Analytical evaluation of the reliability of the active distribution networks considering the scheduling of switching and network recovery

Amin Cheshmeh Roshan[#1], Mehdi Forouzanfar[*2], Seyyed Mohammad Sadegh Ghiasi [#3]

[#] Department of Electrical Engineering, Ahvaz Branch, Islamic Azad University
Ahvaz, Iran
Department of Electrical Engineering, Khouzestan Science and Research Branch, Islamic Azad University
Ahvaz, Iran
[1] amin.susa@gmail.com
[3] ghiasi@iauahvaz.ac.ir
[*] Department of Electrical Engineering, Ahvaz Branch, Islamic Azad University
Ahvaz, Iran
[2] m.forouzanfar@iauahvaz.ac.ir

Abstract — **Given the direct relationship between distribution networks and consumers of the power systems, the reliability of these systems is highly important. So improvement of reliability is the top priority of distribution networks designers and operators. One of the solutions provided in this area is the installation of distributed generation in distribution networks, which allows the islanded operation of the distribution system at the time of fault in upstream networks. In this project, a detailed analytical model was proposed to evaluate the reliability of distribution networks considering distributed generation. In order to more accurately modelling, the time required to recover from a main source, the time needed to open and close the switches and the time needed to recover loads through an alternative source were considered. Moreover, the age of distributed generation sources was modeled and its impact on reliability was examined. Also, the time and volume of calculations were reduced using the concept of segmentation and calculation of reliability indices for each segmrnt. The proposed model was used to evaluate the reliability of a sample distribution network. The results indicated that as the age of distributed generation increased, the reliability of the distribution system was reduced.**

Keyword - reliability of distributed systems, distributed generation (DG), analytical evaluation, islanded operation.

I. INTRODUCTION

In recent years, many efforts have been made to improve the reliability of power systems and distribution networks. One of the solutions considered by many researchers to improve reliability is the implementation and use of renewable energy resources in power systems. In order to improve the conditions for the use of distributed generation (DG), a new concept called microgid was introduced that enables the integration of DG sources and more efficient use of them [1]. Given the increasing presence of DG and microgrids in distribution systems, evaluating the reliability of these networks has become more complex. The evaluation of the reliability of distributed networks along with DG has attracted the attention of many scholars. In some studies, the reliability of microgrids with distributed energy sources such as wind and solar energy is evaluated. For example, in [2, 3, 4, 5], the reliability of distributed networks along with DG is evaluated. In [6], the impact of DG and storage systems on the reliability of the distribution system is studied. In this study, storage system modeling was used to reduce the fluctuations in output power of renewable energy resources.

There are also studies to use Monte Carlo Simulation (MCS) to evaluate the reliability of the system. In [7, 8], the reliability of small islanded power systems and independent microgrids is calculated using load simulation and MCS. In [9], a comprehensive review of reliability models and methods for estimating the impact of renewable energy resources on the availability of generation power is provided. In [10], a study on evaluating the reliability of power systems taking into account wind turbines and energy storage resources is conducted.

In some studies, the Markov process is used to assess reliability. For example, in a study, Markov process is used to model the relative changes in load generation when evaluating the reliability of microgrids including renewable DG. In smart grids, the limitations of distribution networks are removed using smart protection systems with possibility of remote control of equipment. In other words, the new distribution systems can be considered cyber-physical systems (CPSs). Accordingly, in [11], an analytical formulation is proposed to evaluate the impact of CPS vulnerability and central remote control on the reliability of distribution networks with the possibility of

islanded operation. In [12], a reliability evaluation model for distribution systems with wind turbine resources, energy storage system and photovoltaic (PV) is presented.

