Daily Load Changes Consideration by using Distributed Generations (DGs) Scheduling for Distribution Network Reconfiguration

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Abstract: The distributed generation (DG) locations have significant impacts on network configuration and loss. By fixing DGs in suitable optimal locations and by generation power based on the load conditions, the total power loss in the system can be reduced and the system reliability can be improved. In this paper, Fuzzy algorithm is used to obtain the optimum position and size of DG units in the distribution network in order to reduce network loss at the lowest cost. Also, a time-varying load curve for optimal scheduling of DGs considering active power loss and DG cost is used. The result shows the improvement of bus voltage profile and decrease losses due to install the optimal size of DGs by optimal scheduling of distributed generations. The test system is Yangon 66kv; 45-bus and the results obtained reveal the effectiveness of proposed method.

Key Words: Distributed generation, Fuzzy algorithm, Loss reduction, Optimum position, System reliability.

INTRODUCTION:

The power demand growth is a critical concern for the power utilities as they must always supply the customers with the least interruptions and cost. Integration of DG units to distribution networks can be a better solution that defers investments of upgrading existent power systems. If the system topology is assumed to be constant during the planning period, the appearance of new loads or the peak load demand growth to the network [3]. In this case, DG can be a valuable choice for the planning engineers to reduce investments for upgrading the distribution system because it is located near the load and doesn't need as much transmission and distribution infrastructures to served loads. In addition to this advantage, the main advantages of DG can be expressed as follows: improving the system reliability, improving voltage profile, power loss reduction, less pollution emissions (in comparison to traditional machines), feasibility to use CHP (Combine Heat and Power) generation. The problem of DG sizing and allocation has great importance. The installation of DGs at the places that is non-optimal can cause an increase in system losses, resulting an increase in costs and, therefore, having a negative impact [5].

The penetration level of distributed generators is increased due to the restructuring in electric power system. Distributed generators which are used for local power generation in a distribution system are generally connected to the load and directly. These DGs are normally ranged from less than 50 MW and they are not centrally placed. Most of the distribution systems are conventionally planned as passive network and they are capable of unidirectional power flow [6]. However, distribution networks are transferred to active network with bidirectional power flow by installing a DG unit in the distribution system. In spite of the restructuring of electricity market, utilization of DG unit in the distribution system can make many benefits such as voltage profile improvement, real and reactive power loss reduction, environmental concerns, power quality improvement, investment risk reduction, reliability and security improvements [1].

The performance of Yangon distribution system becomes inefficient due to the reduction in voltage magnitude and increase in distribution losses. With this regard, changing environment of power systems design and operation have necessitated the need to consider active distribution network by incorporating Distributed Generation units (DGs) sources [4]. DGs are grid-connected or stand-alone electric generation units located within the electric distribution system at or near the end user. The case study area is Yangon 66kv distribution system and the total customer of Yangon is 1141097 customers.

MATERIALS:

Minimization of power losses and maximization of the load balance are the two most common criteria that used to reconfigure networks. System reconfiguration is a very important function of automated distribution systems to reduce distribution feeder losses, load balancing and improve system reliability. Loads can be transferred from feeder to feeder by changing status of the feeder high-speed switches. The optimal reconfiguration model responds to changes in the network topology by switching the automatic breakers installed in the network. The distribution system loads can be levelled by network reconfiguration. In this scheme, some loads in the heavy loaded feeder shifted to another lightly loaded feeder. The allocation for load shift is executed by sectionalizing switchgear (new interconnection between feeders may be required). Optimal switching allocation may be done by distribution system analysis software. System reconfiguration also consists of installation of new feeders, transformers and substations. Heavy loaded area are to be supplied by new feeder so that existing feeder supplies less loads (for new feeder install, sometimes new HV/MV transformer needed). New substation is to be built in the centre of high load density area so that existing feeder supplies less loads.

METHOD:

The following table-1 shows the bus voltage (per unit) of each bus of power flow solution by Newton-Raphson Method.

