Asian Journal of Water, Environment and Pollution, Vol. 18, No. 2 (2021), pp. 37–43.
DOI 10.3233/AJW210017

Renewable Distributed Generations Optimal Penetration in the Distribution Network for Clean and Green Energy

Amandeep Gill*, Abhilasha Choudhary[1] and Himani Bali[1]
Department of EE, JECRC University, Jaipur, India
[1]Department of ECE, JECRC University, Jaipur, India
✉ aamangill.87@gmail.com

Received January 25, 2021; revised and accepted March 13, 2021

Abstract: For raising the initiatives to supply clean and green energy globally, many renewable distributed generations are attached to the network. Power losses, voltage profile maintenance and environmental pollution are the most significant restrictions, which hinder the existing power system. Random penetration of the distributed generation in the existing network can cause severe problems like voltage instability, increase in power losses, system islanding, reverse power flows, environment pollution, etc. Therefore, for clean and green energy, optimal penetration of eco-friendly renewable distributed generation is required for power loss minimisation and voltage profile enhancement. Optimal penetration of renewable distributed generation has to deal with constraints like size, location, number, power factor and type. Adaptive schemes are based on biogeography-based optimisation and particle swarm optimization methods to satisfy all the constraints related to the optimal penetration of renewable distributed generation systems in the IEEE 33 bus radial distribution network. The adaptive schemes have been applied for (real and reactive) power loss reduction and enhancing voltage profile.

Key words: Distributed generation, radial distribution network, particle swarm optimisation technique, biogeography based optimisation technique.

Introduction

Energy policies are developing swiftly to produce electric power supplies with the least carbon waste to lower greenhouse gas emissions, maintain environmental change, and reduce environmental pollution by using renewable fuel sources. These power policy goals merge using renewable-based distributed generation (RDG) and renewable and cogeneration of combined heat and power (CHP). Deregulation and open access to the distribution network (DN) are most likely to offer higher distributed generation (DG) possibilities. At present, DG is seen mainly to create electric power and contribute little to the network's secondary solutions. DG are treated as well as being compensated as a source of energy. The infiltration of DG in some countries is so high that it is the reason behind the network's operational problems. The focus is on placing the DG in the network to speed up the release of all kinds of DG power sources as opposed to incorporating it right into the overall operation of the network. DG systems are attached generally based on a fit and forget strategy. Optimal integration of DG needs to be performed to bring the following benefits: reducing the centralised generating capacity, increasing transmission and DN ability, enhancing network safety and security, and reducing total expenses and carbon dioxide exhausts (Abbasi and Hosseini, 2016).

For raising the initiatives globally to supply clean and green energy, many RDG are attached to the DN.

*Corresponding Author

For example, PV cells, wind power plants, CHP plants, fuel cells, micro CHP, solar thermal, tidal power plants, and geothermal power plants. The generators utilised for DG depend upon their application and energy resource. As an example, the use of a synchronous generator is for small rating diesel DG sets. In contrast, a wind generation may use an induction generator (squirrel-cage or fixed speed, doubly-fed). High-frequency DC sources like PV systems, fuel cells or micro-turbines need power electronic converter to interfere with the network. The performance and features of various kinds of RDG systems vary significantly. RDG systems have no fuel costs, and also reduce the setup cost, preserving the constant running cost for a long time auxiliaries expenses are reduced. The ecological benefits of RDG systems penetration are effects of land utilisation are reduced, renewable DG systems lessen the expenditures on health as they are eco-friendly and reduce the greenhouse gas discharge pollutants (Ali et al., 2016).

A significant amount of power losses in the existing network lowers its efficiency. A big part of generated power is lost in the transmission and distribution losses. These losses have a direct influence on the network regarding economic outcomes and efficiency of the network. However, to meet the load demand, minimise the power losses, and enhance the voltage profile during peak time, the most commonly used approaches are capacitor placement and DG penetration (Prabha and Jayabarathi, 2016). If the DG systems are not used optimally, it shows an unfavourable effect on the system efficiency like increased power losses and voltage instability. To obtain optimum advantages, optimal penetration of DG units in the DN plays an important function (Moghaddam et al., 2018). Here photovoltaic (PV) type RDG unit is selected for penetration in the radial distribution network (RDN). Photovoltaic (PV) innovations transform solar radiation right into electron current utilising semiconductor tools. Whenever subjected to adequate light, solar cells generate direct current (DC) power of about 0.5 V. To get more power outcome, numerous solar cells are linked in a series connection. Inverter circuits are made to convert the DC outcome acquired by the PV cell into an alternating current outcome. For RDG, PV provides a distinctive benefit over various other kinds of generations. Regardless of the high expense of instalment at first, sunlight is free as well as it is likewise readily available in remote areas. They neither create noise nor produce any contamination in the atmosphere (Gupta et al., 2019).

