Effect of Optimal Multi-DG Siting and Sizing in Transmission System using Hybrid Optimization Technique for Loss Control

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Abstract: The advancement of Distributed Generation (DG) technologies have caused great impact to power system operation. The installation of DG has been expanded in both the transmission and distribution systems. Improper planning of DGs installation may lead to over-compensation or under-compensation. Thus, a reliable optimization is urgent to alleviate any undesirable event. This paper analyses the impact of multi-DGs installation utilizing a pre-developed hybrid optimization technique termed as Immunized-Brainstorm-Evolutionary Programming (IBSEP). It is imperative to study the effect of multi-DGs installation such that a relevant utility can make a correct decision, whether its installation is worth or vice versa. Rigorous study has been conducted in terms of identifying the optimal location and sizing, installed on transmission system for loss control involving different DG types. Comprehensive results embedded in this paper show that more optimal DGs of a particular type are superior to the other in controlling transmission system loss.

Index Terms: Distributed Generation, Hybrid Optimization, Immunized-Brainstorm-Evolutionary Programming, Loss Control, Multi-DG.

I. INTRODUCTION

Distribution generation (DG) can be generally defined as electric power generation with in distribution networks or on the customer side, but can be located at the transmission side of the network too [1].DG technologies were found to be able to reduce power system loss and enhance the voltage stability, when the DG sizing and its placement are carefully selected[2–4]. Power losses do not only reduced efficiency of power transfer but contribute to monetary loss to the power provider.

Various studies were conducted to determine the optimal location and/or size of DG in maximizing the overall power system efficiency at the distribution side [5–10].Nonetheless, only a few studies were conducted to investigate effects of DG installation to the transmission network. These limited works concluded that medium sized DGs are able to reduce transmission network loss and improve voltage stability when DG location, DG size or both, were optimally selected [11–13].

The determination of optimal DG location and/or size, the current trend is to invent reliable and robust technique that can alleviate the current setback experienced in the current techniques [14–17]. Apart from finding higher probability of optimum solution towards the objective functions, new optimization algorithms are also developed to alleviate computational burden in the classical optimization techniques[18]. In 2011, a new member of swarm intelligence algorithm named Brainstorm Optimization (BSO) algorithm has caught attention of many researchers as it mimics the collective behavior of human. Though it is successfully applied to solve science and engineering problems, it has high computational burden due to its K-means clustering technique [19].

In this paper, an optimization technique that incorporates Artificial Immune System (AIS) and BSO into the frame of Evolutionary Programming (EP) is used to determine the optimal locations and sizes of multiple DGs for loss control. The presented hybrid technique is termed as Immunized-Brainstorm-Evolutionary Programming (IBSEP)

II. PROBLEM FORMULATION

Main objective of this study is to compare the capabilities of different types of DGs in reducing transmission system's loss. DGs are categorized into four major types, based on their ability to deliver power. In this paper, comparison between the performance of these four DG types to control system loss will be investigated, based on the definition below[20]:

Type-1. DGs under this category are DGs that capable of delivering only real power. Examples of Type-1 DG are photovoltaic, micro turbines and fuel cells. In this paper, Type-1 DGs will be referred to as **T1** from this point onwards.

Type-2. DGs that able to deliver only reactive power fall under this category. DGs based on synchronous compensator are of this type. Type-2 DGs will be referred to as **T2** from this point onwards.

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Type-3. This type of DG is able to deliver both real and reactive power. Cogeneration and gas turbine are example of Type-3 DG. Type-3 DGs will be referred to as **T3** from this point onwards.

Type-4. DGs under this category are capable of delivering real power, but consume reactive power. Example of Type-4 DGs are doubly fed induction generator (DFIG) and induction generators used in wind farms. Type-4 DGs will be referred to as **T4** from this point onwards.

