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Power loss reduction and reliability improvement of a large-scale electrical distribution system using network reconfiguration

Arun Onlam, Daranpob Yodphet, Apirat Siritaratiwat, Rongrit Chatthaworn , Chayada Surawanitkun and Pirat Khunkitti *

Department of Electrical Engineering, Faculty of Engineering, Khon Kaen University 40002, Thailand.

Abstract

Network reconfiguration of an electrical distribution system is an outstanding technique to improve the performance of a distribution system. The main factors indicating the performance of the system are the electrical power loss and the system reliability. In this paper, the multi-objective reconfiguration of a large-scale electrical distribution system located in Khon Kaen province, Thailand is proposed by using the Enhanced Genetic Algorithm. The total electrical power loss, system average interruption frequency index, system average interruption duration index, energy not supplied and the total cost are analyzed as the objective functions. The results show that the power loss of the illustrative system is significantly reduced as compared to the initial configuration. Furthermore, the reliability indices of the distribution system can be improved, while the total cost is decreased. Thus, it is indicated that the overall performance of the particular distribution system is significantly improved after network reconfiguration, which can be utilized for distribution system expansion planning.

Keywords: multi-objective function reconfiguration, genetic algorithm, optimal total cost, optimal distribution power system

1. Introduction

In electrical distribution systems, electrical power loss and system reliability are the main factors indicating the performance of the system [1]. Meanwhile, economic factors for the system also need to be carefully optimized, as it is widely known that these factors depend mainly on the power loss of the system. The network reconfiguration of electrical distribution systems is one effective technique to improve the performance of the system, i.e. power loss reduction, reliability improvement, load balancing, enhanced benefit/cost ratio, switching maneuvers and voltage profile enhancement [2]. The network reconfiguration is a procedure that changes the status of tie-line and section switches, which can alter the electrical power flow of the system. Since the load demand of the distribution system is always changing over time, this procedure can essentially handle the system alternation.

Several procedures have been proposed for optimizing reconfiguration problems, which are mostly multi-objective with nonlinear scale. The meta-heuristic methods are extensively known to be effective methods for solving those problems; the main advantage of these methods is their robust search of the solution space [3]. Many meta-heuristic algorithms have been proposed to solve the network reconfiguration problem for both single objective and multi-objectives, such as the Genetic Algorithm (GA), the Ant Colony Search Algorithm (ACSA) [3], the Simulated Annealing Algorithm (SA) [4], Tabu Search (TS) [5], Particle Swarm Optimization (PSO) [6], the Shuffled Frog Leaping Algorithm (SFLA) [7], and Honey Bee Mating Optimization (HBMO) [8].

* Manuscript received July 23, 2018; revised November 30, 2018.
Corresponding author. Tel.: +66-86-636-5678; *E-mail address:* piratkh@kku.ac.th.
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In particular, GA has been one of the common methods used to solve optimization problems. The advantage of this algorithm is its ability to efficiently solve for discrete variables and non-linear, non-differential, non-continuous problems. However, there are still some limitations to GA to solve a large-scale electrical distribution system problem, due to the complexity and the radial topology constraints of the systems [9-12]. Accordingly, several methods based on GA have been developed to overcome these limitations, i.e. the Adaptive Genetic Algorithm (AGA) and the Enhanced Genetic Algorithm (EGA) [13, 14]. The AGA is appropriate for solving the multi-objective reconfiguration of distribution systems. The idea of this method is to improve the circumstances of all nodes connected to a power supply, and avoid searching for isolated interior nodes by creating the feasible individuals using graph theory, which results in a short computational time with optimal solutions. Nevertheless, in a large-scale electrical distribution system, system complexity is still the main problem for the AGA. Then, D.-L. Duan et al. proposed the EGA by applying the Kruskal graph theory to the crossover operation of the GA. It was found that the EGA method could guarantee a radial topology of the distribution system, and avoid the tedious mesh checking. Therefore, the EGA has become an appropriate algorithm for solving a complicated electrical distribution system problem.

In this paper, we propose the network reconfiguration for an electrical distribution system by using the EGA. A practical distribution system in Khon Kaen province, Thailand is used in the reconfiguration. The multiple objectives of the network reconfiguration include electrical power loss reduction and reliability improvement. The reliability indices focused on are system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI) and energy not supplied (ENS). The MATLAB program is utilized in the simulations.