Gill et al. (2019), Devabalaji et al. (2018) and Brahma (2011) have attained appealing lead to resolve various problems related to DG penetration, voltage profile, power loss, etc. in the radial distribution network by using various techniques, but there are particular constraints in regarding the optimal penetration of RDG in the existing RDN need to be fulfilled. So, to take care of these constraints, a population-based search strategy is needed. In this paper, adaptive schemes are applied for optimal penetration of distributed generation in the DN. Adaptive schemes are based on biogeography-based optimization (BBO) and particle swarm optimisation (PSO) method for optimal penetration RDG unit in the existing RDN for clean and green energy. The adaptive schemes have been applied for (real and reactive) power loss reduction, and enhancing voltage profile.

Problem Formulation

Load flow analysis is used to discover power loss and voltage representing each branch. The two bus DN is displayed in (Figure 1). The voltage representing that bus k +1 is figured out by using KVL and it is offered by Equation (1).

$$V_{k+1} = V_k - I_{k,\,k+1}(Z_{k,\,k+1}) \tag{1}$$

where $Z_{k,\,k+1} = R_{k,\,k+1} + j\,X_{k,\,k+1}$ is the impedance of the line between k and k+1, V_k is the voltage at bus k, The current supplied at node k is established as well as it is given up (2).

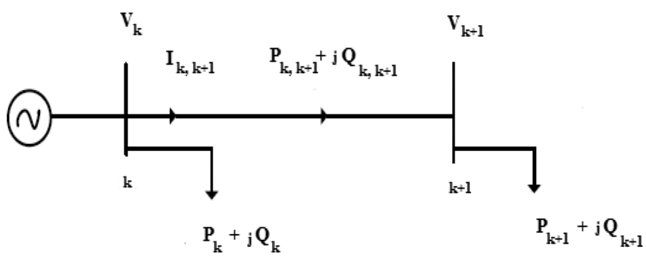

Figure 1: Two bus distribution networks.

$$I_k = \left(\frac{P_k + Q_k}{V_k}\right)^* \tag{2}$$

where P_k and Q_k are the true and reactive power supplied at bus k.

Branch current is figured out at the buses k and k +1 by using KCL and it is offered by Equation (3)

$$I_k = I_{k+1} + I_{k+2} \tag{3}$$

The true and reactive power loss representing the buses k and $k+1$ is established from Equations (4) and (5).

$$P_{l(k,k+1)} = R_{k,k+1}\left(\frac{P_{k,k+1}^2 + Q_{k,k+1}^2}{|V_k^2|}\right) \quad (4)$$

$$Q_{l(k,k+1)} = X_{k,k+1}\left(\frac{P_{k,k+1}^2 + Q_{k,k+1}^2}{|V_k^2|}\right) \quad (5)$$

The complete power loss represents all buses is the addition of losses which is identified making use of Equations (6) and (7).

$$P_{Tl} = \sum_{k=1}^{b} P_{l(k,k+1)} \quad (6)$$

$$Q_{Tl} = \sum_{k=1}^{b} Q_{l(k,k+1)} \quad (7)$$

Whenever RDG devices are penetrated at the optimum bus location they will minimize power loss in a line, enhance the voltage profile, voltage security and peak demand saving. The power loss after penetration of RDG at equivalent buses k and k+1 can be calculated as:

$$P_{RDG,l\,(k,k+1)} = R_{k,k+1}\left(\frac{P_{RDG,k,k+1}^2 + Q_{RDG,k,k+1}^2}{|V_k^2|}\right) \quad (8)$$

$$Q_{RDG,l(k,k+1)} = X_{k,k+1}\left(\frac{P_{RDG,k,k+1}^2 + Q_{RDG,k,k+1}^2}{|V_k^2|}\right) \quad (9)$$

The total real and reactive power loss with the penetration of RDG can be calculated by the addition of the total losses of the network as adhered to:

$$P_{RDG,Tl} = \sum_{k=1}^{b} P_{RDG,l(k,k+1)} \quad (10)$$

$$Q_{RDG,Tl} = \sum_{k=1}^{b} Q_{RDG,l(k,k+1)} \quad (11)$$

where b is for the total number of buses

Real power loss minimization with the penetration of RDG is calculated by power loss index, which is the proportion of total power loss with the penetration of RDG to the total amount of power loss without penetration of RDG and can be created as:

$$F_1 = \text{Real Power loss index} = \left(\frac{P_{RDG,Tl}}{P_{Tl}}\right) \quad (12)$$

$$F_2 = \text{Reactive Power loss index} = \left(\frac{Q_{RDG,Tl}}{Q_{Tl}}\right) \quad (13)$$

The overall quantity of power loss can be minimised with the positioning of RDG and can be improved by reducing the power loss index.