Some of the radial bus voltages are out of the permissible range (±5%). Table-1 indicates that the total load of 989.710MW and the total loss of 6.567MW. For the permissible range of bus voltages, Fuzzy algorithm is used for optimum position of distributed generation.

Table.1
Power Flow Solution by Newton-Raphson Method

BUS NO.	VOLT. MAG.	ANGLE DEG.	LOAD		GEN.		INJ.
			MW	MVAR	MW	MVAR	MVAR
1	1.000	0.000	0.000	0.000	231.274	1.576	50.000
2	1.000	-0.024	145.200	67.700	65.000	92.946	0.000
3	1.030	-0.250	0.000	0.000	0.000	0.000	0.000
4	0.995	-0.315	8.900	5.510	0.000	0.000	0.000
5	0.980	-1.655	54.300	16.000	26.000	38.985	0.000
6	0.990	-1.625	0.000	0.000	15.000	-44.550	0.000
7	0.990	-0.310	0.000	0.000	120.000	34.407	-5.000
8	1.032	-0.873	58.500	28.080	0.000	0.000	0.000
9	0.980	-0.795	0.000	0.000	100.000	47.133	75.000
10	1.018	-1.678	89.190	12.900	0.000	0.000	0.000
11	0.976	-1.149	0.000	0.000	0.000	0.000	25.000
12	0.995	-1.173	33.000	15.840	0.000	0.000	0.000
13	0.988	-1.122	25.300	12.140	0.000	0.000	0.000
14	0.994	-1.239	29.500	14.160	0.000	0.000	0.000
15	0.987	-1.785	9.000	5.580	0.000	0.000	0.000
16	0.987	-1.814	12.500	7.750	0.000	0.000	0.000
17	0.990	-1.137	0.000	0.000	0.000	0.000	0.000
18	0.990	-1.181	0.000	0.000	12.000	61.590	0.000

19	1.000	-1.389	65.000	21.000	45.000	49.062	0.000
20	0.987	-1.393	15.000	6.000	0.000	0.000	0.000
21	0.947	-2.751	51.520	24.730	0.000	0.000	0.000
22	0.931	-3.660	16.000	9.920	0.000	0.000	0.000
23	0.958	-2.284	24.000	11.520	0.000	0.000	0.000
24	0.956	-2.365	8.000	3.840	0.000	0.000	0.000
25	0.944	-4.121	24.000	11.520	0.000	0.000	0.000
26	0.939	-4.272	6.950	4.310	0.000	0.000	0.000
27	0.939	-4.272	1.000	0.620	0.000	0.000	0.000
28	0.981	-1.662	5.000	3.100	0.000	0.000	0.000
29	0.980	-1.731	2.000	1.240	0.000	0.000	0.000
30	0.942	-4.095	10.860	6.730	0.000	0.000	0.000
31	0.935	-4.314	15.240	9.450	0.000	0.000	0.000
32	0.994	-1.294	20.000	1.800	0.000	0.000	0.000
33	0.990	-0.771	0.000	0.000	140.000	-17.606	50.000
34	1.042	-0.787	48.000	30.000	0.000	0.000	0.000
35	1.042	-0.787	17.000	11.000	0.000	0.000	0.000
36	1.037	-1.262	14.000	4.000	0.000	0.000	0.000
37	0.968	-0.348	0.000	0.000	0.000	0.000	50.000
38	0.990	-0.267	0.000	0.000	142.000	-112.485	0.000
39	1.000	-0.162	34.000	16.700	100.000	0.036	0.000
40	0.988	-0.395	17.300	6.910	0.000	0.000	0.000
41	0.990	-0.268	0.180	-0.280	0.000	0.000	0.000
42	0.986	-0.666	67.000	17.800	0.000	0.000	0.000
43	0.989	-0.338	4.570	2.830	0.000	0.000	0.000
44	0.987	-1.135	40.000	19.200	0.000	0.000	0.000
45	0.996	-0.522	17.700	10.970	0.000	0.000	50.000
Total			989.710	420.570	996.274	151.094	295.000
Total loss			6.567	25.533			