In [13], a new approach to clustering existing distribution systems in the form of a set of microgrids is presented to improve reliability. In this approach, the installation of DG and sources of reactive power for the supply of microgrids are also considered. Ref. [14] is one of the most recent work on reviewing the techniques for evaluating the reliability of modern distribution networks. This study is conducted aimed at investigating the techniques used to evaluate the reliability of distribution networks, considering the importance of DG, the use of distributed control and communication and protection technologies. In [15], an analytical technique is developed for assessing the impact of using PV sources, wind turbine generators, energy storage systems and diesel generators on the reliability of distribution systems. The proposed technique is applied to the first feeder of the RBTS system. It is suggested that renewable energy resources improve the reliability of distribution networks. Also in [16], a technique for assessing the reliability of distribution systems is proposed, considering the planning of large-scale storage systems. In this work, the impacts of seasonal changes in load and output power of DG, electricity market prices, islanded operation and state of charge (SOC) are also considered. In distribution systems, the use of gas turbines and uninterruptible power supplies (UPSs) as consumer-side protection sources can reduce the outage time for some consumers. However, cost / value analysis suggests that the cost of increasing the reliability level for this kind of DG is very high [17].

In recent years, the design and implementation of microgrids and smart grids have made it easier and more efficient to use distributed energy resources. Many studies are conducted on the assessment of the reliability of distribution systems considering the renewable DG units. References [17-20] are examples of these studies. The DG remains connected to microgrid and is able to feed the load points on the islanded areas of the distribution network. This feature of DG improves the reliability of the load points on the distribution network [21-24].

In this study, wind turbines were used as DG sources. For modeling wind power, scenario generation-based methods, and also correlation between wind speed and load were used in scenario reduction methods. In the following, the details of the function of the sectionalizers in the process of fault isolation and feed recovery as repair time are involved in assessing reliability. The time required for load recovery through alternative sources is also considered in reliability analysis. Another innovation of this study paying attention to the age of DG in the model, which increases the accuracy of the reliability analysis.

II. RELIABILITY ASSESSMENT

In this study, reliability was assessed based on detailed analysis of fault isolation and feed recovery. In the proposed technique, the operating time of switching equipment and the existence of an alternative feed rout for load points were considered in reliability analysis. Additionally, the age of DG was also considered through their failure rate in the proposed model. In general, based on the above, the proposed framework to evaluate the reliability of the distribution network can be expressed as follows. 1) According to statistical data for hourly load and data on wind speed, several scenarios for load and output power of wind turbine are obtained using recursive scenario reduction methods and wind turbine power curves, 2) The whole distribution network is divided into several segments, based on the network structure and location of the switching devices, 3) The matrix of the network M1 is obtained according to the segments relative to each other. By combining M1 and position of the activated breaker when the fault occurred, the matrix M2 is formed, 4) based on fault isolation and feed recovery, the impact of faults in each segment on other ones is evaluated and reliability indices for load points are obtained, and 5) system reliability indices are calculated on the basis of the reliability index of each load point.