Multi-DG units to be inserted to the network are set to be 2, 3 and 5 units for each DG type. For T1 DG, the real power is limited to 50MW, based on the maximum PV output tabulated in[21]. In terms of apparent power *S*, each T1 DG will be limited to 50MVA, based on (1). For fair comparison, the power of other DGs are then limited to 50MVA each.

$$S = \sqrt{P^2 + Q^2} \qquad (1)$$

where S is the apparent power, in VA, P is the real power, in W and Q is the reactive power, in VAR of the DG.

Transmission system loss before DGs' placement in the system will be compared with the system loss after multiple DGs placement, for each DG type. The objective function and withholding constraints are briefed in the following sections.

Objective Function

The objective function is to minimize total system loss, represented mathematically as (2)

$$O.F. = Min \sum_{i=1}^{n} P_{loss,i} \qquad (2)$$

where$n$ is number of bus in the system, and P_{loss} for each i line can be determined following equation**Error! Reference source not found.**,(4) and (5),

$$\begin{aligned} P_{loss} = \sum_{i=1}^{n}\sum_{j=1}^{n}\big[\alpha_{ij}\left(P_iP_j + Q_iQ_j\right) \qquad (3) \\ + \beta_{ij}\left(Q_iP_j + P_iQ_j\right)\big] \end{aligned}$$

$$\alpha_{ij} = \frac{r_{ij}}{V_iV_j}\cos\left(\delta_i - \delta_j\right) \qquad (4)$$

$$\beta_{ij} = \frac{r_{ij}}{V_iV_j}\sin\left(\delta_i - \delta_j\right) \qquad (5)$$

where r_{ij}represents line resistance between bus i and bus$j$, V_i and V_j represent voltage magnitude, δ_i and δ_j represent voltage angles whileP_i, P_j, andQ_i, Q_j represent active and reactive power at bus i and j.

The objective function is however subjected to power balance equality constraint defined by:

$$\sum_{i=1}^{n} P_i = P_{demand} + P_{loss} \qquad (6)$$

whereP_{demand} is total system load demand and P_{loss} is the total system loss. The following inequality constraints are considered:

$$P_{i,min} \le P_i \le P_{i,max} \qquad (7)$$

$$V_{min} \le V_i \le V_{max} \qquad (8)$$

Where $P_{i,min}$ and $P_{i,max}$ are minimum and maximum real power output of i^{th} generator, respectively. V_{min}andV_{max} should be 0.95 p.u. and 1.05 p.u. respectively based on IEEE standard .

III. PROPOSED METHODOLOGY

In this work, DGs are placed into IEEE-30 RTS to compensate system loss while load increased. In order to maximize the loss reduction, optimal sized DGs must be injected at optimal location. These optimal sized DG and optimal bus location were determined using IBSEP optimization technique. IBSEP technique is explained below.

Proposed Immunized-Brainstorm-Evolutionary Programming (IBSEP)

Flowchart for optimal size and location of DG to minimize loss using IBSEP is shown in **Error! Reference source not found.**. The process is briefly explained:

Step1: Initialization of population number *n*, number of clusters *l*, probability-to-mutate cluster,$p_1$andp_2, reactive load,$_{Qd}$ and location of where Q_d will be incremented. Random DG location, X_n and size, S_n are generated. *n* represents DG's unit number.

Step 2: Fitness of the transmission system, i.e. the total system's loss with optimal DG installation will be determined from load flow. Only individuals capable of reducing the total loss are selected. These individuals, or parents, are then cloned to increase the population. The grown population is then divided into few clusters.

Step 3: Random number p_m and $p_c$are then generated. They are used to decide which cluster to be mutated. Gaussian mutation operator is used to generate new individuals, known as offspring. Load flow is then run to determine the fitness of the offspring.

Step 4: The offspring and the parents are then combined to compete in a tournament process. Only *n* numbers of individuals with best fitness will be transcribed to the next process.