2. Problem Formulation

The multi-objective electrical distribution system reconfiguration is to minimize the real power loss while maximizing the reliability indices under various operating constraints. The electrical system is considered as a balanced three-phase load, while all loads are assumed as constant power loads. Each objective function is formulated as below.

2.1. Real power loss of distribution systems

The real power loss of distribution systems is expressed as (1),

$$P_{loss} = \sum_{i=1}^{i} \frac{R_i\left(P_i^2 + Q_i^2\right)}{V_i^2} \tag{1}$$

subject to the following constraints:

- $I_i \le I_i^{\max}$ (2)
- $V_{\min} \le V_i \le V_{\max}$ (3)
- $g_i(I, \mathrm{k}) = 0, g_v(V, k) = 0$ (4)

where R_i is the resistance of the i^{th} branch, P_i, Q_i, I_i and V_i are real power, reactive power, current magnitude and voltage at the sending end of the i^{th} branch, respectively. $I^{\max}$, $V_{\min}$ and $V_{\max}$ are maximum current, minimum voltage and maximum voltage, respectively, while $g_i(I,k), g_v(V,k)$ represent Kirchhoff's voltage and current laws, respectively.

2.2. Reliability indices of electrical distribution system

As mentioned above, the reliability indices used to evaluate the electrical distribution system reliability are SAIFI, SAIDI and ENS [2]. These indices are generally used to indicate the performance of a distribution system when transmitting continuous electrical power to all customers. The SAIFI, SAIDI and ENS can be calculated as in the following equations.

$$SAIFI = \frac{\sum \lambda_i N_i}{\sum N_i} \tag{5}$$

$$SAIDI = \frac{\sum U_i N_i}{\sum N_i} \tag{6}$$

$$ENS = \sum_{i=1}^{N} L_{avg(i)} U_i \tag{7}$$

where λ_i is the system failure rate per year at load point i, U_i is the annual outage duration per year at load point i, N_i is the total number of consumers at load point i and $L_{avg(i)}$ is the average load connected to load point i.

2.3. Total lost cost

Another important objective function for the network reconfiguration is to minimize the total cost of the system. In this work, the total cost includes the total lost cost, utility cost and customer interruption cost, as expressed in (8). It is noted that the utility cost is the cost lost during system operation and when a failure occurs, while the customer interruption cost is the cost lost when the electrical supply is interrupted. The total lost cost can be written as (8),

$$TC = TLC + UIC + CIC/kWh + CIC/Time \tag{8}$$

where TC denotes the total cost for the electrical distribution system. The cost of annual power loss (TLC) can be expressed as follow [15]:

$$TLC = C_p \sum_{d=1}^{365} \sum_{t=1}^{24} P_{loss} \tag{9}$$

where C_p represents the energy cost (Thai Baht/kWh). P_{loss} is defined as the power loss.

When an interruption occurs in the electrical distribution system, where the power supply utility and customer use are interrupted, the utility interruption cost (UIC) can be derived as follows [16],

$$UIC = C_p \times ENS \tag{10}$$

CIC/kWh is defined as the customer interruption cost per kilowatt-hour, given as [17],

$$CIC/kW = ENS \times IEAR \tag{11}$$

where $IEAR$ is defined as the interrupted energy assessment with the rate of 60.165 Thai Baht/kWh.

$CIC/Time$ is defined as customer interruption cost per time, $UtilityCost$ and $CustumerOutageCost$ are defined as total utility cost and total costumer outage cost written as follows [17]:

$$CIC/Time = SAIFI \times ICPE \tag{12}$$

$$UtilityCost = TLC + UIC \tag{13}$$

$$CustumerOutageCost = CIC / kWh + {CIC}/{Time} \tag{14}$$

where $ICPE$ is defined as the interruption cost per event (62,723 Thai Baht/time).

3. Reconfiguration Procedures of an Electrical Distribution System

In the network reconfiguration of the Khon Kaen electrical distribution system, the EGA is used to solve this problem due to its outstanding properties for solving large-scale systems. The EGA is initialized with a population size of 30 and a maximum generation of 100. As shown in Fig. 1, the procedure for the EGA can be summarized into 7 steps, as follows [12-14]:

Step 1: Read data about the distribution system to define a loop vector population by codification. Then, formulate common branch vectors and prohibited group vectors using graph theory.

Step 2: Generate the initial population with the fitness function.

Step 3: Select two individuals as parents by the selection operation using tournament selection.

Step 4:Search for optimal solutions for the set of open switches by updating the generations with the crossover process. This operation is modified by the Kruskal theory to create a descendant.

