SIMULATING THE RELIABILITY OF ELECTRICAL DISTRIBUTION SYSTEM USING ETAP SOFTWARE

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ABSTRACT

Reliability is an increasingly important issue in power systems with the goal of providing electricity to customers safely and reliably. In particular, the reliability in the distribution grid is a key factor in improving the reliability of the power system in general. This study uses ETAP software to simulate the reliability of the distribution grid in Ninh Kieu district, Can Tho city. To ensure the accuracy of the parameters of the system, the study simulates the IEEE 24 bus standard system by ETAP software and compares it with the results of the system. The research results show that the IEEE 24 bus system has the same results as the standard system. Reliability of power grid in Ninh Kieu district, Can Tho city has been significantly improved after applying reliability enhancement solutions, specific CAIDI is 3,698 hr/customer.interruption, SAIDI index is 2.9413 hr/customer.yr, SAIFI is 0.7955 f/customer.yr, EENS is 700,918 MW hr/yr and ECOST is 365,044.90/yr.

Keyword: *ETAP software, reliability index, distribution system, IEEE 24 bus system.*

1. INTRODUCTION

In the world, the issue of reliability on power system has been of great concern since 1988. Up to date, there are many researches on power system reliability and solutions have been suggested to improve power system reliability. A reliable power supply is of great importance in the network of residential, commercial, and industrial electrical systems for the purpose of economic growth for a given country or location. There are a lot of research interest and research aimed at improving the reliability of power systems.

The paper of Geol, L. et al. determined the reliability for planning the distribution system [1]. Reliability in the distribution system can be improved by restructuring the grid, this was done by closing normally open switches and opening normally closed switches shown in [2]. Ye Bin et al. proposed to restructure the system to increase the reliability value by an improved genetic algorithm [3]. According to Somporn's research, a model was introduced to restructure the system to improve reliability by means of simulation [4].

Vrana et al. have analyzed reliability problems and detailed simulations to illustrate reliability evaluation techniques [5]. Alekhya et al. presented power system reliability by qualitative assessment and its application to economic benefit assessment in power system planning is of increasing interest, it was also introduced using the concept of optimal placement of switches to automate the system [6]. Bowen H. et al. assessed the reliability of the distribution network based on the loading need; RBTS was used for system studies and leaded to price changes over the life of the demand profile, resulting in better reliability performance and smoother load curves [7]. A very simple analytical method implemented to analyze the system in [8].

A combined method to find optimal DG connection specifications was proposed to operate the power system with minimal power loss and highly reliable power transmission and distribution based on the combination. Combination of neural network and genetic algorithm approach was presented in [9].

V.Ashok et al showed that the reliability of the power system which can be calculated by different reliability indicators, the performance can be improved by analysis studies and system planning to switch protective devices in appropriate positions [10].

Z.Kovac et al. demonstrated how to model the subsystem from the point of consumer interruption of the power supply. The reliability evaluation results showed a significant difference depending on the simulation visualize and understand input data [11].

In Vietnam, there have been studies to evaluate the reliability of power companies in districts, cities, etc., from which methods have been proposed to meet the demand for electricity supply. Some of them are research topics such as:

Evaluation of reliability and solutions to improve reliability was perfomed in some local provinces such as applying reliability assessment of medium voltage power grids in Tuyen Quang province [12], in Hau Giang province [13], in Phu Tho province [14]. Calculating, analyzing the reliability of the power supply system and evaluating the efficiency of the segmented devices also was studied by the MSc. Pham Thi Vuong [15]. Evaluation of the reliability of the power distribution grid in Hue city according to IEEE 1366 standard was proposed by Ms. Tran Thi Thuy Trang [16]. Evaluation of power supply reliability of 220 kV transmission grid which is managed and operated by Power Transmission Company 3 was studied by Mr. Pham Minh Dong [17]. Calculating and analyzing the reliability of the power supply system and proposing solutions to improve the reliability of the power grid in Long Ho district, Vinh Long province was shown by Master Le Hong Nhat Huy [18]. The reliability of the power distribution system in Phong Dien district, Can Tho city was simulated by Master Nguyen Anh Tuan, who simulated and offered solutions to improve the reliability of the distribution network in Phong Dien district [19].

