine and if any of this is put in place would promote the reliability of distribution system. If there is any outages in the utility grid supply, these local renewable energy sources will provide the continuous power supply [6]. Electrical energy could be harvested from sunlight via a process named photovoltaic. "Photo" is referred to as light and "voltaic" is also referred to as voltage. Due to the fact that this is normally obtain from the sun, it is usually referred to as photovoltaic or solar cells. There are semiconductor devices that convert that energy obtained from the sunlight to electricity [37 and 42]. High penetration of renewable energy resources would be incorporated into the distribution system. Particle Swarm Optimization (PSO) method would be used for the sizing and placement of the renewable energy and the reliability assessment would be assessed using recurrent neural network with and without solar energy resources with Monte Carlo based RNN to predict and assess the reliability and the solar irradiance of Ado–Ekiti would be obtained from year 2016 to year 2020 and these would be shaped into average monthly. The Solar energy is abounded across the country and people are gradually adopting the technology and it is a clean energy. The annual average radiation ranges from about $42\text{kWhm}^{-2}\text{days}^{-1}$ in the seaside latitudes to $84\text{kWhm}^{-2}\text{days}^{-1}$ in the far north of the country. The solar radiation is evenly distributed across Nigeria, the lowest average is approximately $3.55\text{kWhm}^{-2}\text{days}^{-1}$. Solar generation could generate roughly $3.8\ \text{X}\ 10^{23}\text{kW}$ correspondent of 1,082 million tonnes of oil (Mtoe) value of energy in a day; this is around 4,000 times the petroleum [53]. Some past works have proved that solar radiation in Nigeria would adequately support the solar energy system. The level of solar radiation is lower during the raining season than the dry season in Nigeria.

## 2. REVIEW OF SOME PAST WORKS ON RELIABLITY ASSESMENT AND ASSETS MANAGEMENT

This section would present the existing relevant works on power system reliability, asset management and high penetration of renewable energies by reviewing the different methods that have used to assess reliability.

Zhong *et al*., 2020 [52] assessed the reliability of islanding Micro Grids with high penetration of renewable distributed generations, putting into consideration outages in power electronic device. They developed an analytical classical of the basic outage rate of the said system, carried out in an


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

improved position system and estimated the Energy Not Supplied, System Average Interruption Duration Index, System Average Interruption Frequency Index.
Jose *et al*., 2020 [22] recognized that Micro Grid has electric power electronic apparatus for its control. Examination carried out the influence of electronic apparatus on the reliability of the distribution and the writers recommended a devotion to the low reliability of the electronic power systems in many of the substructures of the Micro Grids.
Kovalev and Lebedeva, 2019 [26] said that Monte Carlo simulation comprises some phases that contains calculation of reliability performance indices and generation of power system haphazard states. The longstanding planning of the Electric Power System extension contains the design of suitability in which the yearly intermission was put into consideration and the unplanned an the planned overhauls of equipment, its random deviations and a change in the load curve were all considered.
Krupenev *et al*., 2020 [28] completed that the suitable mixture of approaches for evaluating shortage of Power System is employ the Sobol categorization joint with the support vector machine (SVM).
Mohammad et al, 2019 [35] introduced a new scientific classical to evaluate the reliability of the distribution assimilated with the smart monitoring systems. The classical employed the Markov technique and integrated the impact of the process failure factors on the complete system reliability. The classical was executed on an actual test system and examined with simulations to evaluate the dissimilar parts of the problem. The outcomes displayed momentous advantages of the utilized classical and indicated 90% enhancement in the reliability of the system when smart monitoring was applied but he did not apply Markov model to predict the life–cycle of any of the components in the system, if the life cycle of the transformer or any other components is not known or cannot be predicted it may be difficult to achieved an improved in reliability in the system.
Hsiang–Hua et.al, 2019 [54] studied the utilization of loss of load expectation as a risk measure to offer perceptions to how the obtainable power size at a countrywide could flop to meet the customer load in which a Monte–Carlo–simulation (MC) was employed to simplify quick estimation of loss of load expectation knowing that national power system involves different renewable energy energies and traditional power sources, the intended scenario–based calculation under the accurate condition that different traditional energies could be upgraded vigorously to compensate losses of load. In other to brand the procedure additional operator–associate and appropriate to power systems, an assertion support system was modelled. But there was no decision reached on how to predict power outages.
Jonathan and Nal,2019 [21] used Markov Chain Monte Carlo approach to reinforce Bayesian extrapolation by making the models from the succeeding distribution over classical constraints. This was done to empower Marko chain and Monte Carlo but the life span of components was not evaluated.
Michallis and Petros, 2019 [32] presented a slope–based erudition technique to robotically acclimatize Markov chain Monte Carlo offer distributions to willful targets. They described an extreme entropy standardized objective purpose, denoted as simplified speed degree, that could be vigorously optimized over the factors of the proposal distribution by utilizing stochastic slope optimization but it was not applied in the field of Electrical Engineering and he crossed breed Markov and Monte Carlo.
Dogan and Chanan, 2018 [10] presented an innovative method for evaluation reliability in power systems. An amalgamation of Multilabel Radial Basis Function and Monte Carlo Simulation classifier was employed for evaluating the reliability. Multilabel arrangement algorithms is differ from solitary label technique, in which each illustration could be allocated to several categorizes. The investigation revealed that Multilabel Radial Basis Function can be employed to categorize


