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Potential and the Role of Dispersed Generation in Yangon, Myanmar

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Abstract

Electricity is the backbone of the development of country's economy. In Yangon as an economic center of Myanmar, high reliability power supply is the urgent issue. Yangon City uses about 44% of total supply. However, the total generation capacity is reached to its 33-47% due to aging existing power facilities, shortage of fuel for thermal power generation, and output constraint of hydropower generation in dry seasons. Therefore, in the Yangon City where the largest amount of power is demanded in Myanmar, electric power supply hardly meets demand, and load shedding is necessary in dry seasons because potential power demand largely exceeds supply. Moreover, the power transmission and distribution losses in the whole Myanmar reach about 25%, with the transmission loss 7% and the power distribution loss 18% as of 2012. Under the tight supply-demand conditions, there are high needs for improving the efficiency and enhancing electric power supply reliability by reducing the loss rate. In this paper, the solution for load shedding problem and loss reduction is investigated with considering distributed generation. And some potential of energy sources which can solve not only power shortage problem but also environmental problem are also presented. Newton-Raphson method is used for load flow analysis in MATLAB and reliability improvement by DG and feeder replacing is also approached analytically.

Keywords: loss reduction, load shedding, Yangon, Dispersed Generation, Load Flow.

1. Introduction

It is very important for power systems to meet the required power demand and to be reliable as possible. In Myanmar, distribution networks are not fully protected and interruptions occur frequently because of failures and faults in distribution networks. In the Yangon City, the demand for electric power is expected to continue to increase due to economic development, and, therefore, the securing of stable electric power supply and the enhancement of electric supply reliability have become urgent tasks. In particular, there is high need for repairing and reinforcing the existing distribution facilities in the Yangon City in order to reduce power distribution loss.

National grid is mostly depended on hydro power in Myanmar. Therefore, dispersed generations in distribution network become essential role to solve the load shedding problem. Currently, gas turbine and gas engine generations are running as DG. However, more power generations is needed to meet the demand. According to the current problems in Myanmar, large power station is difficult to install and we should not depend on the national grid totally. Thus, medium and small dispersed generation is a solution not only to reduce losses but also to solve load shedding.

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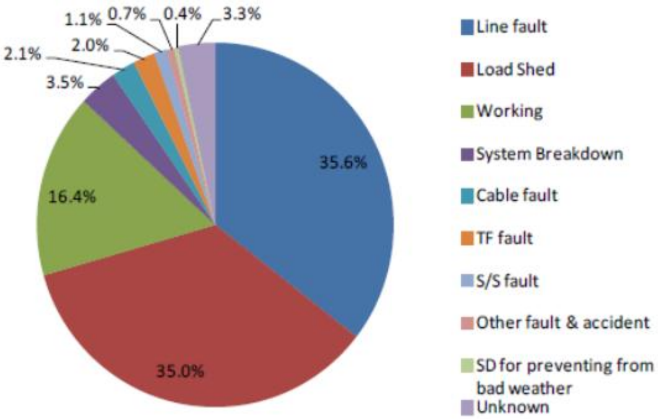

Figure.1 Percentages of Power outage in Yangon [1]

In figure .1, the percentages of power outage in Yangon distribution network is described. Most of interruption is due to load shed and line fault. Installation of DGs is a way to solve the load shed, and replacing very old feeder and using suitable protective device is a solution for line faults. Environmental impact is a major factor in the consideration of any electrical power scheme, and there is a generally accepted concern over gaseous emissions from fossil-fueled plant. As part of the Kyoto Protocol, both the EU and the UK have to reduce substantially emissions of CO2 to help counter climate change. Hence most governments have programs to support the exploitation of the so-called new renewable energy resources, which include wind power, micro-hydro, solar photovoltaics, landfill gas, energy from municipal waste and biomass generation.

According to the current condition in Yangon, dispersed generations using gas solar and municipal solid waste is one of the solution not only for electricity but also for environmental problem.