Since then, we realize that the requirements to ensure the quality of power supply for power companies are increasingly strict. Power supply quality in addition to voltage and frequency requirements also has requirements for continuity of power supply to customers. Following the trend of integration with the world, Vietnam Electricity needs to make quantitative commitments on the continuity of power supply to customers, especially foreign investors. Quantifying the continuity of power supply expressed in the indicators of the frequency of power outages and the total number of hours of power outage of customers in a certain period of time. From the practical requirements of the management and operation of the distribution grid, it is necessary to study the criteria for assessing the reliability of the distribution grid specified by the IEEE - 1366 standard and approved by the power companies in Vietnam. Some countries in the world used it to determine the reliability criteria of the distribution grid.

This study uses ETAP software to simulate the reliability of the electricity distribution system in Ninh Kieu district, Can Tho city, and at the same time proposes solutions to improve the reliability of the electricity distribtion system and meet the increasing demand for electricity supply to customers.

2. ELECTRICAL DISTRIBUTION SYSTEM OF NINH KIEU

Ninh Kieu district, Can Tho city is supplied with electricity from the following sources of the national power system: Ca Mau 1 and Ca Mau 2 power plants. Can Tho 150 MW power plant [20].

Can Tho 110 kV transformer station located in Ninh Kieu district currently has 2 transformers (2x63MVA) with 12 outputs 22 kV to supply power to Ninh Kieu district and a part of Binh Thuy district including wards: An Binh, An Cu, An Hoa, An Hoi, An Khanh, An Lac, An Nghiep, An Phu, Cai Khe, Hung Loi, Tan An, Thoi Binh and Xuan Khanh, in Ninh Kieu district, An Thoi and Bui Huu Nghia wards in Binh Thuy district. In the current period, with 12 plots of 22kV output, the 110kV Can Tho substation will not be additionally exposed. Long Hoa 110 kV substation currently has 2 transformers (2x40MVA) with 5 outflow 22kV supplying power mainly for Ninh Kieu district and a part of Binh Thuy and Bui Huu Nghia districts of Binh Thuy district [20].

3. ETAP SOFTWARE

3.1 Introduction ETAP software

The software is used to design and simulate based on the available blocks to describe the operation of the system. The software is capable of analyzing and calculating system parameters such as: power distribution, calculation, etc. Short circuit calculation, stratification analysis, power system stability analysis and power system reliability assessment.

The basic reliability indicators used to evaluate the reliability of a distributed system include three reliability metrics: Average Failure Rate at Load Point λ; Average Outage Duration at Load Point r; Annual Outage Duration at Load Point U.

To assess the severity of a system outage by using the three basic metrics mentioned above, the two extended sets of metrics listed below must also be calculated.
Two extensive sets of metrics include the number and average load of customers connected at each load point in the system and the cost of customer interruptions such as SAIFI, SAIDI, CAIDI, ASAI, ASUI, EENS , ECOST and IEAR.

3.2 Simulation the IEEE 24 bus system

The detailed IEEE 24-bus system input specifications are given in [21]. The simulation results of the IEEE 24 bus system by R. Billinton and the results from the ETAP software are consistent, showing that the ETAP software is reliable and can be used to simulate large systems in Figure 1.