III. DATA FOR THE STUDIED SYSTEM

The structure of the studied system can be seen in Fig. 1. The distribution system studied is the development of the fourth feeder of the RTBS system, which was studied in [3]. In this network, the lines were sequentially numbered from 35 to 67. In Table (1), the failure rate information for each line, along with the time needed to repair it, was presented. The time needed to repair the lines was selected based on [26]. The number of consumers per load center was also provided in Table (2). Based on the concept of segmentation, the system was divided into six different segments, the area of each one was determined in Figure (1). Wind speed data was obtained from [27] and hourly load data were derived from [28], related to US data in 2012. Two wind turbines as renewable resources were connected to the test system. Scenarios were generated based on hourly load and wind speed data, and appropriate scenarios were selected using the recursive scenario reduction methods. Ten scenarios for load, wind speed and wind speed generation power were selected, using the recursive scenario reduction method. The rated speed of the wind turbine, and the speed of its switch on and switch off were 12, 25 and 3 m / s respectively, and the rated power of the turbine was 1 MW.
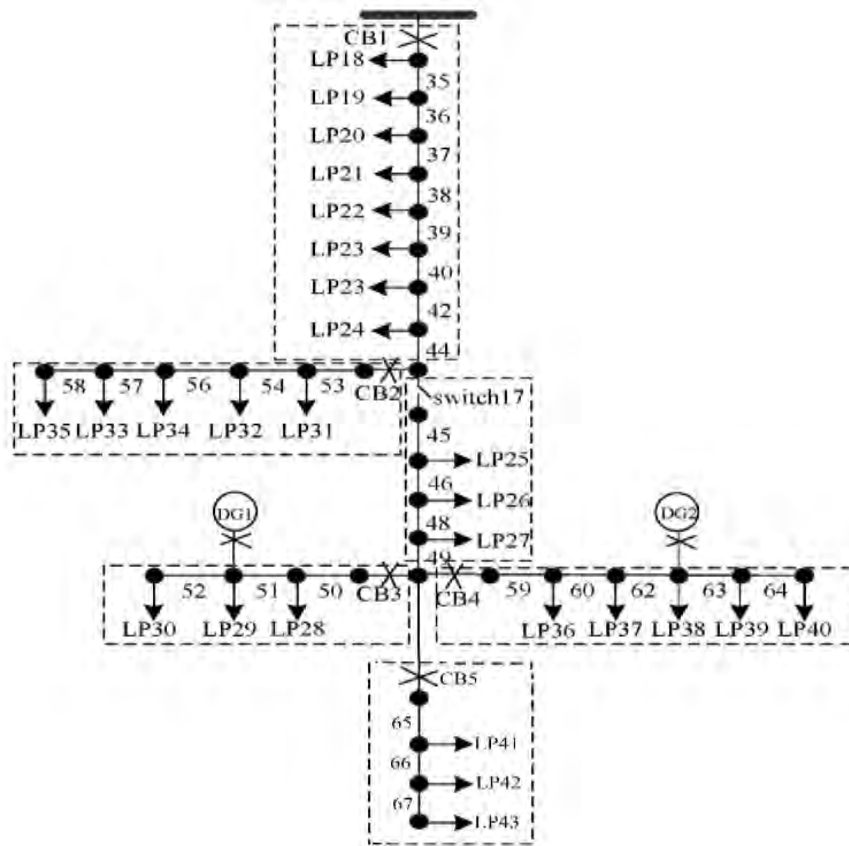
Amin Cheshmeh Roshan et al. / International Journal of Engineering and Technology (IJET)

Fig. 1. The structure of the distribution system studied

TABLE I. Failure rate and repair time of lines [3]

Line number	Fault rate (per year)	Repair time (hour)	Line number	Fault rate (per year)	Repair time (hour)
35	0.0368	8	52	0.115	8
36	0.115	8	53	0.1472	8
37	0.0736	8	54	0.0736	8
38	0.0414	8	55	0.0368	8
39	0.0736	8	56	0.1288	8
40	0.115	8	57	0.115	8
41	0.0276	8	58	0.1472	8
42	0.0736	8	59	0.1288	8
43	0.0345	8	60	0.115	8
44	0.0414	8	61	0.0345	8
45	0.1472	8	62	0.0736	8
46	0.1288	8	63	0.1472	8
47	0.0276	8	64	0.1288	8
48	0.161	8	65	0.0736	8
49	0.0736	8	66	0.1472	8
50	0.1288	8	67	0.1288	8
51	0.1472	8			

TABLE III. The number of consumers in each load center (75)

Load center	The number of consumers	Peak demand on the load center (MW)	Load center	The number of consumers	Peak demand on the load center (MW)	Load center	The number of consumers	Peak demand on the load center (MW)
18	147	0.1659	27	76	0.1585	36	79	0.1554
19	126	0.1808	28	79	0.1554	37	1	0.1929
20	1	0.2501	29	76	0.1585	38	1	0.2831
21	1	0.2633	30	1	0.2501	39	76	0.1585
22	132	0.207	31	79	0.1554	40	1	0.3057
23	147	0.1659	32	1	0.1929	41	1	0.2831
24	1	0.3057	33	76	0.1585	42	76	0.1585
5	79	0.1554	34	1	0.2501	43	1	0.3057
26	1	0.2831	35	1	0.2633			

TABLE IIIII. Elements of each segment of the system under study

Segment	Elements
1	CB1, L35-L44, LP18-LP24
2	CB2, L53-L58, LP31-LP35
3	CB3, L50-52, DG1, LP28-LP30
4	CB4, L59-L64, DG2, LP36-LP40
5	Switch17, L45-49, LP25-LP27
6	CB5, L65-67, LP41-LP43