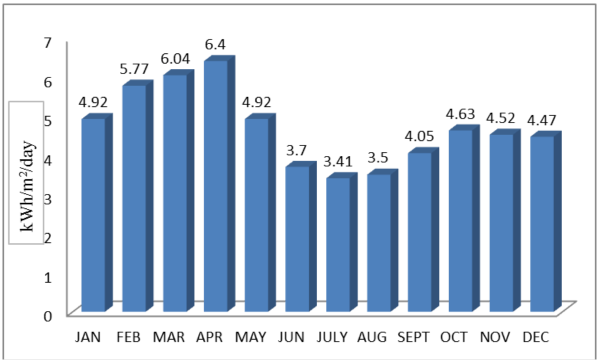

Figure.2 Solar Radiation Data in Yangon [2]

MEPE (Myanmar Electrical Power Enterprise) experimental measurements indicate that irradiation intensity of more than 5 kWh/m^2/day was observed during dry season. Monthly record is shown in Fig.2 for Yangon City [2]. The available hours of radiation is also mentioned in figure 3.

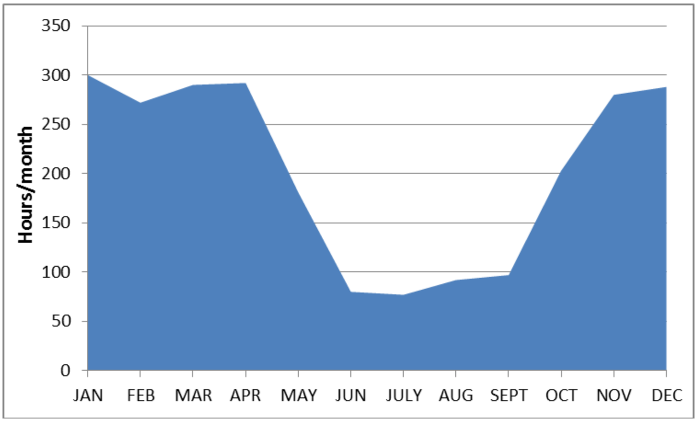

Figure.3 The available hours of radiation in Yangon [3]

Total disposal waste is 1550 tones/day in Yangon as shown in Table 1 [4]. According to the analysis of Waste to Energy Research Technology council which is founded by the Earth Engineering Center of Colombia University, the electricity can be generated 500-600kWh from one tone municipal solid waste.

Table1. System Data

No	Location of disposal site	Disposal capacity (tonnes/day)
1	Htain Bin	847
2	Htwei Chaung	612
3	Dala	10
4	Seikkyi Khanaung To	5
5	Mingalardon	25
6	Shwe Pyi Thar	50
	Total Amount of waste	1550

2. Methodology

2.1 Power Flow Analysis

For large power systems, the Newton Raphson method is found to be more efficient and practical. Thus, Newton Raphson method is recommended for use with any system as a first choice. The number of iterations required to obtain a solution is independent of the system size, but more functional evaluation are required for each iteration. The algorithm of Newton Raphson load flow calculation is shown below [5].
The injected current in term of admittance matrix,

$$I_i = \sum_{j=1}^{n} |y_{ij}||v_j| \tag{1}$$

The real and reactive power at bus i,

$$P_i = \sum_{j=1}^{n} |V_i||V_j||Y_{ij}|\cos(\theta_{ij} - \delta_i + \delta_j) \tag{2}$$

$$Q_i = -\sum_{j=1}^{n} |V_i||V_j||Y_{ij}|\sin(\theta_{ij} - \delta_i + \delta_j) \qquad (3)$$