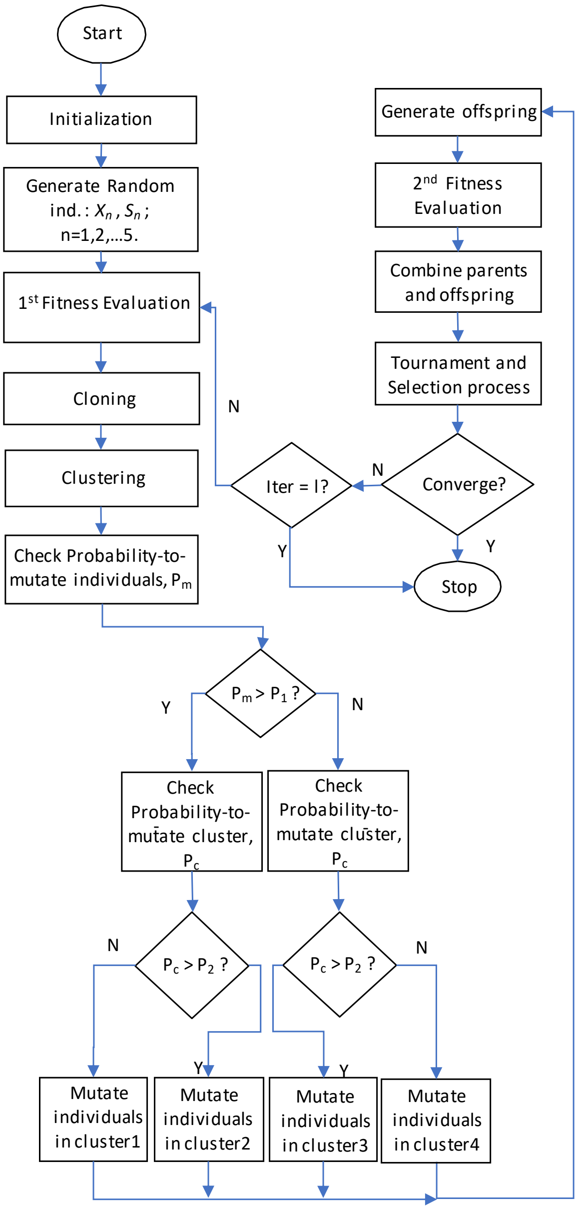

Fig. 1 Flowchart for optimal DG location and sizes using IBSEP technique

Step 5: A convergence test will then take place. In this test, the difference between the highest and lowest fitness values will calculated. Mathematically, it is written as

$$Loss_{max} - Loss_{min} \leq 0.00001 \tag{9}$$

Should this condition is met, optimal DG locations and sizes will be recorded. Otherwise, repeat Step 2 until Step 5.

Algorithm for healthiest and weakest bus identification

DGs will be placed on the transmission network to compensate loss while load demand increases. The demand is increased on a healthy bus and a weak bus. These buses are determined from a simple maximum load ability test on all buses. The steps to do this are:

Step I : Reactive load at selected bus is increased. Load flow analysis is executed.

Step II : Repeat Step I until load flow diverges.

Step III : The load value at when the load flow diverges is recorded.

Step IV : Repeat Step I until III for the other buses, until all buses are done.

Step V : Sort the buses based on step III in ascending order.

From the maximum load ability list of Step V, the weakest and healthiest buses can be identified. The first bus in the list is then the weakest bus, while the last bus in the list is the healthiest bus.

IV. RESULTS AND DISCUSSION

Reactive load, Q_d, on one of load buses of IEEE-30 RTS was incremented, from 0 MVar to 30 MVar. Optimal DGs are to be installed at few load buses to compensate the losses due to the increased demand. Two load buses were chosen for the added reactive loading; Bus-6 and Bus-30. These buses represent the healthy and the weak buses of IEEE-30 RTS, identified from the maximum loadability test.