Step 5: Check for violated rules of the radial topology and correct using the loop vector, common branch vectors and prohibited group vectors.

Step 6: Characterize the load flow and reliability.

Step 7: Repeat steps 3-6 until the number of iterations is satisfied.

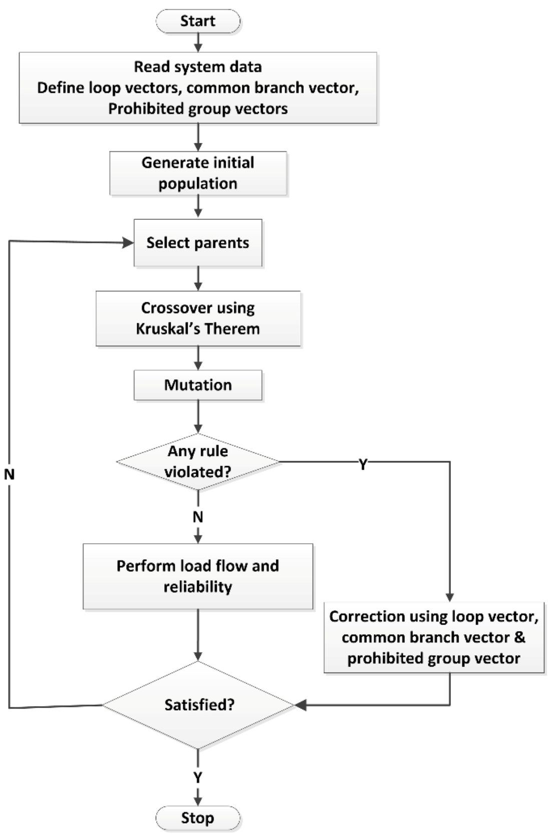


Fig. 1. Overview of the procedure for the EGA algorithm

4. Reconfiguration Results for Khon Kaen Electrical Distribution System

Fig. 2 shows the practical distribution system for Khon Kaen province, Thailand consisting of 123 buses with 144 branches. The rated voltage of this system is 22 kV. The power system and reliability data of this particular distribution system are indicated in **Appendix A**. In the simulations, it is assumed that the load data has a constant value; the total active load power is 87.28 MW with 45.98 MVAR reactive load power. The initial power loss of this system is 1,454 kW. The loss factor of 0.76 is also included in the calculations, which is obtained from the load factor of the practical distribution system. The number of initial normally open switches of the distribution system is 22, which will be equal to those after reconfiguration.