The terms $\Delta P_i^{(k)}$ and $\Delta Q_i^{(k)}$ are,

$$\Delta P_i^{(k)} = P_i^{sch} - P_i^{k} \qquad (4)$$

$$\Delta Q_i^{(k)} = Q_i^{sch} - Q_i^{k} \qquad (5)$$

Jacobian Matrix is

$$J = \begin{bmatrix} \frac{\partial \Delta P}{\partial \delta} & \frac{\partial \Delta P}{\partial |V|} \\ \frac{\partial \Delta Q}{\partial \delta} & \frac{\partial \Delta Q}{\partial |V|} \end{bmatrix} \qquad (6)$$

$$\begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix} = J^{-1} \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} \qquad (7)$$

The new voltage magnitude and phase angle,

$$|V_i^1| = |V_i^0| + \Delta|V_i^0| \qquad (8)$$

$$\delta_i^1 = \delta_i^0 + \Delta\delta_i^0 \qquad (9)$$

where, V is voltage magnitude and δ is phase angle.

2.2 Line Flow and Lossess

After the iterative solution of bus voltages, the next step is the computation of line flows and line losses. Consider the line connecting the two buses i and j in figure 4. The line current I_{ij}, measured at bus i and defined positive in the direction.

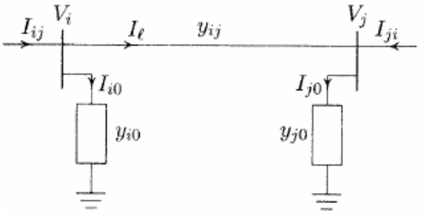

Figure. 3 Line model for calculating line flows

$$I_{ij} = I_l + I_{i0} = y_{ij}(V_i - V_j) + y_{i0}V_i \qquad (10)$$

$$I_{ji} = -I_l + I_{j0} = y_{ij}(V_j - V_i) + y_{j0}V_j \qquad (11)$$

The complex power S_{ij} from bus i to j and S_{ji} from bust j to i are :

$$S_{ij} = V_i I_{ij}^{*} \qquad (12)$$

$$S_{ji} = V_j I_{ji}^{*} \qquad (13)$$

The power loss in line i-j is the algebraic sum of the power flows determined from above two equations.

$$S_{L-ij} = S_{ij} + S_{ji} \qquad (14)$$

2.3 Reliability Index

In this paper, the expected amount of energy not supply to customer or each load point is considered as a reliability index [6].

$$EENS = \sum L_{a(i)} U_i \tag{15}$$

Where La(i) is the average load demand at load point i and Ui is outage time at load point i. The outage time is obtained the failure rate of components, repaired time and switching time according to the different conditions.

3. Test System

In this paper, the load flow analysis is tested in Yangon Distribution Network. Total load is 939.14 MW. The load and generation data is shown in Table 2 and line data can be seen in Table 8. Single line diagram of Yangon Distribution Network is as in figure 4. There are 45 bus in the system[7].