TABLE IVV. Selected scenarios for load and wind speed

Scenario	Wind speed (m / s)	Load (%)	Contingency
1	2.7858	0.4501	0.1129
2	2.7583	0.5462	0.1243
3	4.7543	0.7908	0.0908
4	5.2868	0.4411	0.1577
5	7.7583	0.4645	0.0738
6	1.2595	0.4363	0.0924
7	3.3316	0.6977	0.041
8	4.4748	0.433	0.1625
9	6.4697	0.5392	0.0904
10	4.8355	0.5532	0.0902

IV. ANALYTICAL EVALUATION OF THE RELIABILITY OF THE DISTRIBUTION SYSTEM

According to the definitions given for matrices and , and the networks presented, the matrices and for the network are as follows:

$$
M_1 \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 1 \\ 2 & 0 & 3 & 3 & 3 & 3 \\ 2 & 3 & 0 & 3 & 2 & 3 \\ 2 & 3 & 3 & 0 & 2 & 3 \\ 2 & 3 & 1 & 1 & 0 & 1 \\ 2 & 3 & 3 & 3 & 2 & 0 \end{bmatrix} M_2 \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 1 \\ 2 & 0 & 3 & 3 & 3 & 3 \\ 2 & 3 & 0 & 3 & 2 & 3 \\ 2 & 3 & 3 & 0 & 2 & 3 \\ 0 & 1 & 1 & 1 & 1 & 1 \\ 2 & 3 & 3 & 3 & 2 & 0 \end{bmatrix} \tag{1}
$$

Also, λ_i^s is the equivalent annual failure rate (AFR) and U_i^s is the equivalent annual outage time of the Segment Sj, which are calculated according to Equations (2) and (3).

$$\lambda_i^s = \sum_{k-1}^{N_{c-1}} \lambda_k^c \qquad (2)$$

$$U_i^s = \sum_{k-1}^{N_{c-1}} \lambda_k^c t_k^c \quad (3)$$

Faults have different effects on load points. It is therefore evident that during the faule, the load points are divided into several regions, based on the network structure and activated breaker connections with the load points. So the interrupt time for the load points in different situations is obtained in accordance with Fig. 2. Different switching times are achieved in this form figure due to different switching functions in different states.
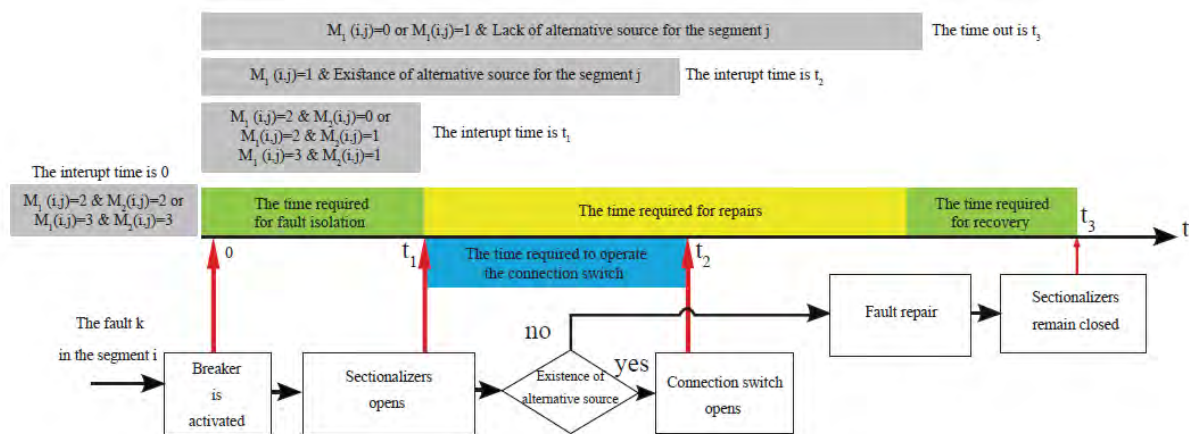

Fig 2. Fault isolation and feed recovery analysis

For the reliability evaluation using the proposed method, four different scenarios were defined as follows. Scenario 1 is the study of the network reliability in the base state. In Scenario 2 it is assumed that Segment 4 has an alternative feed route. In Scenario 3, the system has two DGs based on a wind turbine with a rated capacity of 1 MW, which is installed in Segments 3 and 4. Scenario 4 is similar to Scenario 3, except that the output power of DG is achieved by considering their age. In all scenarios, the operating time for the sectionalizers was considered to be 20 minutes. Reliability was evaluated by computing reliability indices for points using SAIFI, SAIDI, CAIDI and ASAI.