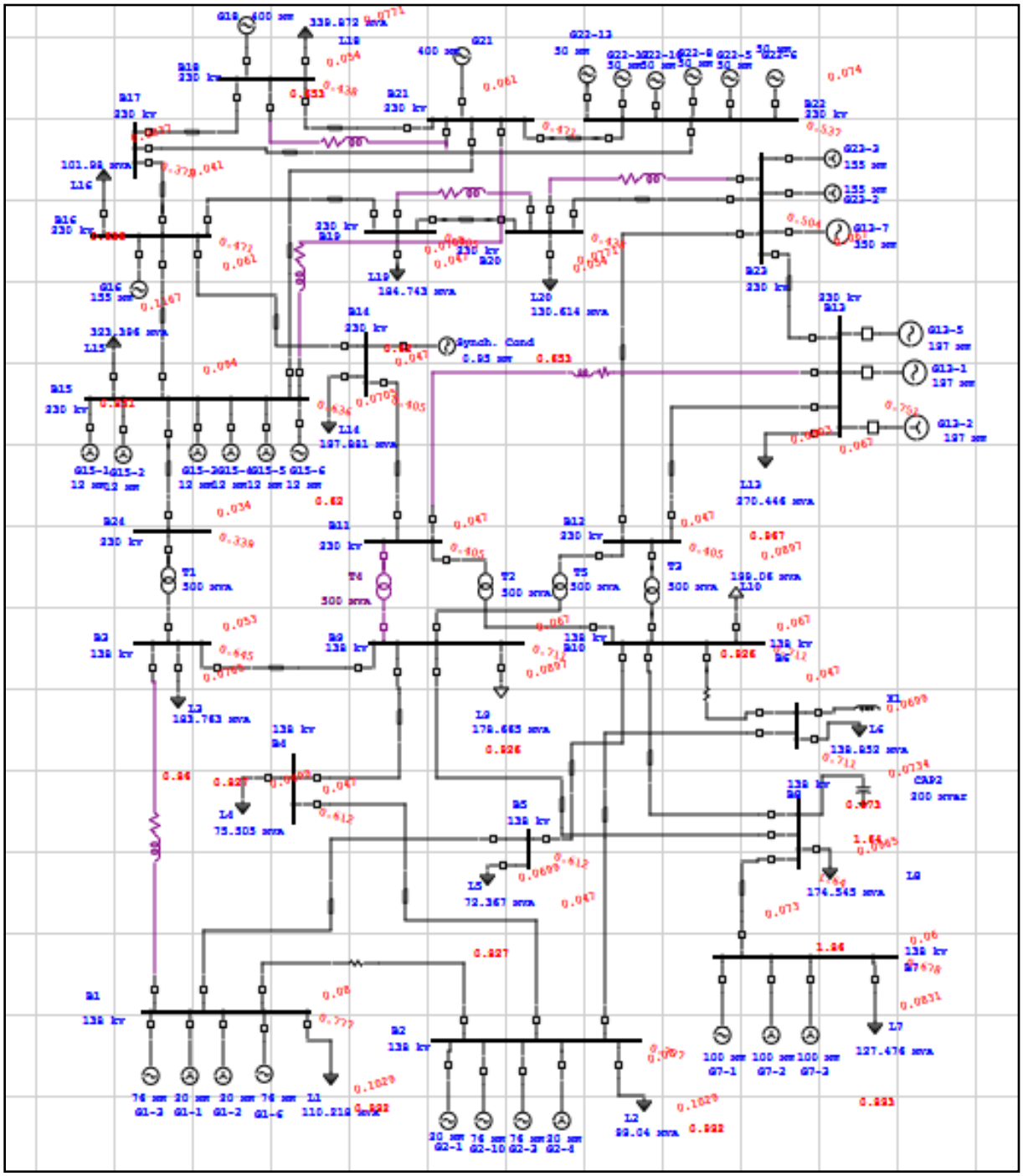

Figure 1: Reliability simulation by etap software of the system IEEE 24 bus

Table 7.13. Bus and System EENS, EIC, and IEAR for the IEEE MRTS for the Base Case

Bus No. or system	EENS (MWh/yr)	EIC (k$/yr)	IEAR ($/kWh)
1	0.00	0.00	
2	0.00	0.00	
3	259.96	160.98	0.619
4	0.00	0.00	
5	0.00	0.00	
6	41.97	21.62	0.515
7	32.42	16.69	0.515
8	0.00	0.00	
9	61.16	32.32	0.528
10	78.87	41.47	0.525
13	32.06	16.51	0.515
14	1.13	1.15	1.018
15	2.66	2.72	1.023
16	66.10	69.57	1.052
18	76.24	78.78	1.033
19	664.96	691.84	1.040
20	574.43	597.92	1.041
System	1891.96	1731.57	0.915