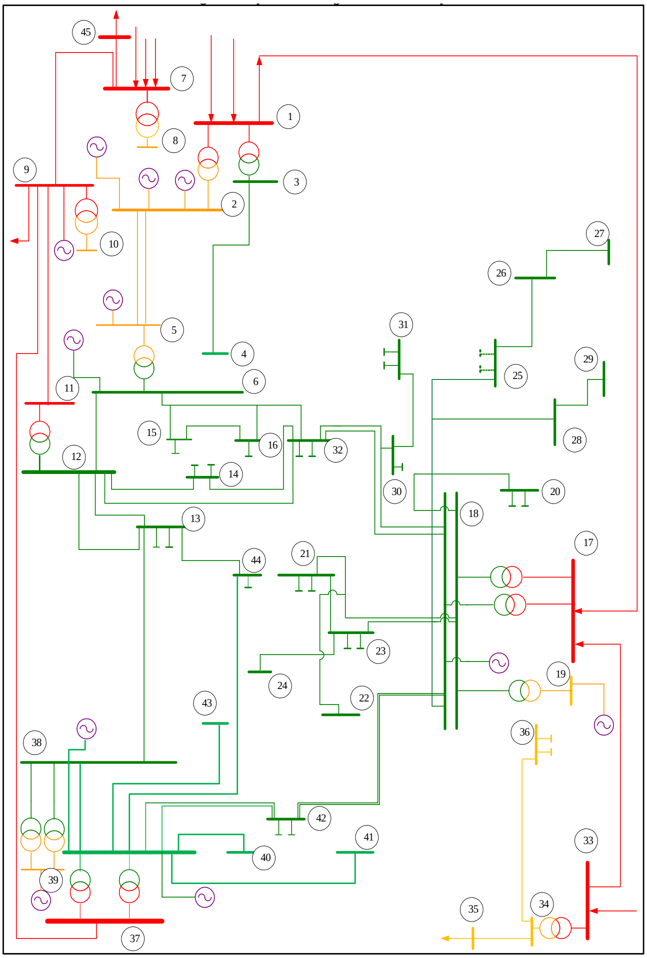

Figure. 4 One Line Diagram of Yangon Distribution Network

Table 2. Load and Generation Data

Bus No	Bus Type	Load		Generation	
		P(MW)	Q(MW)	P(MW)	Q(MW)
1	Slack				
2	Generation	145.2	67.7	65	
3	Load	0	0		
4	Load	89			
5	Generation	54.3	16	26	17
6	Generation	0	0	15	
7	Generation			31	24
8	Load	58.5			
9	Generation	0	0	100	
10	Load	89.19	12.9		
11	Load	0	0		
12	Generation	0	0	33	
13	Load	25.3			
14	Load	29.5			
15	Load	9			
16	Load	12.5			
17	Load	0	0		
18	Generation	0	0	12	
19	Generation	65	21	45	
20	Load	15	-6		
21	Load	15			
22	Load	16			
23	Load	24			
24	Load	8			
25	Load	18			
26	Load	3			
27	Load	1			
28	Load	5			
29	Load	2			
30	Load	10			
31	Load	12			
32	Load	20			
33	Generation			44	
34	Load	48	30		
35	Load	17	11		
36	Load	14	4		
37	Load				
38	Generation			142	
39	Generation	34	16.7		
40	Load	17.3	6.91		
41	Load	0.18	-0.28		
42	Load	67	17.8		
43	Load	4.57			
44	Load	40			
45	Load	17.7			

Table 3. Line Data

No	Bus No (from-to)	R	X
1	1-2	0.000097	0.00044
2	1-3	0.000055	0.01797
3	2-4	0.012743	0.06476
4	3-5	0.050994/2	0.25907/2
5	5-6	0.000054	0.01797
6	6-15	0.006392	0.02524
7	6-16	0.011232	0.04434
8	15-16	0.003804	0.01502
9	6-32	0.016807	0.06635
10	7-8	0.000055	0.01797
11	7-9	0.003230	0.02165
12	9-10	0.00005	0.01797
13	9-11	0.0009	0.00671
14	11-12	0.000	0.00044
15	12-14	0.00101	0.00325
16	14-32	0.002284	0.00902
17	12-32	0.003672	0.01449
18	12-13	0.010045/2	0.03966/2
19	12-13	0.010045/2	0.03966/2
20	13-44	0.000530	0.00209
21	37-38	0.000400	0.00202
22	38-39	0.000659	0.00260
23	38-13	0.010045	0.03966
24	38-44	0.015048	0.05941
25	38-40	0.003579	0.01413
26	38-41	0.002659	0.01049
27	38-42	0.007574/2	0.01676/2
28	38-42	0.007574/2	0.01676/2
29	38-43	0.007952	0.03139
30	37-9	0.002016	0.01355
31	17-1	0.003036	0.01785
32	17-33	0.011135	0.00705
33	33-34	0.000097	0.00044
34	34-35	0.000074	0.00012
35	34-36	0.017496	0.06907
36	17-18	0.000097	0.00044
37	18-19	0.000055	0.01797
38	18-20	0.006788	0.02679
39	18-28	0.034991	0.13814
40	28-29	0.017496	0.06907
41	18-25	0.029113	0.11493
42	25-26	0.018213	0.03089
43	26-27	0.000332	0.00056
44	18-32	0.027080/2	0.13758/2
45	18-32	0.027080/2	0.13758/2
46	18-30	0.027080	0.13758
47	30-31	0.014543	0.02368
48	18-21	0.034912	0.05686
49	21-23	0.013647	0.02786
50	18-23	0.019404	0.03160