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

compound power system states without necessitating optimal power flow investigation, with exemption of training stage. Hence, this method displays that the calculational effectiveness of the reliability assessment investigation to appraise reliability indices could be substantially improved. The intended technique was applied to the IEEE Reliability Test System (IEEE–RTS–79) for diverse load levels. The consequences of case revealed that Multilabel Radial Basis Function algorithm offered good categorization accurateness in reliability assessment while dropping computation time significantly.

A study that reviewed the impact on the reliability of the electric power system when Energy Storage System were applied was put in consideration by Mohamad et al., 2018.

Leonardo V. et al, 2018 [29] grew a credit scoring model to substitute the pre–risk check of the risk Solution Services and e–commerce risk management system that is presently the utmost employed to evaluate purchasers' evasion probability. The pre–risk checked data from included exclusion rules, a generic credit scoring model and the order process. A genetic programming to credit scoring was offered in the work. The model developed on an real–world dataset presented by the well–known German monetary firm.

Hossein A. H. and Hamed M.R, 2018 [16] presented an assessment of the differentiated parts in big data analytics advances in power systems. Several terminologies were considered and evaluated on the occurring and the misplaced elements in the structures and methods related with big data investigative in electrical energy and also presented an all–inclusive outline categorization and, research opportunities, succinct dialogues application areas, on the technical methods, for energy big data analytics.

Kezunovic *et .al*,2017[25] the novel method provided by Kezunovic *et .al* exposed many opportunities to talk the exclusive fundamental matters of how to efficiently fuse network data and weather in space and in time for the advantage of visualizing possibility of outages under harsh weather conditions that may lead to an improved operation strategies and maintenance and how the risk calculation would improve by the use of Big Data associated to environmental and other weather impacts that may lead to outages and asset decline and deterioration and however, the components that are causing the outages were not put into consideration.

Mahind and Patil, 2017 [30] presented how computational intelligence (CI) and novel machine technologies were discovered in present day applications. Presently machines are available to offer the knowledge–based education which are responsible for refining the intelligence. However, it was just a review article that reviewed on the overall perceptions of machine learning and artificial intelligence.

Bolun et al, 2017 [8], presented a novel approached that intended to assess the reliability of power systems. Instead of offering a single–valued calculation outcome, a belief function and a plausibility function were gambled to evaluate lower bounds and upper bounds of the expected unsupplied energy, the loss of load expectation, the expected unsupplied load and the loss of load probability. The suggested method could trail the connection of the actual data well and retain it to the end of the assessment but the basic reliability indices required in distribution was not dealt with.

Hector et *al* ,2016 [14] presented Monte Carlo technique that is called Conditional Monte Carlo that has Intermediate Estimations, that proposed to lessen the discrepancy of the estimator in a framework of big and extremely reliable Markovian technique. But this was not used to estimate the reliability.

Somia Alfatih et al, 2015 [50] described Engineering asset management(EAM) as the management of engineering assets (EAM) and that would offer recommendations on the real usage of all engineered assets in the establishment. It is considered crucial to recognize the idea of real Engineering asset management and how it is been executed in an establishment.