While the reactive loading was increased, the unit of DGs was varied; 2, 3, and 5 units, for each DG types. Figshows the system losses before and after 2 units DGs injected to the network. From this figure, it can be seen that two T1 DGs has the lowest system loss while two T2 DGs has the highest system loss as the reactive load increases. Loss reduction percentage (LRP)that is calculated using(10), revealed that the loss reduction was more than 40% with two T1 DGs, followed by two T3 DGs, T4 DGs and lastly T2 DGs. While other DG types were able to reduce the loss to more than 28% in all loading conditions, T2 DGs barely made it towards 5%.

$$LRP = \frac{Loss_{pre-opt} - Loss_{DG}}{Loss_{pre-opt}} \times 100\% \tag{10}$$

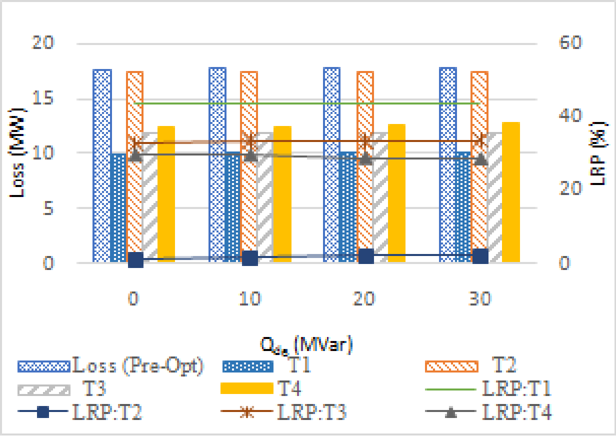

Fig. 2 Loss and LRP with 2-DGs of Different Types when Reactive Load Incremented at Bus-6

System's voltage profile was monitored along with system loss as the main objective function, to check the health of the network. Fig.shows the network's minimum voltage profile and voltage enhancement percentage (VEP). It can be seen that two optimal T3 DGs were capable to enhance the system's minimum voltage profile to the highest value, approaching 1.01 p.u in all loading conditions.

Two T4 DGs, however, was the only DG type that reduce the minimum voltage profile of the system. As(11)was used to calculate VEP, it can be seen that two optimal T4 DGs VEP was of negative percentage, while the VEP for two optimal T3 DGs keep increasing as the reactive load increases. Nonetheless, the system's minimum voltage profile was between the range sin(8).

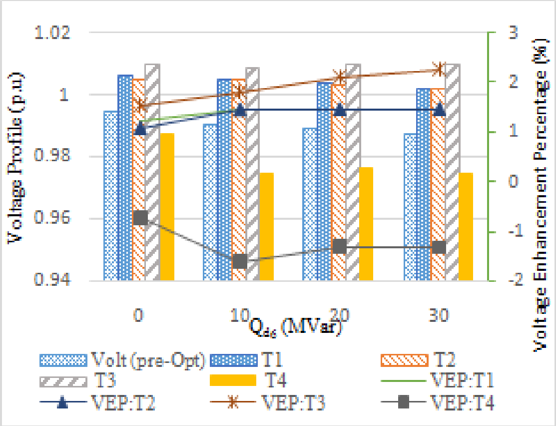

Fig. 3 Min voltage profile and VEP with 2-DGs of Different Types when Reactive Load Incremented at Bus-6

$$VEP = \frac{Volt_{DG} - Volt_{pre-opt}}{Volt_{pre-opt}} \times 100\% \qquad (11)$$

Two-optimal DGs were then placed into the system to compensate losses due to incremented demand at the weak Bus-30, yielding results of the system's loss and minimum voltage profile as inFig. and Fig. 5.