No	Bus No (from-to)	R	X
51	23-24	0.009441	0.01538
52	21-22	0.017503	0.06909
53	18-42	0.017976/2	0.09133/2
54	18-42	0.017976/2	0.09133/2
55	7-45	0.002302	0.01546

In figure 5, single line disgram of substation No.1 in Dagon Seikkan township is shown[8]. The load data is mentioned in table IV. The failure rate of feeder is taken 0.1 for the condition before replacing and 0.03 for after replacing[9].

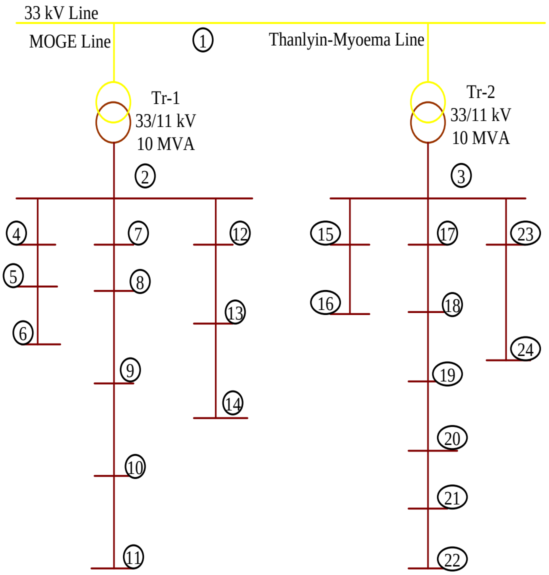

Figure. 5 Substation (No.1) Radial Distribution System of Dagon Seikkan Township

Table 4. Load Data of Substaion No.1

Bus	Load	Bus	Load
4	0.163	15	0.091
5	0.207	16	0.116
6	0.041	17	0.193
7	0.02	18	0.003
8	0.004	19	0.014
9	0.067	20	0.012
10	0.006	21	0.046
11	0.012	22	0.071
12	0.183	23	0.394
13	0.19	24	0.096
14	0.163		

4. Test Results

4.1 Load Flow and Line Losses

Using the system data, we can figure out the load flow condition of all buses in Yangon Electricity Supply Cooperation (YESC) network. The main target is to check the load flow from the national grid to slack bus (bus 1). The load flows of current condition at bus 1 is shown in figure 5. The real power flow from grid to bus 1 is 364.093 MW and reactive power flow is -51.239 Mvar.

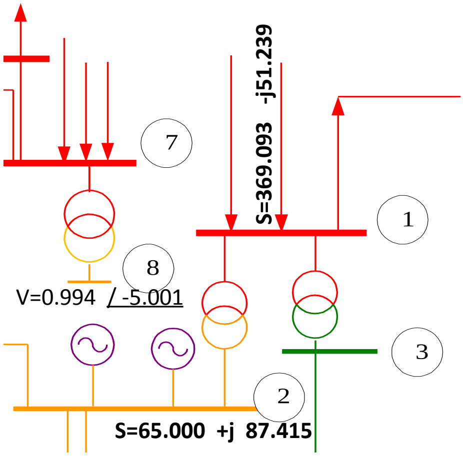

Figure. 5 Load Flow From National Grid at Bus 1

Table 5. Total load, generation and line lossess

Load		Generation		Line Lossess	
MW	MVA	MW	Mvar	MW	Mvar
939.14	430.53	949.098	164.089	9.953	28.56

Total load, generation and line lossess results can be seen in table V. Using line flow method, line lossess occurred every lines is calculated and the total lossess for the system is 9.953 MW and 28.56MVA. The voltage level at each bus is also simulated. For example, voltage at bus 8 is 0.994 per unit.