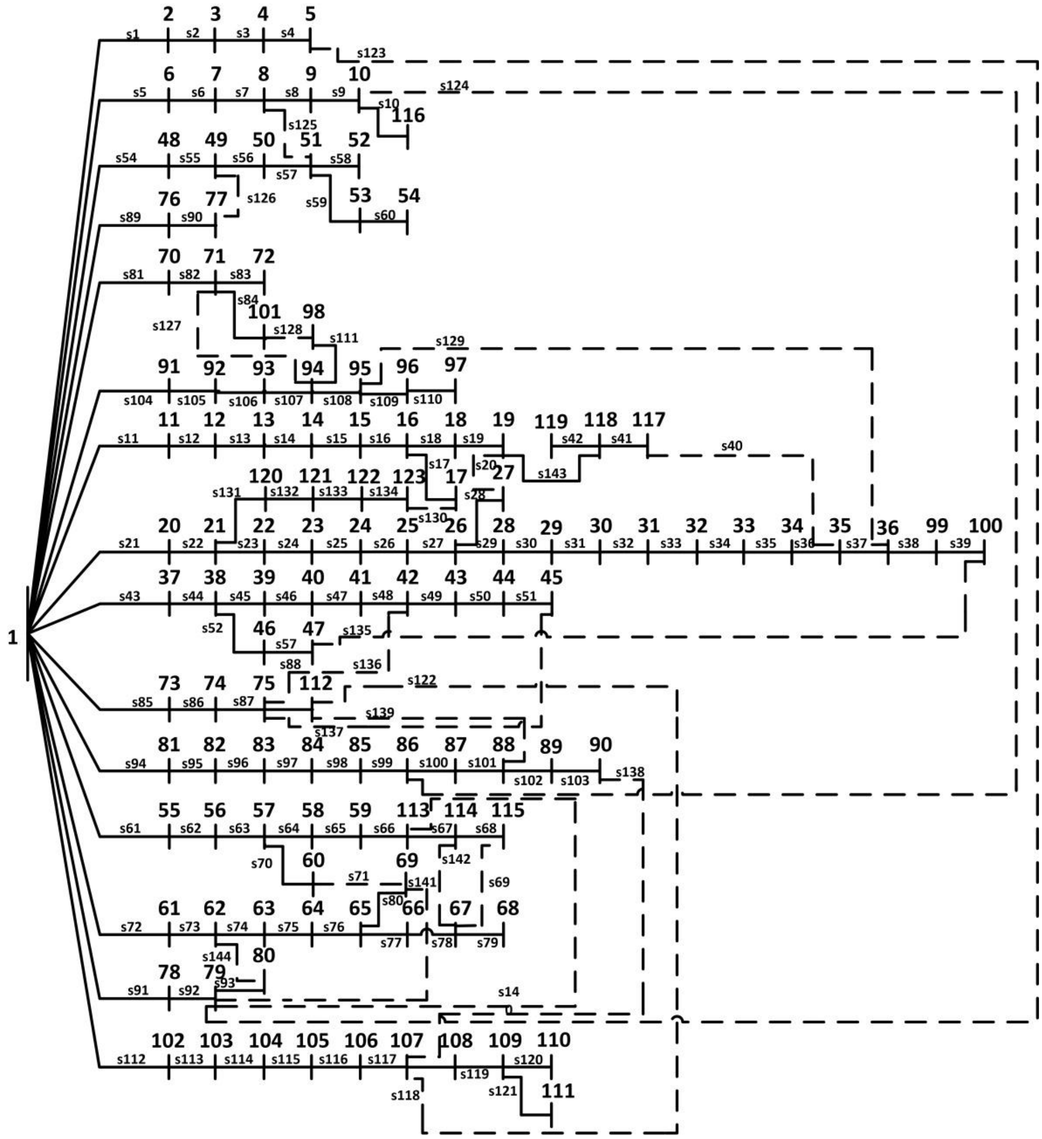


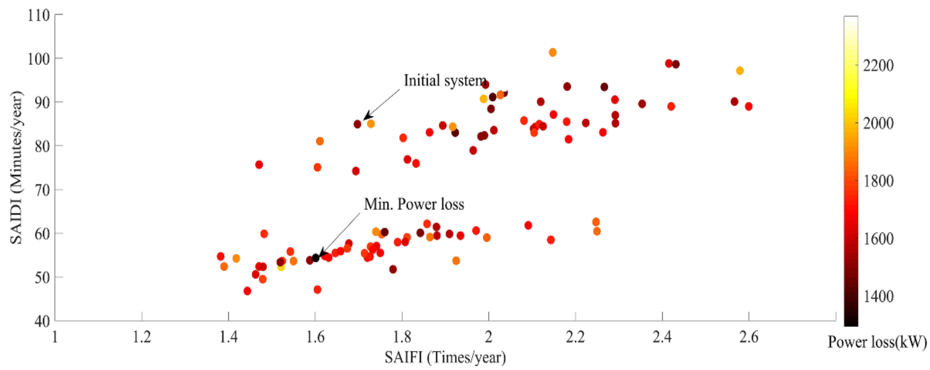
Fig. 2. The practical 123-bus distribution system in Khon Kaen province, Thailand

The simulation results for the network reconfiguration are shown in Table 1. The objective functions indicated in each row of the table include total power loss (kW), SAIFI (T/Y), SAIDI(M/Y), ENS (Kwh), utility cost (Baht), customer outage cost (Baht), total cost (Baht) and opened switches. Meanwhile, the focused objective functions are indicated as 4 cases in each column, including min. total power loss (case 1), min. SAIFI (case 2), min. SAIDI (case 3) and min. total cost (case 4). As shown in Table 1, the total power losses, SAIFI, SAIDI, ENS and the total cost in case 1 are less than those of the base case. In case 2 and case 3, it is seen that SAIFI, SAIDI, ENS are less than the base case, whereas the total power loss and the total cost are lower than the base case. Similarly to case 1, the total power losses, SAIFI, SAIDI, ENS and the total cost in case 4 are less than the those of the base case. In addition, ENS in every case has decreased from the base case. It was found that case 1 indicates the minimum utility cost. This is because the power loss has the most significant impact on the utility cost. Moreover, the customer outage cost is decreased from the base case in every case due to a reduction of SAIFI and ENS.