Two objectives are considered while designing a fuzzy logic for identifying the optimal DG locations. The two objectives are: (i) to minimize the real power loss and (ii) to maintain the voltage within the permissible limits. Voltages and power loss indices of distribution system nodes are modelled by fuzzy membership functions. A fuzzy inference system (FIS) containing a set of rules is then used to determine the DG placement suitability of each node i^n the distribution system. DG can be placed on the nodes with the highest suitability.

For example, it is intuitive that a section in a distribution system with high losses and low voltage is highly ideal for placement of DG. Whereas a low loss section with good voltage is not ideal for DG placement. A set of fuzzy rules has been used to determine suitable DG locations in a distribution system [8].

In the first step, load flow solution for the original system is required to obtain the real and reactive power losses. Again, load flow solutions are required to obtain the power loss reduction by compensating the total active load at every node of the distribution system. Loss Reduction Index (LRI) value for ith node can be obtained using equation 1.

$$\text{LRI} = \frac{(Lossreduction(i) - Lossreduction(\text{min}))}{(Lossreduction(\text{max}) - Lossreduction(\text{min}))} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

These power loss reduction indices along with the p. u. nodal voltages are the inputs to the Fuzzy Inference System (FIS), which determines the nodes that are more suitable for DG installation.

Seven membership functions are selected for PLI. They are VL, L, ML, M, MH, H and VH. All the seven membership functions are triangular as shown in figure-1. Seven membership functions are selected for Voltage. They are VL, L, ML, M, MH, H and VH. These membership functions are trapezoidal as shown in figure-2. Seven membership functions are selected for DSI. They are VL, L, ML, M, MH, H and VH. These seven membership functions are Gaussian as shown in figure-3.

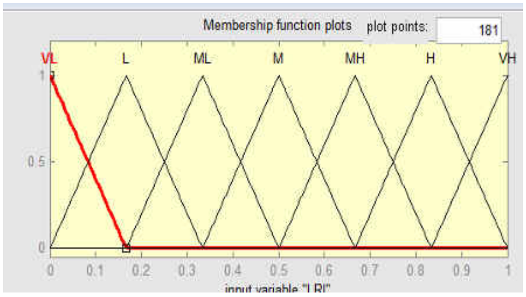

Figure1. Specifying the first input Variables as PLI

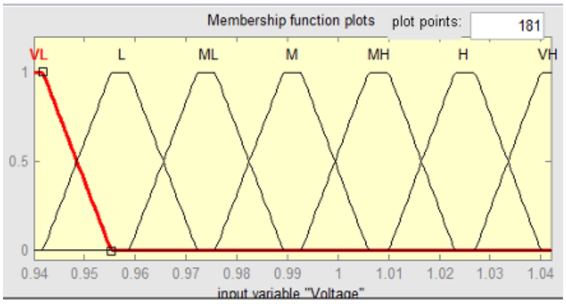

Figure2. Specifying the second input Variables as VOLT

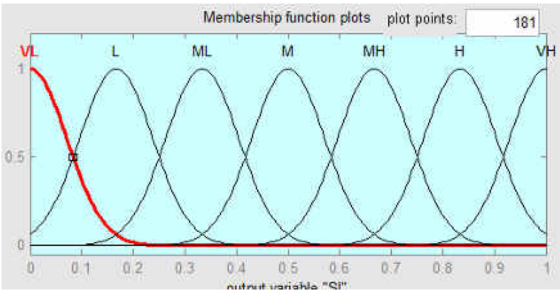

Figure3. Specifying the Output Variable Suitability-Degree

IF premise (antecedent), THEN conclusion (consequent). For determining the suitability of DG placement at a particular node, a set of multiple-antecedent fuzzy rules has been established [5].