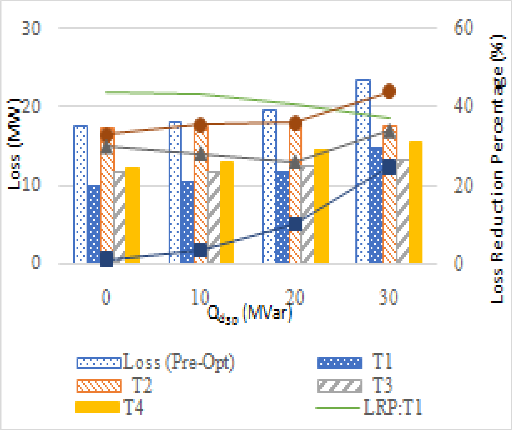

Fig. 4 Loss and LRP with 2-DGs of Different Types when Reactive Load Incremented at Bus-30

Comparing all four DG types, it can be seen from Fig.that T1 DGs were able to reduce system loss the most, followed by T3, T4 and lastly T2 DGs, except when Q_{d30} = 30 MVarat when two-optimal T3 DGs has the lowest system's loss. However, as reactive demand increases, the LRP values for T1 decreases whereas LRP values for T2 and T3 increases.

Fig. 5 shows that all DG types excluding T4, were capable of enhancing the minimum voltage profile, except when Q_{d30} = 30 MVar. Here, two-optimal T4 DGs were also able to enhance the system's minimum voltage profile. Noticed that as Q_{d30}increases, the pre-optimized minimum voltage profile decreases and optimal T2 and T3 DGs displayed that they are able to improve the minimum voltage profile towards 0.95 p.u. As the system going very near to divergence at Q_{d30} = 30 MVar, two-optimal T2 DGs enhanced the system's minimum voltage up to 40%, the highest VEP among the others.

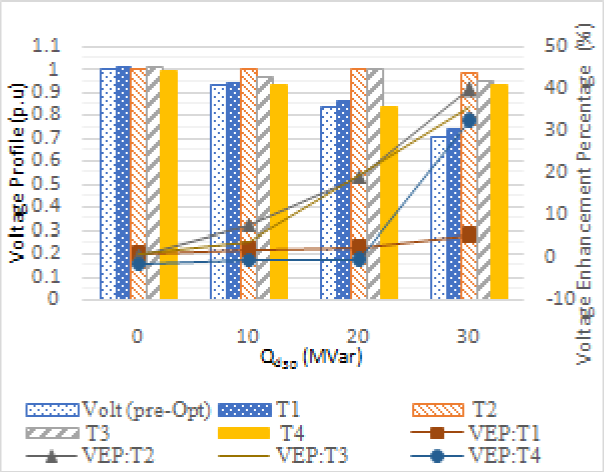

Fig. 5Min voltage profile and VEP with 2-DGs of Different Types when Reactive Load Incremented at Bus-30

The study was then continued with the same reactive loading buses and reactive loading values, but with three and five DGs. The LRP of these arrangements when Qd6 and Qd30 increases are tabulated in **Error! Reference source not found.** and **Error! Reference source not found.** respectively, together with the LRP for two-optimal DGs scenario.Table 2 lists the optimal location and sizes of multiple DGs searched by IBSEP to optimally reduce IEEE-30 RTS system loss.

Table. 1 Loss Reduction percentage (LRP) With Multi- Units of Different DG Types when Reactive Load Incremented at Bus- 6

Q_{d_6} (MVar)	No. of DGs	LRP (%)			
		T1	T2	T3	T4
0	2	*54.93*	1.01	43.85	37.80
	3	*54.84*	1.04	40.79	37.76
	5	***67.47***	**55.67**	**59.43**	**49.04**
10	2	*51.75*	3.36	42.77	37.31
	3	*52.75*	1.70	43.81	37.80
	5	***67.61***	**63.96**	**59.61**	**48.79**
20	2	*48.64*	9.87	45.27	34.49
	3	*52.70*	2.10	41.49	37.52
	5	***67.55***	**64.52**	**59.56**	**46.67**
30	2	43.95	23.93	*50.10*	35.93
	3	*52.63*	2.48	41.68	36.22
	5	***71.00***	**64.09**	**59.47**	**45.57**

Table. 2 Optimal DGs Locations and Sizes when Q_d incremented at Bus-6 and Bus-30