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Table I: Review of some past authors, approaches, limitations and objectives

| Authors | Objectives | Limitation |
|---|---|---|
| Olajuyin et al, 2021[39] | Statistical package was used and denoted the assessed reliabilities and failure rates in charts | They used statistical package in excel with analytical analysis. The approach cannot generalize, it is slow and cannot learn from historical data |
| Kalesanwo et al, 2020 [24] | It examined the reliability of autonomous systems using the favored writing things for methodical reviews and meta–analyses method | A review article that proposed probabilistic approach and it is not capable of predicting failure and it is very slow, cannot generalize, cannot optimize and not so effective |
| Vahi, et al, 2020 [55] | A new machine learning context for reliability assessment of solder joints in electronic systems. | Software or computational techniques of reliability calculation of solder joints in electronic systems and could not be able to handle sequence data and inability to provide incredible memorizing capacities |
| Shivani and Bal, 2020 [42] | The paper reviewed the previous work done by researchers in the field of software reliability with component–based software | Genetic Programming and Genetic algorithm cannot generalize and excessive amount of computational time |
| Sachin K. et al, 2020 [47] | This paper presented the Reliability Assessment of renewable energies interfaced Electrical Distribution System putting into the consideration electrical loss minimization | He only used software method not hybrid method |
| Bharathi and Selvarani, 2019 [7] | The model devised assessment probability of occurrence of the nu merical error and its propagations from the initial to other states | Software reliability assessment was applied in the field of automotive–industries, to assess reliability of hidden design errors. A stable output free from vagueness was not able to achieve. |
| Michallis K.T. and Petros D, 2019 [32] | Gradient–based learning approach was automatically adapted Markov chain Monte Carlo proposal distributions to intractable targets that defined maximum entropy regularized objective function | Combination of two probabilistic methods and this was not used in the field of power systems. It is very slow and may introduce complication in handling it. |
| Jonathan H. and Nal K.,2019 [21] | Markov Chain Monte Carlo methods enable Bayesian inference by generating samples from the posterior distribution over model parameters. | Combination of both Markov and Monte Carlo (two Probabilistic methods). Inability to generalize and ambiguity is a serious issue and a deeper understanding of the method is required |
| Baseem et al,2019 [6] | Probabilistic and deterministic methods were employed to evaluate the reliability of distribution system. | The method is slow, it is not suitable for bulky system and cannot generalize. |
| Kulamala et al,2018 [27] | An overview of using Computational Intelligence Techniques was given | Software methods were surveyed and proposed |
| Surender R.S,2018 [48] | Asset management could reduce the risk of equipment failure, prolong the assets life and abates the occurrence of unintended outages. | He reviewed the following tools: Asset/Work Management Systems, Distribution Management System, Geographical Information System and to manage their utility plants. He did not use any particular software or method of analysis |
| Athraa A. K. et *al*, 2017 [5] | Disparity evolution enhanced the performance of the probability of mutation in a genetic algorithm by integrating features from the paradigm into the disparity theory. | Their model (software method) did not address forecasting of power outages. |
| Adefarati, et al, 2017 [1] | He developed a software in the Matlab programming with the support of fmincon optimization tool to study the economic effect of renewable systems | The method is very slow compared to recurrent neural network and it cannot generalize. |
| Jannie S. N. and John D. S.,2017 [23] | The method was used for calibration of a Markov deterioration model using past data on wind turbine blade | This method (probabilistic approach only) was used in the generation components of the power systems. |
| Mauricio S. and Jorge C. 2016 [31] | It showed how a pattern Self–Organizing Maps could be applied to model Markov using state assignment | Probabilistic method but, was applied to any distribution. They were presented how it can be used for reliability evaluation. |
| Torborn S., 2015 [44] | It linked the areas of distribution system reliability and performance–based regulation | Probabilistic analysis approach was used to estimate financial risk |
| Vrana T. K. and Johansson E., 2011 [46] | A review on of the art of systematic power system reliability calculation methods were carried out. | Analytical method of power system reliability assessment may not be suitable for bulk network, |
| Hongyan L. et *al*., 2011 [15] | Self–Organizing Map in the framework of power distribution effectiveness performance conception was carried out. | Software method was used to consider Electricity distribution regulation and efficiency and yardstick regulation were considered but reliability performance indices in distribution was not dealt with. |
| Hao Y. et *al*., 2011 [13] | A review on various methods of designing and training radial basis function network. | A review article on software method that expressed how it can be applied but not in power systems |
| Fangxing L. and Nura S., 2008 [11] | It developed the influence of distributed generation to distribution network reliability via an inclusive, serial Monte Carlo model. | Probabilistic technique was employed to assess the influence of reliability of distributed generation on distribution network and not on the whole reliability of power distribution. |