Table.2
Rule Base for Suitability Index

Voltage / LRI	VL	L	ML	M	MH	H	VH
VH	VH	VH	H	H	MH	MH	M
H	VH	H	H	MH	MH	M	ML
MH	H	H	MH	MH	M	ML	ML
M	H	MH	MH	M	ML	ML	L
ML	MH	MH	M	ML	ML	L	L
L	MH	M	ML	ML	L	L	VL
VL	M	ML	ML	L	L	VL	VL

Total load and line loss are calculated by using MATLAB software. Firstly, load flow is running to obtain network losses. Then power loss reduction is evaluated by compensating the same minus active load at every node, and load flow solutions are required. Power loss index (LRI) can be evaluated by eq.1 that normalizes loss reduction to take values between minimum and maximum such that the highest reduction takes the value of 2.096 and the lowest reduction takes the value of -0.708.

Table.3
Calculation table

Bus No	Ploss_orginal	Ploss_new	Ploss_reduction (PLI)	Volt_ibus	LRI	Suitability Indices
22	6.567	5.635	0.932	0.94	0.584879	0.667
26	6.567	6.298	0.269	0.945	0.348431	0.61
31	6.567	6.139	0.428	0.946	0.405136	0.601

The suitability indices were calculated by using loss reduction index and voltage.

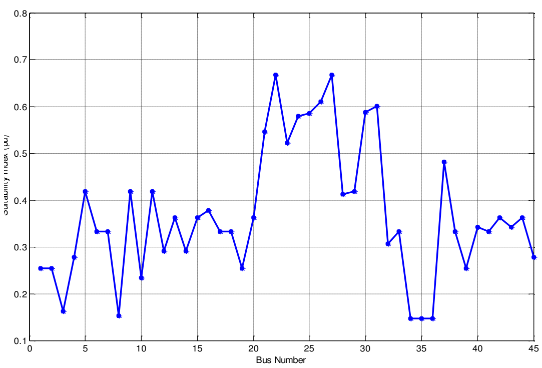

Figure4. Suitability Index

According to the calculation results, the highest suitability indices of buses are bus number 22, 26 and 31. For the improving of bus voltage profile and decrease losses, the optimal sizes of DGs are installed in these buses.

Discussion: The test system used in this paper is Yangon 66kv distribution system. In Yangon, if a transformer or line is failure, the repaired time takes long time that is about 48 hours or more. It is not reasonable for power system improvement.

(A) Data surveying and situational data analysis
(B) Load flow running by using Newton-Raphson method
(C) Finding the optimal size and location of DGs by using Fuzzy
(D) Optimal Scheduling of DGs by using time-varying load
(E) Result and discussion Mat-lab for power flow calculation