	No. of DG	DG Location (Bus)				DG Sizes (MVA)			
		T1	T2	T3	T4	T1	T2	T3	T4
Qd6= 0	2	7,25	3,24	19,21	7,28	49.96, 18.26	16.15, 11.69	36.44, 42.98	33.64, 32.25
	3	4, 15, 22	3, 19, 25	9, 9, 22	9, 12, 22	32.69, 38.95, 45.19	18.83, 7.61, 2.58	40.39, 40.39, 26.66	40.39, 33.96, 26.66
	5	7, 10, 10, 25, 28	7, 9, 12, 20, 23	7, 9, 14, 18, 21	7, 10, 10, 25, 28	33.2, 36.0, 38.6, 9.3, 30.7	18.20, 46.93, 17.98, 4.19, 13.80	23.84, 46.88, 34.08, 44.33, 24.11	32.91, 35.62, 38.25, 9.18, 30.42
Qd6=10	2	7, 25	4, 21	19, 21	19, 28	49.96, 18.26	45.14, 13.87	36.44, 42.98	38.21, 48.15
	3	14, 28, 7	10, 12, 27	4, 15, 15	9, 12, 22	40.45, 32.58, 33.98	28.62, 38.99, 16.98	32.36, 38.56, 38.56	40.39, 33.96, 26.66
	5	7, 10, 10, 25, 28	7, 9, 12, 20, 22	7, 9, 14, 18, 21	7, 10, 10, 25, 28	33.2, 36.0, 38.6, 9.3, 30.7	34.75, 47.50, 21.29, 13.02, 6.63	23.84, 46.88, 34.08, 44.33, 24.11	32.91, 35.62, 38.25, 9.18, 30.42
Qd6=20	2	7, 25	4, 21	7, 25	7, 28	49.96, 18.26	45.14, 13.87	49.45, 18.07	33.64, 32.25
	3	14, 28, 7	10, 12, 27	9, 9, 22	9, 12, 22	40.45, 32.58, 33.98	41.47, 41.61, 20.33	40.39, 40.39, 26.66	40.39, 33.96, 26.66
	5	7, 10, 10, 25, 28	7, 9, 12, 17, 24	7, 9, 14, 18, 21	7, 9, 9, 12, 29	33.2, 36.0, 38.6, 9.3, 30.7	41.85, 42.29, 21.18, 15.32, 4.45	23.84, 46.88, 34.08, 44.33, 24.11	4.01, 34.26, 38.45, 47.13, 19.30
Qd6=30	2	7, 25	4, 21	7, 25	7, 28	49.96, 18.26	45.15, 13.87	49.45, 18.07	33.64, 32.25
	3	14, 28, 7	10, 12, 27	9, 9, 22	9, 12, 22	40.45, 32.58, 33.98	41.47, 41.61, 20.33	40.39, 40.39, 26.66	40.39, 33.96, 26.66
	5	3, 6, 7, 21, 23	4, 4, 7, 9, 12	7, 9, 14, 18, 21	7, 10, 10, 25, 28	23.2, 45.2, 32.3, 48.13, 17.2	14.61, 26.34, 49.71, 21.41, 18.80	23.84, 46.88, 34.08, 44.33, 24.11	32.91, 35.62, 38.25, 9.18, 30.42
Qd30=0	2	7, 25	4, 24	19, 21	7,28	49.96, 18.26	26.04, 11.02	36.44, 42.98	33.64, 32.25
	3	4, 15, 22	3, 19, 25	4, 15, 15	9, 12, 22	32.7, 39.0, 45.2	18.8, 7.6, 2.6	32.4, 38.6, 38.6	40.4, 34.0, 26.7
	5	7, 10, 10, 25, 28	9, 12, 14, 21, 27	6, 6, 22, 23, 25	7, 10, 10, 25,28	33.2, 36.0, 38.6, 9.3, 30.7	48.2, 42.0, 4.8, 48.2, 12.1	38.7, 24.7, 24.7, 49.3, 21.0	32.9, 35.6, 38.2, 9.2, 38.2