Voltage Inconsistency Index, when the RDG systems are placed optimally in the DN, it improves the voltage profile of this network. This is given by the voltage inconsistency index principle.

$$F_3 = \text{Voltage inconsistency index}$$

$$\text{Max}\left(\frac{|V_1| - |V_k|}{|V_1|}\right) \text{ where } k = 1.2 \ldots n \quad (14)$$

where V_1 is the nominal voltage i.e. 1 per unit (p.u). With the penetration of RDG in the DN, the suggested method reduces the voltage inconsistency index near to zero and boosts the voltage profile of the network (Hashemi et al., 2013).

Objective Feature Formulation

The multi-objective feature is developed to reduce the actual power loss and enhance the voltage profile of the RDN that is offered as adhered to.

$$\text{Min}(F_T) = \text{Min}(Ø_1\, F_1 + Ø_2\, F_2 + Ø_3\, F_3) \quad (15)$$

In the multi-objective feature, the weighting variables ($Ø_1$, $Ø_2$ and $Ø_3$) are altered according to the value of F_1, F_2, and F_3. The established objective feature is to satisfy numerous constraints of RDN (Hedayati et al., 2008).

Constraints

RDG Unit Size

The limit for the RDG unit size in kW should be in range as shown in Equation (16).

$$S_{\text{DGmax}} \geq S_{\text{DGk}} \geq S_{\text{DGmin}} \quad (16)$$

where S_{RDGmax} and S_{RDGmin} are the maximum and minimum apparent power limitation of the RDG at node k, respectively.

RDG Unit Power Factor (PF)

The RDG PF should be within the limit as shown in Equation (17).

$$\text{PF}_{\text{RDG (max)}} \geq \text{PF}_{\text{RDGk}} \geq \text{PF}_{\text{RDG (min)}} \quad (17)$$

where $\text{PF}_{\text{RDGmax}}$ and $\text{PF}_{\text{RDGmin}}$ are the maximum and minimum PF limitation of the DG at node k, respectively.

Voltage Sensitivity Index for finding the Optimal Location for RDG Penetration

To find the voltage sensitivity of the buses, RDG at 30% loading was placed at each load bus at a time. Voltage sensitivity index (VS) can be acquired by Equation (18). RDG unit is placed at bus k, VS for bus k is as follows:

$$VS_k = \sqrt{\frac{\sum_{k=1}^{n}(1-V_k)^2}{n}} \tag{18}$$

where V_k is the voltage at the bus k and n is the number of buses. The bus with the lowest VS will be the optimal location for RDG penetration.

Optimal Sizing for RDG

For finding the optimal sizing for RDG, penetrate the RDG at the bus having the lowest VS. At constant PF vary the size of RDG from minimum range to the range equal to the branch load capacity in steps until minimum real and reactive power loss is attained. This is the optimal size for RDG (Ma et al., 2018).

If all the constraints are satisfied after that only the resultant service is approved or else it should be rejected. RDG system placement optimal location, type, PF and sizes are recommended and measured by the adaptive schemes based on PSO and BBO techniques.

Adaptive Scheme

Particle Swarm Optimisation based Adaptive Scheme

A fundamental version of the PSO algorithm functions by having a populace (called a swarm) of prospect remedies (called fragments). These fragments are moving in the search area following basic regulations. Their best-recognised placement directs the motion of the fragments in the search-area as well as the whole swarm's best-recognised placement. When enhanced placements are being found these will certainly involve directing the motions of the swarm. This procedure is repeated and also by doing, so it is wished, however, not ensured, that a satisfying solution will be found.

Assume F: $F_c^n \rightarrow F_c$ be the cost feature which should be reduced. The feature takes a prospect remedy as an argument in the form of a vector of real numbers. It generates a real number as an outcome which suggests the objective feature value of the provided prospect remedy. The gradient of F is unknown. The objective is to discover a remedy B for which $F(B) \leq F(A)$ for all A in the search-area, which would suggest B is the global minima. Maximisation can be executed by taking into consideration the feature $H = -F$ rather.