SUMMARY

System Indexes

ACCI	kVA / customer
AENS	111.2704 MW hr / customer.yr
ALII	kVA pu
ASAI	0.9999 pu
ASUI	0.00008 pu
CAIDI	10.940 hr / customer interruption
CTAIDI	hr / customer
ECOST	1,726,213.00 $ / yr
EENS	1891.597 MW hr / yr
IEAR	0.913 $ / kW hr
SAIDI	0.6720 hr / customer.yr
SAIFI	0.0614 f / customer.yr

Figure 2: Reliability results of R. Billinton and ETAP software [21]

4. SIMULATION OF NINH KIEU ELECTRICAL DISTRIBUTION SYSTEM

From the existing system, the study proposes to develop more busbars, build 02 underground lines to supply power to Ninh Kieu district's power grid, build 02 new lines to connect the loop, underground 10 routes to improve reliability. The results of simulation of reliability of the distribution grid system in Ninh Kieu district after renovation show that, after the renovation, the reliability index from the system increased, showing that the method aimed at improving the reliability achieved high results, from which it can be put into practice to improve reliability, the resulting SAIFI index is 0.7955 f/customer.yr, SAIDI is 2.9413 hr/customer.yr, CAIDI is 3,698 hr/customer interruption, ECOST index is 365,044.9 $/yr and EENS number 700,918 MW hr/yr as showed in Figure 3.

SUMMARY

System Indexes

ACCI	kVA / customer
AENS	7.6465 MW hr / customer.yr
ALII	kVA pu
ASAI	0.9995 pu
ASUI	0.00049 pu
CAIDI	6.451 hr / customer interruption
CTAIDI	hr / customer
ECOST	641,998.30 $ / yr
EENS	1016.990 MW hr / yr
IEAR	0.631 $ / kW hr
SAIDI	4.3006 hr / customer.yr
SAIFI	0.6667 f / customer.yr

SUMMARY

System Indexes

ACCI	kVA / customer
AENS	5.2701 MW hr / customer.yr
ALII	kVA pu
ASAI	0.9997 pu
ASUI	0.00034 pu
CAIDI	3.698 hr / customer interruption
CTAIDI	hr / customer
ECOST	365,044.90 $ / yr
EENS	700.918 MW hr / yr
IEAR	0.521 $ / kW hr
SAIDI	2.9413 hr / customer.yr
SAIFI	0.7955 f / customer.yr

Figure 3: Reliability results of the electricity distribution system in Ninh Kieu district