It should be noted that in the case of the inclusion of DG in a distribution system, the reliability indices of the load points located in the same segments will not be equal. In this context, only loads with higher priority were considered for feed.

V. SIMULATION RESULTS

For Scenario 1, if the system has no DG, the reliability indices of the load points in the same segments will no be equal. For the first scenario, the annual failure rate and the resulting annual outage time rate for each segment are shown in Fig. 3a and 8a. According to the figures, it is evident that the location of the faults had different effects on the reliability of the load points in different segments. As previously mentioned, according to the concept of the segmentation, the load points in the same segments had the same reliability indices. This feature increased the efficiency of the proposed technique. As can be seen in Fig. 3a for Scenario 2, due to the existence of alternative routes from other feeders, the outage time for some load points which had access to an alternative source after the fault isolation, was significantly reduced. However, the failure rate for the scenario remained 1. Fig. 3a indicated that the outage time for the load points of Section 4 was substantially reduced. Additionally, the reliability level of load points in Segments 3 and 5 also increased, because in the event of a fault in Segment 1, it was also possible to access to an alternate source for Segments 3 and 5.

Based on the results observed in Fig. 3a and 4a, for Scenario 3, the following results were obtained regarding the impact of DG on reliability indices of sources. For the load points located in the microgrid, both the fault rate and the outrage time decreased. However, for loads outside of the microgrid, the reliability level was equivalent to the state that in which there was no DG. The reliability of the load centers located in a microgrid depended on their importance coefficient, so that with the increasing importance coefficient of load centers, their reliability

also increased. This was because the loads that had a higher importance coefficient were the priority for feeding through DG.

In Scenario 4, the effect of the age of DG on the reliability of the distribution system was examined. To do this, the system reliability indices were calculated for three different states. In all these states, conditions were similar to Scenario 3, with the difference that the age of DG for states 1 to 3 was considered to be 1, 5, and 10 years, respectively. The initial failure rate of DG was assumed to be 0.25 fault per year during the first year, increasing by 0.05 per year and reaching 0.5 fault per year during the tenth year. Fault rate and outage time of each load point for these states were shown in Fig. 3b and 4b. According to Fig. 3b and 4b, with increasing age of DG, the failure rate and outage time of load points relatively increased. This was due to increased failure rate of DG, which reduced their usable output power.
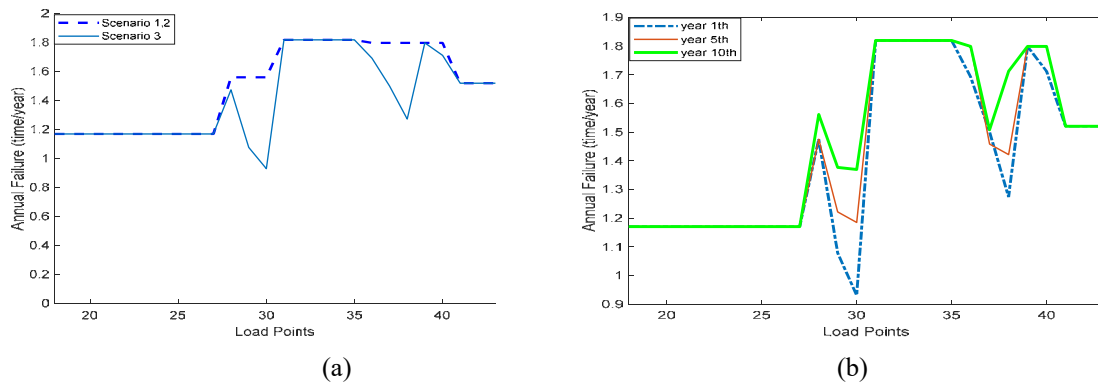

(a)   (b)