Assume s be the variety of fragments in the swarm, each having a placement $X_j \in F_c^n$ in the search-area as well as a speed $V_j \in F_c^n$. Assume P_j be the best-recognised placement of fragment j and also assume G be the very best-recognised placement of the whole swarm. A standard PSO algorithm is as:

- For every fragment j = 1,..., s:
  - Initialise the fragment's placement with a consistently dispersed arbitrary vector: $X_j \sim E$ (l, u), where l and also u are the lower as well as upper limits of the search-area.
  - Initialise the fragment's best-recognised placement to its first placement: $P_j \leftarrow X_j$.
  - If ($F(P_j)$ <$F(G)$) upgrade the swarm's best-recognised placement: $G \leftarrow P_j$.
  - Initialise the fragment's speed: $V_j \sim E$ (-|u-l |,|u-l|).
- Till a discontinuation requirement is fulfiled (e.g. a variety of iterations executed, or an option with appropriate objective feature value is discovered), repeat:
  - For every fragment j = 1, ..., s do:
    - Choose arbitrary numbers: R_P, R_G ~ E(0,1).
    - For every measurement m = 1, ..., n:
      - Upgrade the fragment's speed: $V_{j,m} \leftarrow ØV_{j,m} + Ø_P R_P (P_{j,m} - X_{j,m}) + Ø_G R_G (G_m - X_{j,m})$.
    - Upgrade the fragment's placement: $X_j \leftarrow X_j + V_j$.
    - If ($F(X_j)$ <$F(P_j)$):
      - Upgrade the fragments best-recognised placement: $P_j \leftarrow X_j$.
      - If ($F(P_j)$ <$F(G)$) upgrade the swarm's best-recognised placement: $G \leftarrow P$j.
- Currently, G holds the best-discovered solution.

The specifications Ø, $Ø_P$, and also $Ø_G$ are chosen by the expert and the actions and performance of the PSO technique managed (Basser et al., 2015).

Biogeography based Optimization based Adaptive Scheme

The BBO formula is an effective optimisation method. Originally, this method was derived from the bio-organics circulation method in various environments. A collection of prospect remedies is called Islands, islands that are well-matched as environments for organic species are stated to have a high island viability index (IVI). Various parameters such as rain ranking, plant life density, temperature level and the soil kind is determining IVI ranking. All remedy features are called a viability index variable (VIV). VIV's are independent variables of the island, as well as IVI, which is the dependent variable. An excellent method illustrates an island with high IVI, and a weak one defines a low IVI island. The high IVI methods have an extra propensity to share function with the low IVI approach, and it is executed by immigration as well as emigration drivers. Immigration to low IVI islands can enhance its IVI.

Emigration as well as Immigration

Emigration and immigration are standard principles of the stated formula, and they are:

$$\rho_s = e\left(\frac{s}{s_m}\right) \tag{19}$$

$$\sigma_s = i\left(1-\frac{s}{s_m}\right) \tag{20}$$

Here i is the optimum practical immigration rate, which happens when there are zero species on the island and e is the optimum practical emigration rate, which happens when the island has the biggest variety of species (s_m). As the variety of species rises, fewer species can go into the island, so the value of i declines. The factor at which i end up being zero is the widest practical variety of species on the island (s_m).

For emigration contour, if the variety of species is zero, then the value of e should be zero. As the variety of species rises, even more species will certainly leave the island, so the value of e rises. Whenever the island has the widest variety of species, the maximum value of e happens. The balance variety of species is the factor at which i and e are equivalent.

Mutation

In the BBO method, sudden changes triggered by happenings like natural calamities are designed as mutations. The VIV of the island mutates with a figured-out possibility and changes the IVI of that island. The mutation procedure protects against the formula from capturing into local minima after sudden changes. The rate of mutation is computed as:

$$\mathrm{M(s)} = M_m\left(1-\frac{p_s}{p_m}\right) \tag{21}$$

where M_m is the optimum rate of mutation which is identified by the customer taking into consideration the trouble condition, p_s is the possibility which island consisted of precisely s species and also $p_m = \max(p_S)$, $s = 1,2,3,......\ s_m$ (Ghaffarzadeh and Sadeghi, 2016).

Results and Discussion

The adaptive scheme based on BBO and PSO techniques has been applied for the optimal penetration of RDG in the RDN. The adaptive scheme is tested on 12.66 kV, IEEE 33 bus RDN as shown in (Figure 2). The total actual and reactive load values are 2.8 MW as well as 1.4 MVAR. Line and bus data for the 33 bus RDN are taken from the study by Sahoo and Prasad (2006).