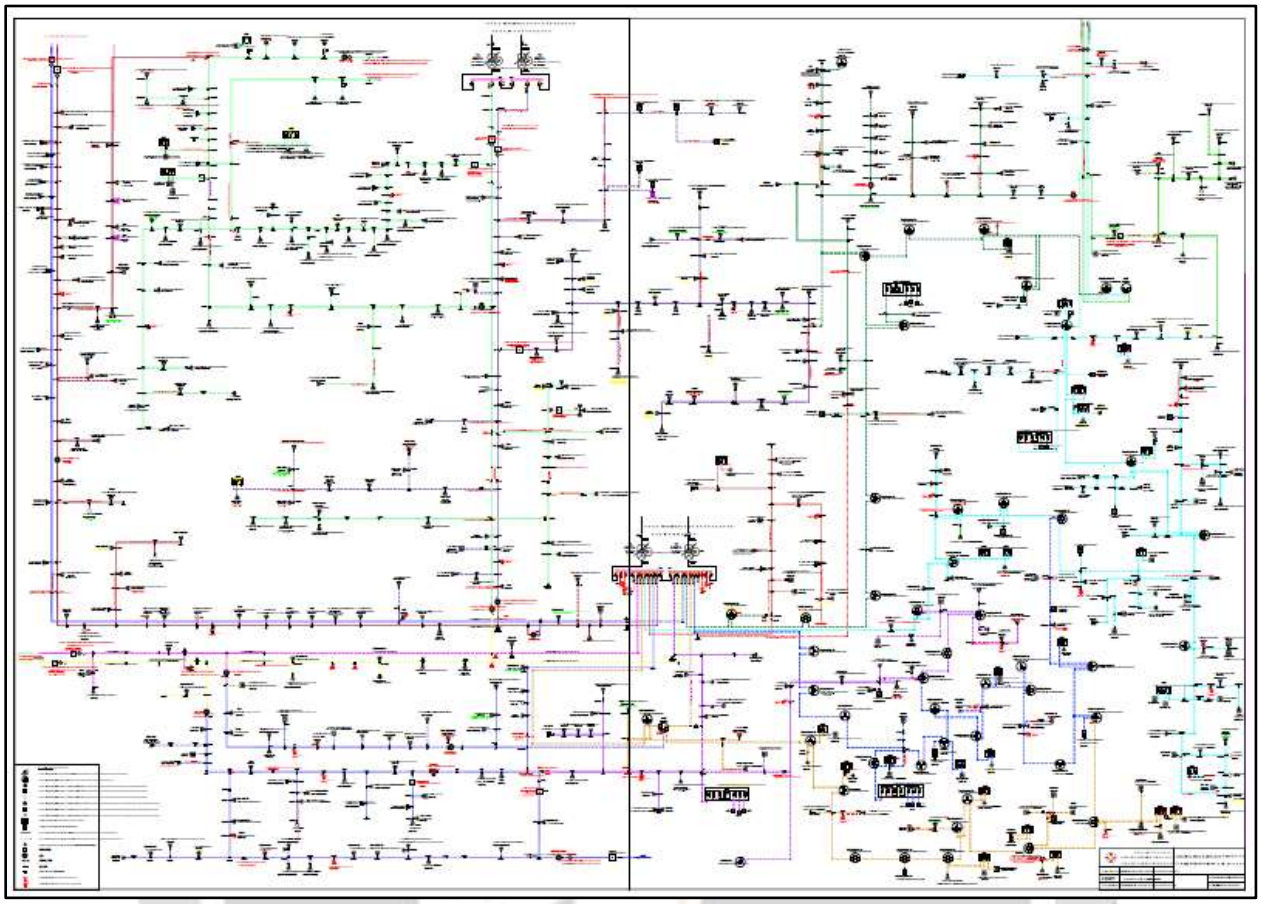

Figure 4: Ninh Kieu's electrical distribution system

5. CONCLUSIONS

The simulation study on the reliability of Ninh Kieu district distribution network by ETAP software gives the following results:

- Evaluate all system reliability indicators when using standard IEEE 24 Bus system of R. Billinton. The simulation results by ETAP software coincide with the results of R. Billinton, specifically the EENS index is 1891.59 MW hr/yr, the IEAR index is $0.913/kWhr, the ECOST index is $1716.213/yr.

- Research and propose solutions to improve the reliability of Ninh Kieu district's power system such as: undergrounding lines, developing exposed 110 kV station, line 480CT to create a loop, underground from 477CT to 473HP to create circuit loop, underground route 472CT to 471 HP, underground route 473CT to 471HP, underground route Xuan Khanh market to Quang Trung bridge, underground route from Vo Van Kiet street to Ninh Kieu district.

- Simulate the distribution system of Ninh Kieu district before and after renovation. The results show that the system reliability is consistent with the actual operation and the reliability indexes are significantly improved, specifically CAIDI is 3,698 hr/customer.interruption, SAIDI index is 2.9413 hr/customer.yr, SAIFI is 0.7955 f/customer.yr, EENS is 700,918 MW hr/yr and ECOST is 365,044.90$/yr.

6. REFERENCES

[1] Geol, L. & Billinton R. ―Determination of Reliability Worth for Distribution System Planning‖, IEEE Transactions on Power Delivery, (July 1994), Vol. 9, No. 3, pp. 1577-1583, (1994).