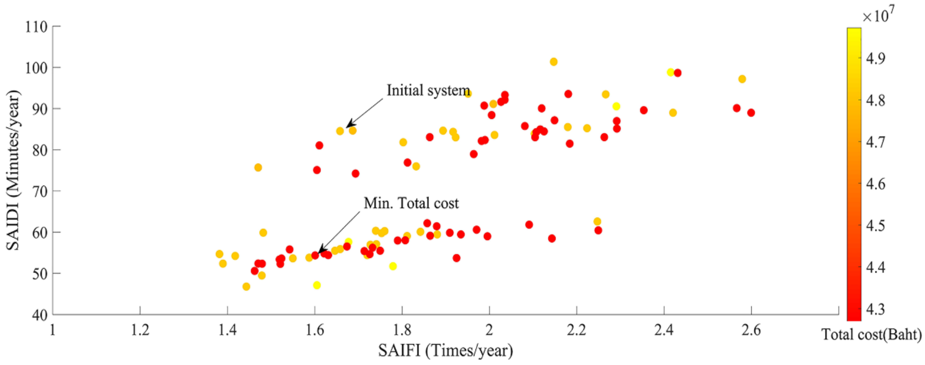
From the above discussions, it is concluded that the objective functions in case 1 and case 4 can provide the best results for network reconfiguration, because overall worthiness of the system is improved from the base case. In particular, it is found that the total power loss, the total cost, SAIFI and SAIDI of case 1 and case 4 are reduced about 11.02%, 12.15%, 3.6% and 53.33 % from the base case, respectively.

Table 1. Optimal solutions of network reconfiguration results with different objectives.

Focused objective function	Initial configuration (Base case)	Min. total power loss (case 1)	Min. SAIFI (case 2)	Min. SAIDI (case 3)	Min. total cost (case 4)
Total power loss (kW)	1,454.60	1,294.25	1,884.69	1,729.74	1,294.25
SAIFI (times/year)	1.66	1.60	1.33	1.53	1.60
SAIDI (minutes/year)	86.28	54.33	56.79	50.49	54.33
ENS (Kwh)	82,682.51	64,827.23	70,013.62	68,466.77	64,827.23
Utility cost (Baht)	43,504,888.61	38,679,532.33	56,242,281.03	51,632,492.32	38,679,532.33
Customer outage cost (Baht)	5,079,026.21	4,000,749.69	4,295,889.15	4,215,279.82	4,000,749.69
Total cost (Baht)	48,583,914.82	42,680,282,02	60,538,170.18	55,847,772.14	42,680,282.02
Opened switches.	20,40,69,71, 122,123,124,125, 126,127,128,129, 130,135,136,137, 139,138,140,144, 142, 144	17,19,35,41, 47,51,65,67, 68,80,100,103, 111,122,123,124, 125,126,127,135, 141,144	8,19,26,29, 38,50,57,67, 80,87,90,100, 103,106,122,123, 127,130,140,141, 142,144	9,26,32,38, 40,64,69,76, 80,89,103,107, 111,115,123,125, 131,136,137,139, 141, 144	17,19,35,41, 47,51,65,67, 68,80,100,103, 111,122,123,124, 125,126,127,135, 141,144



(a)



(b)

Fig. 3. Relationships between SAIDI and SAIFI and different values of (a) power loss and (b) total cost

Figs. 3(a) and 3(b) show the relationships between SAIDI and SAIFI for different values of power loss and total cost, respectively. When focusing on minimum power loss and minimum total cost as the objective functions, it is found that the power loss and the total cost of the system can be significantly reduced from the initial value, while the reliability indices of the system are increased. Also by focusing on the minimum SAIFI or minimum SAIDI, the system reliability can be improved from the initial configuration. However, the power loss of the system in these cases is increased. It is thus concluded that the minimal power loss and minimal total cost are the most suitable objective functions for the network reconfiguration of this particular distribution system.

5. Conclusion

In this paper, the multi-objective reconfiguration of a large-scale electrical distribution system of Khon Kaen province, Thailand is presented in order to improve the performance of the distribution system. We focused on four objectives being minimized total power loss, minimized SAIFI, minimized SAIDI and minimized total cost under distribution system constraints. It was found that the optimal solution for the network reconfiguration of this system occurs when the minimized total power loss and minimized total cost are optimized. The results show that the total power loss, total cost, SAIFI and SAIDI of the reconfigured system are reduced by 11.02%, 12.15%, 3.6% and 53.33 % respectively from the initial configuration. Moreover, the pareto front indicates that when the minimized power loss and total cost occur, the reliability indices of the distribution system can be significantly improved. However, the system analysis indicates more total power loss than the initial value when the minimized reliability indices are focused on. From the results, it is seen that the overall performance of this particular system can be improved by network reconfiguration, which also reduces the expenses regarding system operation. The results can also be used to provide optimal solutions for network planning for further system expansion.