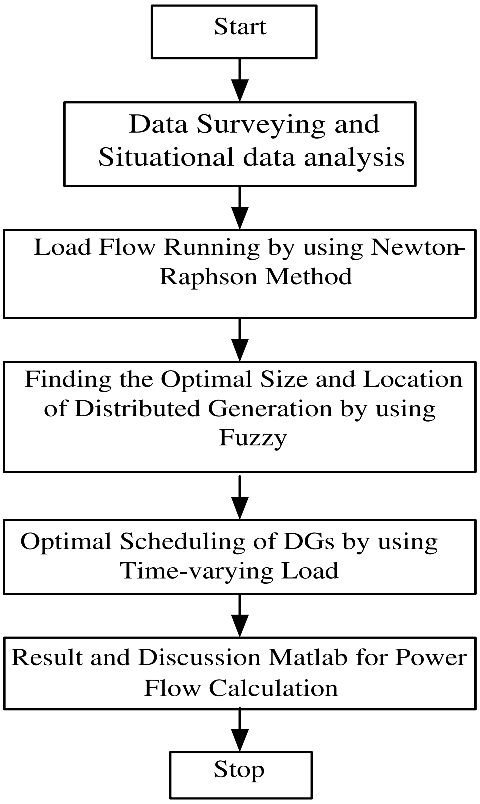

Figure5. Flow Chart of the proposed method

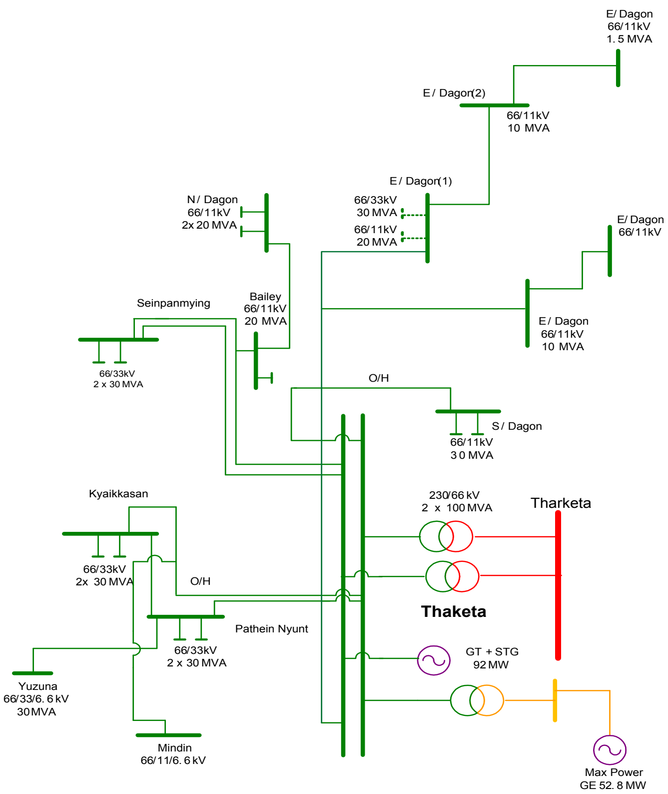

Figure6. Test system of Yangon distribution system

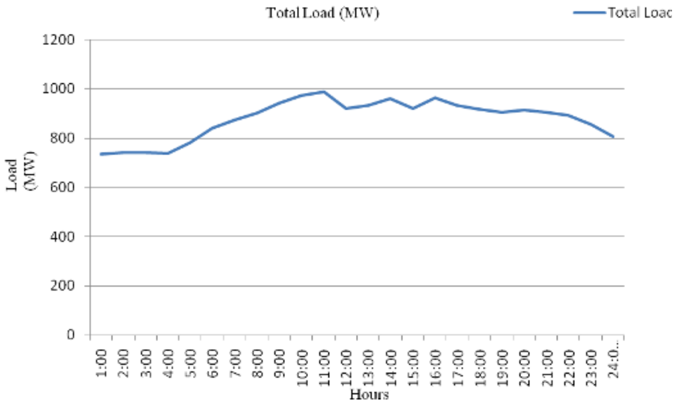

Figure7. Daily Load of Yangon Distribution System

Analysis: The penetration level of distributed generators is increased due to the restructuring in electric power system. Distributed generators which are used for local power generation in a distribution system are generally connected to the load and directly.

Table.4
Maximum Power Rating

Line	Size	Ampere (from table)	Power Factor	Stability Margin	Power (MW)
Bus 21-22	605MCM	760A	0.85	0.7	52.6
Bus 25-26	120mm^2	460A	0.85	0.7	31.3
Bus 30-31	397.5MCM	590A	0.85	0.7	40.8

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Table.5
DG Sizing

Hours	Case	SSI
1:00	Case 1	0.723
	Case2	0.705
	Case 3	0.676
2:00	Case 1	0.724
	Case2	0.707
	Case 3	0.675
3:00	Case 1	0.72
	Case2	0.714
	Case 3	0.672
4:00	Case 1	0.725
	Case2	0.718
	Case 3	0.672
5:00	Case 1	0.731
	Case2	0.729
	Case 3	0.687
6:00	Case 1	0.733
	Case2	0.732
	Case 3	0.696
7:00	Case 1	0.744
	Case2	0.732