Qd30= 10	2	7,25	25,30	19, 28	6, 12	49.96, 18.26	6.81, 12.19	38.21, 48.15	41.00, 29.75
	3	7,14,28	12, 25, 30	4, 15, 15	9, 12, 22	34.0, 40.4, 32.6	30.0, 6.8, 12.2	32.4, 38.6, 38.6	40.4, 34.0, 26.7
	5	7, 10, 10, 25, 28	7, 9, 9, 12, 29	7, 9, 14, 18,21	7, 10, 10, 25, 28	33.2, 36.0, 38.6, 9.3, 38.6	4.0, 34.6, 38.8, 47.6, 38.8	23.8, 46.9, 46.9, 44.3, 24.1	32.9, 35.6, 38.2, 9.2, 38.2
Qd30= 20	2	7,25	10,30	15,30	6,12	49.96, 18.26	2.86, 27.11	42.63, 22.00	41.00, 29.75
	3	7, 14, 28	3,10,30	16, 30, 30	9, 12, 22	34.0, 40.4, 32.6	40.4, 26.1, 29.2	21.4, 40.2, 40.2	40.4, 34.0, 26.7
	5	7, 10, 10, 25, 28	7, 9, 10, 15, 30	12, 19, 21, 25, 30	4, 4, 7, 9, 12	33.2, 36.0, 38.6, 9.3, 38.6	38.3, 48.4, 13.4, 39.0, 38.3	29.0, 38.0, 29.0, 38.5, 47.2	14.5, 26.1, 49.2, 21.2, 21.2
Qd30= 30	2	7, 25	10, 30	15,30	26,29	49.96, 18.26	2.87, 27.12	42.63, 22.00	13.81 ,13.63
	3	6, 27, 28	15, 25, 30	22, 22, 25	22, 22, 27	28.6, 46.0, 38.5	18.4, 8.1, 43.2	48.9, 48.9, 34.1	43.0, 39.6, 21.8
	5	7, 10, 10, 25, 28	7, 10, 10, 25, 28	12, 19, 21, 25, 30	6, 7, 15, 25, 26	33.2, 36.0, 38.6, 9.3, 38.6	33.2, 36.0, 38.6, 9.3, 38.6	29.0, 38.0, 29.0, 38.5, 47.2	38.2, 18.2, 38.2, 2.6, 29.4

Table. 3 Loss Reduction Percentage (LRP) with Multi-Units of Different DG Types When Reactive Load Incremented at Bus- 30

Q_{d30} (MVar)	No. of DGs	LRP (%)			
		T1	T2	T3	T4
0	2	*43.52*	0.95	32.81	29.87
	3	*54.93*	1.01	43.85	37.80
	5	***67.57***	**58.75**	**59.95**	**49.27**
10	2	*42.95*	3.27	35.32	28.10
	3	*51.75*	3.36	42.77	37.31
	5	***66.34***	**63.50**	**58.43**	**47.44**
20	2	*40.55*	9.98	35.92	26.05
	3	*48.64*	9.87	45.27	34.49
	5	**62.44**	***64.90***	**58.98**	**40.49**
30	2	36.91	24.85	*43.82*	33.82
	3	43.95	23.93	*50.10*	35.93
	5	**55.59**	**55.58**	***66.89***	**56.30**

Referring to Table 1, when reactive load was incremented at healthy Bus-6, injecting five DGs to the network would minimize system loss the most, as in bold, compared to two- and three-DGs arrangement. Whereas, in terms of DG type, T1 DGs are found to be the best type in reducing system loss in all situation but one, as emphasized with italic font. The corresponding optimal DG locations and sizes.