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References

[1] López JC, Lavorato M, Rider MJ. Optimal reconfiguration of electrical distribution systems considering reliability indices improvement. *International Journal of Electrical Power & Energy Systems*, 2016; 78:837-845.

[2] Sultana B, Mustafa MW, Sultana U, Bhatti AR. Review on reliability improvement and power loss reduction in distribution system via network reconfiguration. *Renewable and Sustainable Energy Reviews*, 2016; 66:297-310.
[3] Su CT, Chang CF, Chiou JP. Distribution network reconfiguration for loss reduction by ant colony search algorithm. *Electric Power Systems Research*, 2005; 75(2-3):190-199.
[4] Jeon YJ, Kim JC, Kim JO, Shin JR, Lee KY. An Efficient Simulated Annealing Algorithm for Network Reconfiguration in Large-Scale Distribution Systems. *IEEE Transactions on Power Delivery*, 2002; 17(4):1070-1078.
[5] Abdelaziz AY, Mohamed FM, Mekhamer SF, Badr MAL. Distribution system reconfiguration using a modified Tabu Search algorithm. Electric Power Systems Research, 2010; 80(8):943-953.
[6] Yoshida H, Kawata K, Fukuyama Y, Takayama S, Nakanishi Y. A Particle swarm optimization for reactive power and voltage control considering voltage security assessment. *IEEE Transactions on Power Systems*, 2000; 15(4):1232-1239.
[7] Kavousi-Fard A, Akbari-Zadeh MR. Reliability enhancement using optimal distribution feeder reconfiguration. *Neurocomputing*, 2012; 106:1-11.
[8] Olamaei J, Niknam T, Arefi SB. Distribution feeder reconfiguration for loss minimization based on modified honey bee mating optimization algorithm. *Energy Procedia*, 2011; 14:304-311.
[9] Nara K, Shiose A, Kitagawa M, Ishihara T. Implementation of Genetic Algorithm for Distribution Systems Loss Minimum Reconfiguration. *IEEE Transactions on Power Systems*, 1992; 7(3):1044-1051.
[10] Zhu JZ. Optimal reconfiguration of electrical distribution network using the refined genetic algorithm. *Electric Power Systems Research*, 2002; 62(1):37-42.
[11] Mendoza JE, López ME, Coello Coello CA, López EA. Microgenetic multiobjective reconfiguration algorithm considering power losses and reliability indices for medium voltage distribution network. *IET Generation, Transmission & Distribution*, 2009; 3(9):825-840.
[12] Gupta N, Swarnkar A, Niazi KR, Bansal RC. Multi-objective reconfiguration of distribution systems using adaptive genetic algorithm in fuzzy framework. . *IET Generation, Transmission & Distribution*, 2010; 4(12):1288-1298.
[13] Gupta N, Swarnkar A, Niazi KR. Distribution network reconfiguration for power quality and reliability improvement using Genetic Algorithms. *International Journal of Electrical Power & Energy Systems*, 2013; 54:664-671.
[14] Duan DL, Ling XD, Wu XY, Zhong B. Reconfiguration of distribution network for loss reduction and reliability improvement based on an enhanced genetic algorithm. *International Journal of Electrical Power & Energy Systems*, 2014; 64:88-95.
[15] Yin SA, Lu CN. Distribution feeder scheduling considering variable load profile and outage costs. *IEEE Transactions on Power Delivery*, 2009; 24(2):652-660.
[16] Allan RN, Da Silva MG. Evaluation of reliability indices and outage costs in distribution systems. *IEEE Transactions on Power Systems*, 1995; 10(1):413-419.
[17] Teng JH, Lu CN. Feeder-switch relocation for customer interruption cost minimization. *IEEE Transactions on Power Delivery*, 2002; 17(1):254-259.

Appendix A:

Table A.1 Power system and reliability data of a distribution system in Khon Kaen province, Thailand.