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Olulope, 2014 [43], said Computational intelligence method could be employed to solve compound problems that cannot be modeled by systematic method. The chief motive of employing Computational intelligence in modeling is to recognize a classical of unidentified assets in order to forecast the performance of the assets. Also, arithmetical classical may not be precise to describe many lively processes. The importance of Computational intelligence methods over the mathematical modeling is that they can model any occurrences applying data when there is no created mathematical equation and give the results of the forecasting accurately and timely. Table I, reviewed some past methods of reliability assessment and assets management, authors, titles, objectives and their limitations.

## 3. RESEARCH GAPS

High dimensionality increases the complication of the deliberated systems and introduce complexity when Monte Carlo method is applied for the reliability assessment and assets management of distribution system. This affects the speed of the assessment. One drawback of the probabilistic methods is that this method requires undue amount of computational time resolving optimization equations. The probabilistic methods involve in excessive and massive use of memory. Reinforcing probabilistic methods or Monte Carlo simulation with computational intelligence will make the assessment to be quicker and it will make up for unnecessary use of memory in Monte Carlo simulation and eradicate some abridging assumptions that required to be made to reduce the bulkiness to a controllable size.

The addition of computational intelligence to conventional methods of reliability assessment (hybrid method) would permit instantaneous interfaces between asset management such as active maintenance planning that could help increase organization sensitivity and quality and an algorithm that can evaluate, prevent and predict catastrophic failures, measure and update the reliability indices and system performance within a short time and to manage outages data on assets and on the entire system for quick and rapid decisions making is needed. Integrating renewable energies into distribution system would increase energy generating capacity and enhance reliability of electrical power system and made available electrical energy to the common man since the excess power is fed to the grid from those that have excess power generation from their solar energy and reduce emission of carbon into the air. In this research, the network would be modeled with high penetration solar PV, distributed generators and the reliability assessment would be carried under different scenario with Monte Carlo.

Optimization of distribution assets, solar PV resources would be carried out and the economic analysis of connecting under different scenario and would be carried out. The temperature rise in cable /wire of the distribution network would be monitored using the algorithm that would be developed to prevent cable or wire burnt or melting and carbon emission to the surrounding would be evaluated with the algorithm and the strategies that will improve power reliability (outages prevention) would be recommended.

## 4. STATE OF ART OF THE RESEARCH WORK – SERIOUS OPINIONS ON RELIABILITY IN TRADITIONAL POWER SYSTEMS

- Electrical power systems integrating the Traditional energies have been divided into three hierarchal levels for reliability assessments. Assessment processes were improved by using diverse approaches and by utilized them to diverse hierarchal levels. Hierarchical Levels with functional zones for power system reliability assessment is showed in figure 1 below.
- The reliability assessment method originated from deterministic standards and later moved to probabilistic approaches encompassing of Monte Carlo and analytical methods and now moving to hybrid and artificial.
- In all the hierarchal levels only, HL II has an extensive number of assessment methods because of complications HL III has few approaches for reliability evaluation.


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

— HL I, principal method is analytical but for HL II the major method usually employed is hybrid that could be combined with Monte Carlo simulation–based approach.
— Artificial intelligence–based (AI) approaches are latest for reliability assessment but these still have huge potential to solve the difficult reliability.
— The value of reliability analysis could be realized when an optimization between economic gains and reliability for a system can be launched. Many indices are needed to be established to calculate the same e.g. Loss of Load Cost (LOLC) [39 and56].