4.2 Option For DG Installation

The location and amount of DG can be chosen in line flow study by comparing the amount of line losses reduced. However, the flow from grid is not changed. In this analysis, the total generation of DGs ,103 MW is installed in different buses. The power flow from grid is 258.578 MW and -97.178 Mvar.

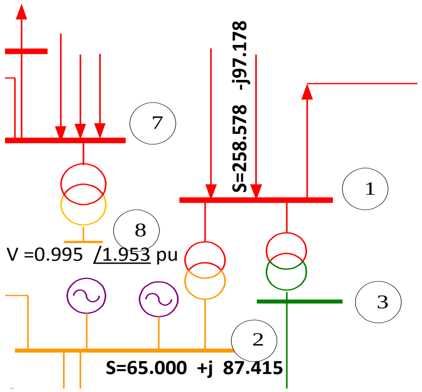

Figure 6. Load Flow From National Grid at Bus 1

Table 6. Generation Condition and DG installation

Load		Current Condition		Additional DG Installation	
MW	Mvar	MW	Mvar	MW	Mvar
939.14	430.53	369.093	-51.239	258.578	-97.178

In table 6, we can check the load data and amount of required power from the national grid to bus 1. Total load is 939.14 MW and 430.53Mvar. By installing additional DGs 103.64 MW in the network, the reduced amount of the generation flow is 114.586 MW and 15.533Mvar.

DG location can be chosen by load flow method with the comparison of losses reduction. We can chose the best location to install the DGs. In figure 7, we can see two options for DG location. The first option is installing DGs , 30 MW at bus 6, 20 MW at bus 12, 50 MW at bus 18 and 3.64 MW at bus 36. The buses except bus 36 are 66 kV bus and 36 bus is 33 kV bus. In this condition is line lossess is reduced to 3.317 MW and 14.8 Mvar. For option 2, 20 MW at bus 8, 10 MW at bus 10, 20 MW at bus 12, 1M at bus 16, 1MW at bus 21, 1MW at bus 22, 5 MW at bus 23, 10 MW at bus 31, 10 MW at bus 34 and 0.62 MW at bus 36 are installed. And line losses is decreased to 2.593 MW and 10.722 Mvar. According to the comparison of option 1 and 2, option 2 is more effective to reduce line losses. Although the total amount of DG installed is same, small DGs are installed in different buses in option 2. Apparent power at bus 1 for option 2 is 257.994 -j96.853.

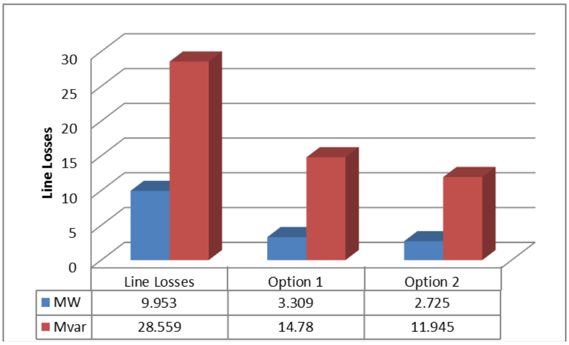

Figure. 7 Line losses Reduction

4.3 Expected Energy Not Supply

The expected energy not supply is forecasted on the system shown in figure 5 which is bus number 36 of load flow test. The DGs is installed as 250 kW at bus 6, 20 kW at bus 11, 200 kW at bus 14, 150 kW at bus 16 and 22 and 100 kW at bus 24. Total capacity is 0.87MW and it is the same as DG installation of bus 36 in option 2.