When reactive load was incremented at weak Bus-30, it can be seen from bold fonts in Table 3, that five-DGs installation is superior than two- and three-DGs arrangement in minimizing the system loss. The italic font in Table 3 represents the highest LRP across different DG types. When Q_{d30} were 0 MVar and 10 MVar, T1 DGs were able to compensate system loss the most. However, as the bus was further burdened with reactive demand, DGs that provide reactive power proved that they are better in compensating the loss.

Table4 and Table 5 list down the VEP yielded by the optimal DGs determined by IBSEP techniques to compensate system losses while reactive demand was incremented at Bus-6 and Bus-30 respectively. Last column of these tables tabulates the minimum voltage profile of the network before DGs placement. Highest VEP calculated at every Q_d is in bold.

When Q_d was incremented at healthy Bus-6, T2 DGs portrait their ability to enhance system's minimum voltage profile, while T4 DGs lowered down the reading at most of the time as shown in Table4. But, with enhanced or lowered minimum voltage profile, the IEEE-30 RTS was still in healthy mode as the voltage profile was still within allowable range.

From Table V, T3 DGs displayed their ability to enhance the minimum voltage profile the most when Q_{d30} were 20 MVar and 30 MVar followed by T2 DGs. During these reactive loading, system minimum voltage profile deviated too away from the ideal range defined by IEEE. By installing DGs capable of delivering reactive power, the voltage profile could be enhanced.

V. CONCLUSION

This paper has presented effect of multiple different optimal DG types in terms of power delivering capabilities towards total transmission network loss while monitoring the system's minimum voltage profile. It is concluded that optimal DGs that deliver pure real power minimize system loss the most, followed by DGs that deliver real and reactive power and lastly by DGs that deliver reactive power only, when reactive load was incremented at a healthy load bus. When load demand increases at a weak bus, T1 DGs reduce the system loss the most, but not when the load bus was heavily burdened that the voltage profile way below 0.95 p.u. It is also concluded that system loss can be further minimized when more optimal DG units are added. Finally, IBSEP optimization technique is able to locate optimal-sized DGs at multiple optimal locations to minimize transmission network loss.

Table. 4 Voltage enhancement Percentage(VEP) with multi- Units of Differenct DG Types When Reactive Load Incrementd at Bus- 6

Q_{d_6}(MVar)	No. of DGs	VEP (%)				$VP_{pre\text{-}opt}$
		T1	T2	T3	T4	(p.u)
0	2	1.21	1.08	1.54	-0.72	0.9945
	3	7.95	**17.42**	10.42	10.95	
	5	1.16	0.22	0.03	-4.23	
10	2	1.45	1.45	1.82	-1.63	0.9907
	3	8.37	**17.41**	9.95	11.02	
	5	1.41	0.43	0.27	-4.00	
20	2	1.46	1.45	2.11	-1.32	0.9892
	3	8.40	**17.39**	10.39	11.10	
	5	1.41	0.52	0.28	-7.54	
30	2	1.46	1.46	2.26	-1.32	0.9877
	3	8.44	**17.37**	10.39	11.36	
	5	0.97	0.65	0.28	-5.89	

Table. 5 Voltage Enhancement Percentage (VEP) with Multi- Units of Diffent DG types when Reactive load incrementd at Bus – 30

$Q_{d_{30}}$ (MVar)	No. of DGs	VEP (%)				$VP_{pre\text{-}opt}$
		T1	T2	T3	T4	(p.u)
0	2	0.64	0.28	0.64	-1.42	1.0036
	3	0.48	0.19	0.64	-2.64	
	5	0.64	0.52	0.58	-4.62	
10	2	1.66	7.68	3.85	-0.52	0.9326
	3	1.09	**7.85**	3.99	-2.38	
	5	1.61	3.44	0.32	-4.62	
20	2	2.13	19.04	19.37	-0.66	0.8438
	3	1.39	19.52	**19.70**	-3.28	
	5	2.06	2.64	19.70	-2.69	
30	2	4.99	39.89	35.42	32.01	0.7069
	3	9.89	42.31	42.88	8.25	
	5	4.88	4.88	**42.89**	37.02	

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