Fig 3. Annual failure rate for load points A) Scenario 1-3, b) Scenario 4

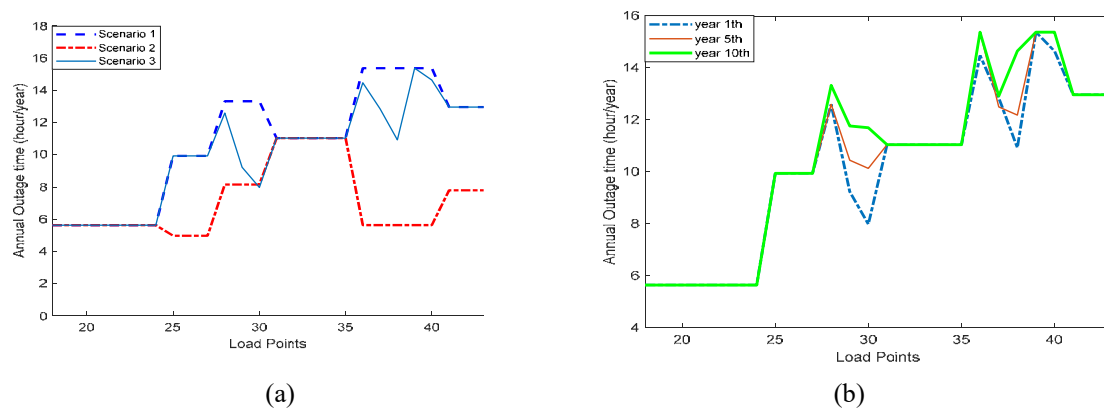(a)   (b)

Figure 4. Annual outage time (h / yr) for load points A) Scenario 1-3, b) Scenario 4

In Table 5, system reliability indices in scenarios 1 to 3 can be seen. According to the table, Scenarios 2 and 3 had a smaller SAIDI and CAIDI than Scenario 1. In addition, the ASAI reliability index improved further in Scenario 2. Generally, the following results were obtained: (1) the use of alternative sources did not affect SAIFI, but the use of DG reduced the SAIFI value, (2) the use of alternative sources significantly reduced SAIDI. The addition of DG also slightly reduced SAIDI. This was also the case for CAIDI. (3) The use of alternative sources and DG improved ASAI, but alternative sources had a higher effect. Based on the results, we find that both alternative sources and integration of DG improved all reliability indices. However, alternative sources for most of the indices was more effective than DG. This was due to the limited capacity of DG sources, in which, contrary to the existence of alternative sources, it was not possible to feed all the load centers. As previously stated, an adequacy analysis was performed on islanded operation of microgrids, and only loads with a high importance coefficient were fed.

In Table 6, the system reliability indices are given taking into account three different ages for DG. According to the table, increasing age of DG worsened all reliability indices of the distribution system. This was the result of increased failure rate and outage time of the load points, the reason for which was explained. The results suggested that the age of DG had a significant effect on the reliability of distribution systems with DG and should be considered in reliability analysis.

TABLE V. System reliability indices in Scenarios 1 to 3

Index	Scenario 1	Scenario 2	Scenario 3
SAIFI	1.4	1.4	1.3582
SAIDI	9.4664	6.6746	9.1065
CAIDI	6.7587	4.6754	6.7047
ASAI	0.9989	0.99924	0.999

TABLE VI. System reliability indices in Scenario 4

Index	Age of DG		
	1	5	10
SAIFI	1.3582	1.3739	1.3891
SAIDI	9.1065	9.2392	9.3682
CAIDI	6.7047	6.725	6.7443
ASAI	0.99896	0.99895	0.99893

VI. CONCLUSION

In this study, an analytical technique was proposed to calculate reliability indices of distribution system based on the concept of segmentation. To this end, a series of scenarios was first generated for modeling the system load as well as the output power of DG based on renewable energies. In this work, wind turbines were used as DG sources. So the scenarios were the system load and wind speed. Based on the simulation results, it can be argued that considering the alternative sources, the outage time of the load points that accessed to the alternative route decreased, but the error rate of these load points remained unchanged. Also, in the event of integration of DG in the distribution system, reliability indices for the load points located in the microgrid improved both in terms of failure rate and outage time. With the addition of DG to the distribution system, the failure rate and outage time in one segment were not the same. The reason for this was the limitation of DG generation power, which only allowed feeding one part of the microgrid loads. Accordingly, improved reliability due to the addition of DG for loads with a higher importance coefficient was more than the other ones. Finally, considering the age of DG reduced output power available to them which led to increased failure rate and outage time o of the microgrid load centers. This led to a reduction in the reliability of the distribution system due to the increased age of DG.