In the analysis, case I is the system without consideration of DG and case II is the system with DG. The improvement for MOGE line and Thanlyin-Myoema Line can be seen in table 7 and 8. According to the results, EENS and outage time is decreased. Using DG can reduce not only line losses but also outage time and EENS for each load points.

Table 7. System Improvement in MOGE Line

	Case I	Case II	Reduced
Failured(f/yr)	4.3	4.3	-
Outage(hr)	21.5	8.7	12.8
EENS(MWh/yr)	1.693	0.7938	0.8992

Table 8. System Improvement in Thanlyin-Myoema Line

	Case I	Case II	Reduced
Failured(f/yr)	4	4	-
Outage(hr)	20	10	10
EENS(MWh/yr)	1.7	0.8404	0.8596

4.4 Impact *of* old feeder replacing

According to the previous results, the failure rate is not decreased for both cases. In order to reduce the failure rates, the aging components in the system are necessary to replace. In this test, aging feeder is replaced for the system shown in figure 5. Failure rate reduction results can be seen in Table 9 and 10. Case I and II are the cases mentioned in section C. Case III is the system without DG and replacing feeder and case IV is the system with DG and replacing feeders. By comparing case I&II and case II and IV, the impact of feeder replacing can be seen clearly. The failure rates is decreased from 4.3 to 0.43 per years for MOGE line. For Thanlyin-Myoema line, the failure rate is decreased from 4 to 0.4 per year.

Table 9. Failure Rate Reduction in MOGE Line

	Case I	Case II	Case III	Case IV
Failured(f/yr)	4.3	4.3	0.43	0.43
Outage(hr)	21.5	8.7	2.15	0.87
EENS(MWh/yr)	1.693	0.7938	0.1693	0.07938

Table 10. Failure Rate Reduction in Thanlyin-Myoema Line

	Case I	Case II	Case III	Case IV
Failured	4	4	0.4	0.4
Outage	20	10	2	1
EENS	1.7	0.8404	0.17	0.08404

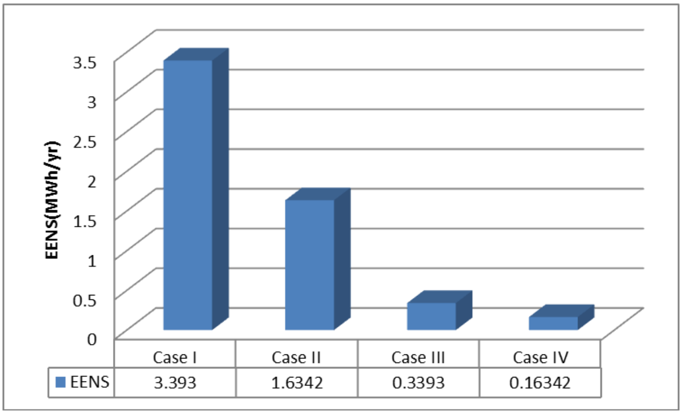

Figure. 8 EENS Affected by Feeder Replacing

Replacing feeder can decrease EENS as well as failure rates. In figure 8, the impact to feeder replacing on EENS can be see for the network of substation(1) described in figure 5.

Conclusions

According to the results, the problems such as load shedding, line losses and interruptions occurred by aging networks is solved by dispersed generation using different sources. Location of DG can be suggested by Load flow method by comparing the amount of loss reduction. Even though DG can improve EENS, it cannot reduce the failure time and interruption rates. However, feeder replacing can make the failure rate decreased. Network reconfiguration can also be considered for system improvement as future work. Currently, installing large power station within short period is also not possible. Therefore, small generation systems or DGs becomes a key solution for power sector. According to the study in this paper, we can conclude that DG can solve the load shedding and line losses. Moreover, DG can reduce the EENS for each load. Based on the results, we can say that installing small DGs in different places is more effective than larger ones. Feeder replacing is also an important task to make system enhancement. The less the systems depend on the grid, the better the system's performance is.

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