Branch No.	Fbus	Tbus	R	X	Failure rate (Times/Year)	Duration Time (Minutes/Year)	Bus No.	P Load (kW)	Q Load (kVar)	No. Customers
1	1	2	0.0000	0.0007	2.33	118	1	0.000	0.000	0
2	2	3	0.1345	0.1906	2.33	118	2	0.000	0.000	0
3	3	4	0.2146	0.3061	2.33	118	3	0.491	0.259	1,227
4	4	5	0.0245	0.0866	2.33	118	4	1.779	0.937	2,000
5	1	6	0.0000	0.0006	3.33	81.33	5	2.402	1.265	2,773
6	6	7	0.1165	0.1651	3.33	81.33	6	0.000	0.000	0
7	7	8	0.0840	0.1191	3.33	81.33	7	1.964	1.035	374
8	8	9	0.1749	0.2479	3.33	81.33	8	0.424	0.224	5
9	9	10	0.0927	0.1314	3.33	81.33	9	0.906	0.477	1,460
10	10	116	0.2381	0.3375	3.33	81.33	10	3.048	1.606	1,388
11	1	11	0.0001	0.0014	0.33	7.33	11	0.000	0.000	0
12	11	12	0.0869	0.1231	0.33	7.33	12	1.714	0.903	142
13	12	13	0.0020	0.0029	0.33	7.33	13	0.000	0.000	0
14	13	14	0.0085	0.0120	0.33	7.33	14	0.166	0.087	2
15	14	15	0.0032	0.0045	0.33	7.33	15	0.000	0.000	0
16	15	16	0.0035	0.0049	0.33	7.33	16	0.788	0.415	4
17	16	17	0.0117	0.0165	0.33	7.33	17	0.139	0.073	4

Branch No.	Fbus	Tbus	R	X	Failure rate (Times/Year)	Duration Time (Minutes/Year)	Bus No.	P Load (kW)	Q Load (kVar)	No. Customers
30	28	29	0.0001	0.0013	1.67	34.33	30	0.000	0.000	0
31	29	30	0.0000	0.0009	1.67	34.33	31	0.082	0.043	25
32	30	31	0.0000	0.0000	1.67	34.33	32	0.000	0.000	0
33	31	32	0.0000	0.0000	1.67	34.33	33	0.000	0.000	0
34	32	33	0.0000	0.0004	1.67	34.33	34	0.255	0.134	1
35	33	34	0.0000	0.0010	1.67	34.33	35	0.000	0.000	0
36	34	35	0.0000	0.0006	1.67	34.33	36	4.139	2.180	642
37	35	36	0.0005	0.0092	1.67	34.33	37	0.000	0.000	0
38	36	99	0.0183	0.0260	1.67	34.33	38	2.771	1.460	1,454
39	99	100	0.0138	0.0195	1.67	34.33	39	0.734	0.387	685
40	35	117	0.0360	0.0510	1.67	34.33	40	0.872	0.459	1,242
41	117	118	0.0055	0.0078	1.67	34.33	41	0.016	0.008	2
42	118	119	0.0378	0.0535	1.67	34.33	42	0.480	0.253	321
43	1	37	0.0186	0.0263	0.33	2.67	43	0.000	0.000	0
44	37	38	0.0752	0.1066	0.33	2.67	44	0.000	0.000	0
45	38	39	0.0727	0.1030	0.33	2.67	45	0.922	0.486	1,011
46	39	40	0.0596	0.0845	0.33	2.67	46	0.308	0.162	311
47	40	41	0.0067	0.0094	0.33	2.67	47	1.217	0.641	133
48	41	42	0.0777	0.1101	0.33	2.67	48	0.000	0.000	0
49	42	43	0.0019	0.0027	0.33	2.67	49	1.626	0.856	1,309
82	70	71	0.0665	0.0942	0.67	26	82	0.681	0.359	31
83	71	72	0.0773	0.1096	0.67	26	83	0.000	0.000	0
84	71	101	0.0527	0.0747	0.67	26	84	0.395	0.208	10
85	1	73	0.0000	0.0009	2.33	57.67	85	0.627	0.330	6
86	73	74	0.1192	0.1690	2.33	57.67	86	0.008	0.004	1
87	74	75	0.2825	0.4004	2.33	57.67	87	0.000	0.000	0
88	75	112	0.0085	0.0121	2.33	57.67	88	0.199	0.105	288
89	1	76	0.0000	0.0008	0.33	30	89	1.470	0.775	3
90	76	77	0.1462	0.2073	0.33	30	90	3.088	1.627	5,062
91	1	78	0.0000	0.0006	3.33	62.67	91	0.000	0.000	0
92	78	79	0.1306	0.1851	3.33	62.67	92	0.287	0.151	101
93	79	80	0.0269	0.0381	3.33	62.67	93	0.828	0.436	446
95	81	82	0.1166	0.1653	2.67	146.67	95	1.006	0.530	258
96	82	83	0.0010	0.0014	2.67	146.67	96	0.558	0.294	205
97	83	84	0.1114	0.1579	2.67	146.67	97	0.573	0.302	336
98	84	85	0.1880	0.2665	2.67	146.67	98	0.259	0.137	426
99	85	86	0.0339	0.0481	2.67	146.67	99	0.065	0.034	85
100	86	87	0.0021	0.0030	2.67	146.67	100	0.027	0.014	42
101	87	88	0.1180	0.1672	2.67	146.67	101	2.145	1.130	1,316
102	88	89	0.0176	0.0249	2.67	146.67	102	0.000	0.000	0
103	89	90	0.2494	0.3534	6.67	462.67	103	0.522	0.275	172
104	1	91	0.0001	0.0020	0.67	10.33	104	0.507	0.267	14
105	91	92	0.0313	0.0444	0.67	10.33	105	0.061	0.032	30
106	92	93	0.0379	0.0537	0.67	10.33	106	0.322	0.170	185
107	93	94	0.0159	0.0579	0.67	10.33	107	0.087	0.046	323
108	94	95	0.0032	0.0046	0.67	10.33	108	0.000	0.000	0
109	95	96	0.0117	0.0165	0.67	10.33	109	0.000	0.000	0
110	96	97	0.0046	0.0065	0.67	10.33	110	0.595	0.313	4
111	94	98	0.0001	0.0012	0.67	10.33	111	2.618	1.379	2,411
112	1	102	0.0001	0.0018	3	101	112	0.000	0.000	0
113	102	103	0.0623	0.0883	3	101	113	0.895	0.471	688
114	103	104	0.0575	0.0814	3	101	114	0.000	0.000	0
115	104	105	0.0357	0.0506	3	101	115	1.906	1.004	3,605
116	105	106	0.2006	0.2844	3	101	116	2.811	1.481	634