REFERENCES

[1] T. Ackermann, G. Andersson, And L. Söder, "Distributed Generation: A Definition1," Electric Power Systems Research, Vol. 57, Pp. 195-204, Apr. 2001.
[2] Y. G. Hegazy, M. M. A. Salama, And A. Y. Chikhani, "Adequacy Assessment Of Distributed Generation Systems Using Monte Carlo Simulation," IEEE Transactions On, Power Systems, Vol. 18, Pp. 48-52, 2003.
[3] R. Yokoyama, T. Niimura, And N. Saito, "Modeling And Evaluation Of Supply Reliability Of Microgrids Including Pv And Wind Power," In Power And Energy Society General Meeting - Conversion And Delivery Of Electrical Energy In The 21st Century, 2008 IEEE, Pp. 1-5, 2008
[4] B. In-Su And O. K. Jin, "Reliability Evaluation Of Distributed Generation Based On Operation Mode," IEEE Transactions On, Power Systems, Vol. 22, Pp. 785-790, 2007.
[5] P. M. Costa And M. A. Matos, "Assessing The Contribution Of Microgrids To The Reliability Of Distribution Networks," Electric Power Systems Research, Vol. 79, Pp. 382-389, 2// 2009.
[6] H. Liang, J. Su, And S. Liu, "Reliability Evaluation Of Distribution System Containing Microgrid," In Electricity Distribution (Ciced), 2010 China International Conference On, Pp. 1-7, 2010.
[7] R. Karki And R. Billinton, "Reliability/Cost Implications Of Pv And Wind Energy Utilization In Small Isolated Power Systems," Energy Conversion, IEEE Transactions On, Vol. 16, Pp. 368-373, 2001.
[8] P. S. Georgilakis And Y. A. Katsigiannis, "Reliability And Economic Evaluation Of Small Autonomous Power Systems Containing Only Renewable Energy Sources," Renewable Energy, Vol. 34, Pp. 65-70, 1// 2009.
[9] Borges Cl. An Overview Of Reliability Models And Methods For Distribution Systems With Renewable Energy Distributed Generation. Renewable And Sustainable Energy Reviews 1;16(6):4008-15, Aug 2012.
[10] Oh U, Choi J, Kim Hh. Reliability Contribution Function Considering Wind Turbine Generators And Battery Energy Storage System In Power System. Ifac-Papersonline, 1;49(27):301-6, Jan 2016.
[11] Conti S, La Corte A, Nicolosi R, Rizzo Sa. Impact Of Cyber-Physical System Vulnerability, Telecontrol System Availability And Islanding On Distribution Network Reliability. Sustainable Energy, Grids And Networks. 1; 6:143-51, Jun 2016.
[12] Adefarati T, Bansal Rc. Reliability Assessment Of Distribution System With The Integration Of Renewable Distributed Generation. Applied Energy. 1; 185:158-71, Jan2017.
[13] Hasanvand S, Nayeripour M, Waffenschmidt E, Fallahzadeh-Abarghouei H. A New Approach To Transform An Existing Distribution Network Into A Set Of Micro-Grids For Enhancing Reliability And Sustainability. Applied Soft Computing 1; 52:120-34, Mar 2017.
[14] Escalera A, Hayes B, Prodanović M. A Survey Of Reliability Assessment Techniques For Modern Distribution Networks. Renewable And Sustainable Energy Reviews. 31; 91:344-57 Aug 2018.
[15] Adefarati T, Bansal Rc. The Impacts Of Pv-Wind-Diesel-Electric Storage Hybrid System On The Reliability Of A Power System. Energy Procedia 1; 105:616-21, May 2017.
[16] Narimani A, Nourbakhsh G, Ledwich Gf, Walker Gr. Optimum Electricity Purchase Scheduling For Aggregator Storage In A Reliability Framework For Rural Distribution Networks. International Journal Of Electrical Power & Energy Systems. 1; 94:363-73, Jan 2018.