	Case 3	0.727
8:00	Case 1	0.781
	Case2	0.765
	Case 3	0.76
9:00	Case 1	0.821
	Case2	0.794
	Case 3	0.792
10:00	Case 1	0.83
	Case2	0.818
	Case 3	0.788
11:00	Case 1	0.838
	Case2	0.819
	Case 3	0.817
12:00	Case 1	0.792
	Case2	0.77
	Case 3	0.774
13:00	Case 1	0.821
	Case2	0.792
	Case 3	0.791
14:00	Case 1	0.82
	Case2	0.815
	Case 3	0.791
15:00	Case 1	0.791
	Case2	0.782
	Case 3	0.78
16:00	Case 1	0.82
	Case2	0.813
	Case 3	0.792
17:00	Case 1	0.821
	Case2	0.793
	Case 3	0.791
18:00	Case 1	0.819
	Case2	0.792
	Case 3	0.791
19:00	Case 1	0.781
	Case2	0.757
	Case 3	0.754
20:00	Case 1	0.791
	Case2	0.782
	Case 3	0.78
21:00	Case 1	0.779
	Case2	0.754
	Case 3	0.739
22:00	Case 1	0.771
	Case2	0.742
	Case 3	0.736
23:00	Case 1	0.734
	Case2	0.733
	Case 3	0.714
24:00:00	Case 1	0.728

	Case2	0.725
	Case 3	0.685

Table.6
Comparison of the Best Case by Hourly

Hour	Case	Ploss	Q loss	Ploss_org	Qloss_org	Ploss_reduc:	Qloss_reduction	% reduction (P)	% reduction (Q)
1:00	Case 3	5.43	27.113	5.664	25.135	0.234	-1.978	4.309392265	-7.29539335
2:00	Case 3	5.394	26.743	5.773	25.292	0.379	-1.451	7.026325547	-5.42571888
3:00	Case 2	5.661	28.826	5.717	25.111	0.056	-3.715	0.989224519	-12.8876708
4:00	Case 3	5.27	26.941	5.912	25.812	0.642	-1.129	12.18216319	-4.19063880
5:00	Case 3	4.824	23.627	5.71	24.546	0.886	0.919	18.36650083	3.88961781
6:00	Case 2	4.497	22.675	5.649	23.157	1.152	0.482	25.61707805	2.125689085
7:00	Case 2	3.959	20.58	5.49	21.803	1.531	1.223	38.67138166	5.942662779
8:00	Case 1	3.942	20.395	5.738	22.461	1.796	2.066	45.56062912	10.12993381
9:00	Case 3	3.775	19.383	6.251	24.129	2.476	4.746	65.58940397	24.48537378
10:00	Case 2	3.514	17.637	6.311	24.568	2.797	6.931	79.59590211	39.29806656
11:00	Case 2	3.509	17.591	6.567	25.533	3.058	7.942	87.14733542	45.14808709
12:00	Case 1	3.983	19.795	6.075	23.652	2.092	3.857	52.5232237	19.48471836
13:00	Case 2	3.771	19.496	5.979	23.445	2.208	3.949	58.55210819	20.25543701
14:00	Case 1	3.724	19.06	6.358	24.658	2.634	5.598	70.73039742	29.37040923
15:00	Case 1	3.81	19.831	5.815	22.867	2.005	3.036	52.62467192	15.30936413
16:00	Case 1	3.51	17.715	6.145	24.055	2.635	6.34	75.07122507	35.78887948
17:00	Case 3	3.807	19.472	6.195	23.749	2.388	4.277	62.72655634	21.96487264
18:00	Case 2	3.833	19.657	6.014	23.077	2.181	3.42	56.90060005	17.39838226
19:00	Case 1	3.952	20.425	5.71	22.496	1.758	2.071	44.48380567	10.13953488
20:00	Case 1	3.851	19.888	5.816	22.727	1.965	2.839	51.02570761	14.27493966
21:00	Case 3	3.918	19.591	5.794	22.622	1.876	3.031	47.88157223	15.47138992
22:0	Case	3.827	19.87	5.614	22.096	1.787	2.226	46.694538	11.2028183