117	106	107	0.1658	0.2350	3	101	117	0.930	0.490	864
118	107	108	0.0015	0.0022	3	101	118	0.057	0.030	118
119	108	109	0.0857	0.1215	3	101	119	1.096	0.577	383
120	109	110	0.0825	0.1169	3	101	120	0.000	0.000	0
121	109	111	0.2472	0.3504	3	101	121	0.067	0.035	1
122	107	112	0.0470	0.0666	3	101	122	0.000	0.000	0
123	5	79	0.0592	0.0839	3.33	62.67	123	0.000	0.000	0
124	10	86	0.0296	0.0419	2.67	146.67	-	-	-	-
125	8	51	0.1267	0.1795	3.33	81.33	-	-	-	-
126	49	77	0.1475	0.2091	0.33	30	-	-	-	-
127	71	94	0.0003	0.0066	0.67	26	-	-	-	-
128	98	101	0.0001	0.0012	0.67	26	-	-	-	-
129	95	36	0.0457	0.0648	0.67	10.33	-	-	-	-
130	17	123	0.0144	0.0204	0.33	7.33	-	-	-	-
131	21	120	0.0000	0.0002	1.67	34.33	-	-	-	-
132	120	121	0.0174	0.0246	1.67	34.33	-	-	-	-
133	121	122	0.0000	0.0002	1.67	34.33	-	-	-	-
134	122	123	0.0144	0.0204	1.67	34.33	-	-	-	-
135	47	100	0.0138	0.0195	1.67	34.33	-	-	-	-
136	75	42	0.0757	0.1073	2.33	57.67	-	-	-	-
137	75	45	0.0736	0.1043	2.33	57.67	-	-	-	-
138	90	107	0.2646	0.3751	2.67	146.67	-	-	-	-
139	88	112	0.0473	0.0670	2.67	146.67	-	-	-	-
140	79	113	0.0187	0.0265	3.33	62.67	-	-	-	-
141	79	69	0.0265	0.0376	3.33	62.67	-	-	-	-
142	67	114	0.1145	0.1622	1.33	41.67	-	-	-	-
143	19	118	0.0125	0.0177	0.33	7.33	-	-	-	-
144	62	80	0.0269	0.0381	3.33	62.67	-	-	-	-