[17] Chen C, Wu W, Zhang B, Singh C. An Analytical Adequacy Evaluation Method For Distribution Networks Considering Protection Strategies And Distributed Generators. IEEE Transactions On Power Delivery. 30(3):1392-400, Jun 2015.

[18] M. Al-Muhaini And G. T. Heydt, "Evaluating Future Power Distribution System Reliability Including Distributed Generation," IEEE Trans. Power Del., Vol. 28, No. 4, Pp. 2264–2272, Oct. 2013.

[19] S. Wang, Z. Li, L. Wu, M. Shahidehpour, And Z. Li, "New Metrics For Assessing The Reliability And Economics Of Microgrids In Distribution System," IEEE Trans. Power Syst., Vol. 28, No. 3, Pp. 2852–2861, Aug. 2013.

[20] Z. Bie, P. Zhang, G. Li, B. Hua, M. Meehan, And X. Wang, "Reliability Evaluation Of Active Distribution Systems Including Microgrids," IEEE Trans. Power Syst., Vol. 27, No. 4, Pp. 2342–2350, Nov. 2012.

[21] K. Purchala, R. Belmans, L. Exarchakos, And A. Hawkes, "Distributed Generation And The Grid Integration Issues," Kuleuven, Imperial College London, 2006.

[22] R. Allan, Reliability Evaluation Of Power Systems: Springer Science & Business Media, 2013.

[23] L. D. M. Carvalho, Advances On The Sequential Monte Carlo Reliability Assessment Of Generation-Transmission Systems Using Cross-Entropy And Population-Based Methods. Porto: University Of Porto, 2013.

[24] R. Billinton And R. N. Alan, Reliability Evaluation Of Engineering Systems, 2nd Edition. New York: Plenum Press, 1992.

[25] M. Al-Muhaini And G. T. Heydt, "Evaluating Future Power Distribution System Reliability Including Distributed Generation," IEEE Trans. Power Del., Vol. 28, No. 4, Pp. 2264–2272, Oct. 2013.

[26] S. Wang, Z. Li, L. Wu, M. Shahidehpour, And Z. Li, "New Metrics For Assessing The Reliability And Economics Of Microgrids In Distribution System," IEEE Trans. Power Syst., Vol. 28, No. 3, Pp. 2852–2861, Aug. 2013.

[27] Z. Bie, P. Zhang, G. Li, B. Hua, M. Meehan, And X. Wang, "Reliability Evaluation Of Active Distribution Systems Including Microgrids," IEEE Trans. Power Syst., Vol. 27, No. 4, Pp. 2342–2350, Nov. 2012.

[28] M. H. Moradi And A. Khandani, "Evaluation Economic And Reliability Issues For An Autonomous Independent Network Of Distributed Energy Resources," Int. J. Elect. Power Energy Syst., Vol. 56, Pp. 75–82, 2014.

[29] R. Allan, Reliability Evaluation Of Power Systems: Springer Science & Business Media, 2013.

[30] Xu X, Mitra J, Wang T, Mu L. Evaluation Of Operational Reliability Of A Microgrid Using A Short-Term Outage Model. IEEE Transactions On Power Systems. 29(5):2238-47, Sep 2014.

[31] Mesonet Measurement Stations. 2012. [Online]. Available: Http://Www. Mesonet.Ttu.Edu/

[32] 2012 Ercot Hourly Load Data. [Online]. Available: Http://Www. Ercot.Com/Gridinfo/Load/Load_Hist.

AUTHOR PROFILE

Amin Cheshmeh Roshan, Master Student, Department of Electrical Engineering, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.
  Master Student, Department of Electrical Engineering, Khouzestan Science and Research Branch, Islamic Azad UniversityAhvaz, Iran.

Mehdi Forouzanfar, Assistant professor, Department of Electrical Engineering, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.

Seyyed Mohammad Sadegh Ghiasi, Assistant professor, Department of Electrical Engineering, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.