0	3							8	2
23:00	Case 2	4.173	21.701	5.34	21.525	1.167	-0.176	27.96549245	-0.81102253
24:00	Case 3	4.735	23.142	5.542	23.315	0.807	0.173	17.04329461	0.747558552

FINDINGS:

Distributed generators which are used for local power generation in a distribution system are generally connected to the load and directly. These DGs are normally ranged from less than 50 MW and they are not centrally placed. Most of the distribution systems are conventionally planned as passive network and they are capable of unidirectional power flow.

Table.7
Comparison of Per Unit Voltage with and without DGs Unit

1:00AM			
W/O DG	Case 1	Case 2	Case 3
0.962	0.976	0.987	0.976
0.956	0.989	1.017	0.989
0.969	0.977	0.983	0.977
0.967	0.975	0.981	0.975
0.964	1.001	0.991	0.991
0.961	1.013	1	1
0.961	0.998	0.977	0.998
0.956	1.005	0.976	1.005

RESULT:

It is intuitive that a section in a distribution system with high losses and low voltage is highly ideal for placement of DG. Whereas a low loss section with good voltage is not ideal for DG placement.

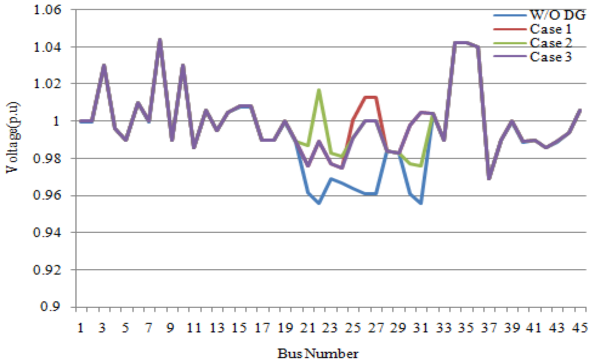

Fig8. Comparison of Per Unit Voltage

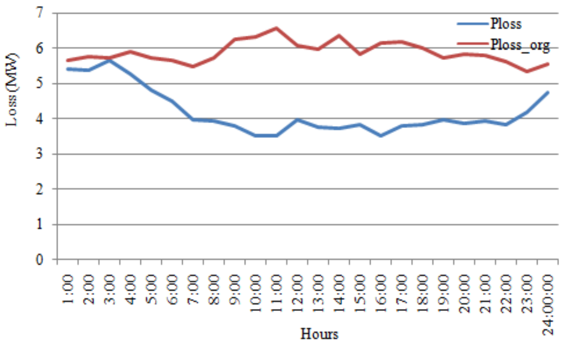

Fig9. Comparison of Losses

RECOMMENDATIONS:

Calculation of reliability indices for the existing system by hourly period and comparison of decrease losses with and without DGs cases.

CONCLUSION:

In this paper, Fuzzy method was implemented by using MATLAB and was tested for a Yangon 66kv, 45-bus test system. This method was compared after connecting one DG, two DGs, and three DGs to the system at different load power values. The suitability indices improvement show the location of radial buses where the DGs should be introduced. By installing DGs at the radial buses, the total power loss of the system has been reduced drastically and the voltage profile of the system was also improved. The calculation results of table-6 and 7 were showed that appropriate size and location of DG units will lead a significant role to minimize the losses in distribution system. In this system if the DG of more capacity reliability of system will improves more but cost of DG will much higher than service availability. Moreover, it was found that losses reduction and voltage profile improvement is more in the Yangon network by installing the DG units.

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