[2] Brown, R. E. ―Distribution Reliability Assessment and Reconfiguration Optimization‖, *IEEE Transmission and Distribution Conference and Exposition*, Vol. 2, ISBN 0780372859, USA, October 2001, Atlanta, pp. 994-999, (2001). International Conference on Advanced in Management and Technology (ICAMT-2020) November/2020

[3] Bin, Y.; Xiu-Li W.; Bie Zhao-Hong, B. & Xi-Fan, W. ―Network Reconfiguration of Distribution System for Reliability Worth Enhancement‖, *Proceedings of International Conference on Power System Technology*, Vol. 4, pp. 2547-2550, ISBN 978-0-852-96748-5 , China, October 2002, Kunming, (2012).
[4] Somporn Sirisumrannukul. ―Distribution System Network Reconfiguration for Reliability Worth Enhancement by using Simulated Annealing‖, Theory with Applications, Rui Chibante (Ed.), (2010)
[5] T. K. Vrana, E. Johansson, ―Overview of Power System Reliability Assessment Techniques‖, 21, rue d'artois, F-75008 PARIS , (2011).
[6] K. Alekhya, P. Murthy and C. Bhargava. ―Assessment of Reliability for Distribution Feeders on the Basis of Cost Analysis‖, Bonfiring International Journal of Power Systems and Integrated Circuits, Vol.1, pp. 15-19, (2011).
[7] Bowen Hua, Haipeng Xie, Yongkai Zhang and Zhaohong Bi. ―Reliability Evaluation of Distribution Systems by Considering Demand Response. School of Electrical Engineering‖, Xi'an Jiaotong University Application of IEEE Std 1366™-, (2012).
[8] Sudip Manandhar,‖ Reliability Assessment of Smart Distribution System and Analysis of Automatic Line Switches‖, The University of Tennessee at Chattanooga Chattanooga, Tennessee, May (2013).
[9] S Chandrashekhar Reddy, P.V.N.Prasad, A. Jaya Laxmi. ―Reliability Improvement of Distribution System: A Hybrid Approach Based on GA and NN‖, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-6, January (2013).
[10] V.Ashok, Harikrishna K.V, P.Chandhra Shekar, T.Raghunatha, C.P.Jairam, ―Performance Assessment in Power Distribution System Based on Reliability Indices‖, World Academy of Science, Engineering and Technology 74, (2013).
[11] Zoran Kovač, Goran Knežević, Danijel Topić. ―Modeling of Power System Reliability Assessment‖, 1, 93-98, (2013).
[12] Thesis Evaluation of reliability and solutions to improve the reliability of medium voltage power grids in Tuyen Quang province.
[13] Thesis Evaluation of reliability of power system in Hau Giang province by Master Tran Ngoc Nam.
[14] Thesis Evaluation of the reliability of the distribution grid in Phu Tho province by Master Tran Trang Nguyen.
[15] Thesis Calculation and analysis of the reliability of the power supply system and the evaluation of the efficiency of the segmentation devices by Master Pham Thi Vuong.
[16] Evaluation of the reliability of the power distribution grid in Hue city according to IEEE 1366 standard of Master Tran Thi Thuy Trang.
[17] Evaluation of power supply reliability of 220 kV transmission grid managed and operated by Power Transmission Company 3 by Master Pham Minh Dong.
[18] Calculating and analyzing the reliability of the power supply system and proposing solutions to improve the reliability of the power grid in Long Ho district, Vinh Long province by Master Le Hong Nhat Huy.
[19] Simulating the reliability of the power supply and distribution system in Phong Dien district, Can Tho city, by Master Nguyen Anh Tuan, he simulated and offered solutions to improve the reliability of the distribution network in Phong Dien district.
[20] Can Tho Power Company.
[21] Roy Billinton and Wenyuan Li, 1994 "Reliability Assessment of Electric Power Systems Using Monte Carlo Methods".