## 5. RELIABILITY WORTH

Reliability worth tool in investment planning and value–based system operation, to optimize the total cost of providing the electricity versus the reliability level. In planning of investment, reliability worth can be used to communicate the value of possible investments to the worth of the reliability enhancement that the investment would have. In operation planning, reliability worth can be used to recognize the interruption cost versus optimum operational reserves. The reliability worth varies with several parameters such as time of day, duration of interruption and type of customer. Analyzing the direct worth and willingness to pay from different customers. It is important to realize the difficulties in quantifying a true consumer interruption cost, if such a thing really does exist, when performing reliability worth analyses. This intricacy also implies further difficulties in identifying the true optimal reliability level [46].

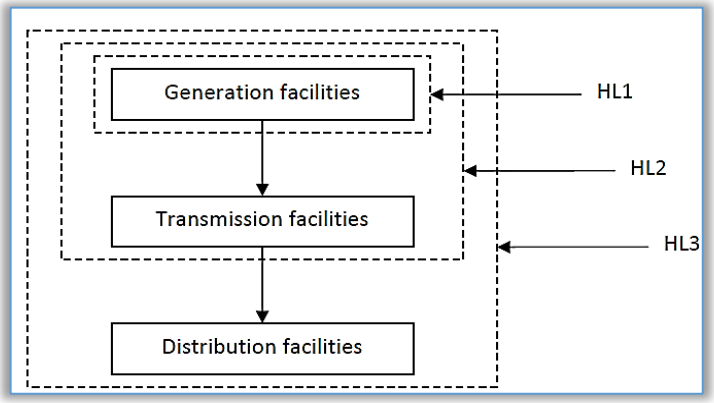


Figure 1: Hierarchical Levels with functional zones for power system reliability assessment [39 and 45].

## 6. RELIABILITY OF POWER SYSTEM NETWORK

The power system is a very multifaceted infrastructure that is operated on a large– scale. All human activities depend on it; hence it is expected to be reliable at all times. "Reliability of electrical power system is the probability that a power system will meet the consumers' load requirements at any time" [2]. Reliability of electrical power system could be described as: "The reliability of a System is the ability of the system to function satisfactorily under stated planned actions for a certain time frame" [49]. "Reliability is the ability of an item to perform a required function, under given environment and operational conditions and for a stated period of time .The power system reliability is a measure of the ability of the system to meet the consumer requirements with quality electrical energy". In general, "reliability" is usually divided into two aspects, system adequacy and system security as shown in Figure 2.

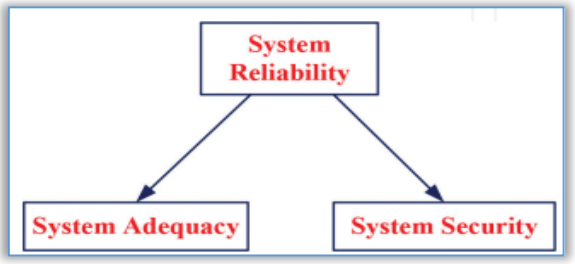


Figure 2: Categorization of power system reliability [19].

## 7. PROCEDURE FOR MONTE CARLO BASED RECURRENT NEURAL NETWORK FOR RELIABILITY ASSESSMENT

Data would be collected from the logbook of Benin Electricity Distribution Company Injection Substation and some reliability Indices will be evaluated using the data adopted from the injection station such as the Average Service Availability Index (ASAI), Momentary Average Interruption Frequency Index (MAIFI) , Customer Average Interruption Frequency Index (CAIFI), System Average Interruption Frequency Index (SAIFI), Loss of load expectation (LOLE), Energy not supplied (ENS) and System Average Interruption Duration Index (SAIDI) Etc.


ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

## 8. CONCLUSION

The problem in Nigeria power sector is critical and it has affected and crippled the economy negatively because many factories, homes manufacturing industries are running on generators and the population is increasing every day without increasing the generation capacity and every individual and industry want to use electricity and that is the reason for energy crises. The network would be modeled with high penetration solar PV, distributed generators and the reliability assessment would be carried under different scenario with Monte Carlo. Optimization of distribution assets, solar PV resources, distributed generators, wind energy would be carried out. The temperature rise in cable /wire of the distribution network would be monitored using the algorithm that would be developed to prevent cable or wire burnt or melting and carbon emission to the surrounding would be evaluated with the algorithm and the strategies that will improve power reliability (outages prevention) would be recommended.

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ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665