Some assumptions for the modelling of the IEEE 33 bus RDN, which are as follows:

- Load flow analysis should be done by considering base apparent power (S_b = 100MVA) and base voltage (V_b =12.66 kV).
- Two PV type RDG that operated at various unity PF, i.e. supplying real power are placed in the RDN.
- The buses connected with the load will be considered for RDG penetration, and the source buses will not be considered for RDG penetration.
- Assume the voltage at the initial bus as 1.0 per unit (p.u).
- The upper and lower limitations of bus voltages are between ± 0.05 p.u.
- There should be one RDG placed on each bus.
- The loads utilised in the modelling should be uniform with continuous power.

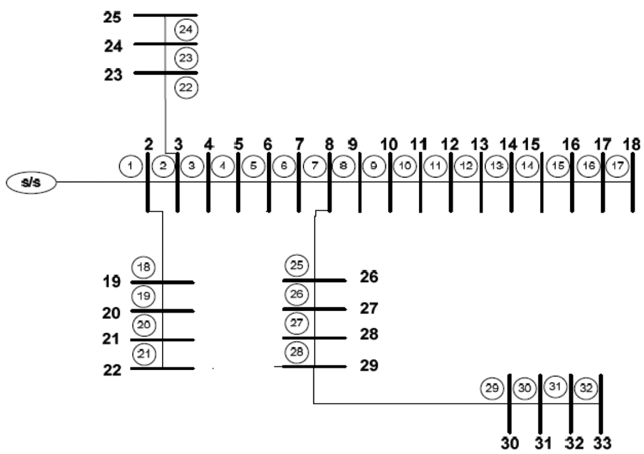

Figure 2: The IEEE 33 Bus RDN.

The power loss is 213.25 kW, and the minimum bus voltage is 0.9072 per unit (p.u) in this RDN. Two PV type RDG units at unity PF is selected for penetration in the RDN. Here, the RDG system penetrations are shown at different buses, which reduce the existing power losses and enhance the voltage profile of the RDN. Table 1 shows the comparison of RDG size, location and voltage profile of adaptive schemes based on BBO and PSO techniques with the RDN and without any RDG penetration and RDN with random RDG penetration. Table 2 shows a comparison of real and

Table 1: Comparison of RDG size, location and voltage profile

Techniques applied on IEEE 33 Bus RDN	*RDG Size (kW)*		*RDG Bus Location*		*Voltage Profile (p.u)*
	Unity PF	*Unity PF*	*Unity PF*	*Unity PF*	
With Random RDG	46.23	50.51	10	26	0.9487
PSO	41.74	45.53	19	21	0.9547
BBO	35.41	40.13	19	20	0.9684

Table 2: Comparison of real and reactive power losses

Techniques applied on IEEE 33 Bus RDN	*Real power losses*			*Reactive power losses*		
	P loss (kW)	*P loss minimisation (kW)*	*P loss minimisation (%)*	*Q loss (kVAR)*	*Q loss minimisation (kVAR)*	*Q loss minimisation (%)*
Without RDG	213.25	-	-	147.13	-	-
With random RDG	201.39	11.86	5.56	139.64	7.49	5.09
PSO	187.47	25.78	12.08	131.14	15.99	10.86
BBO	175.23	38.02	17.82	123.37	23.76	16.14

The reactive power loss obtained using the BBO technique is 123.37 kVAR, the PSO technique is 131.14 kVAR, 139.64 kVAR with random RDG unit and the 147.13 kVAR from RDN without RDG unit. Minimisation of reactive power loss by the BBO technique is 16.14%, the PSO technique is by 10.86% as compared with 5.09% by the random RDG unit.

reactive power losses between adaptive schemes, these results are compared with random penetration of RDG and RDN without any RDG penetration.

Using the BBO technique, the optimal sized 35.41 kW and 40.13 kW RDG unit (PV type at unity PF) are connected with the optimal bus 19 and 20. By using the PSO technique, the optimal sized 41.74 kW and 45.53 kW RDG unit (PV type at unity PF) is connected to the optimal bus 19 and 21. The BBO technique reduced the RDG size by 10.82 kW and 10.38 kW, and PSO technique reduced the RDG size by 4.49 kW and 4.98 kW as compared to the random RDG unit size, i.e. 46.23 kW and 50.51 kW. The real power loss obtained from the BBO technique is 175.23 kW, the PSO technique is 187.47 kW, 201.39 kW with random RDG unit and the 213.25 kW from RDN without RDG unit. Minimisation of power loss by the BBO technique is 17.82%, with the PSO technique, it reduces by 12.08% as compared with 5.56% by the random RDG unit.

The voltage profile enhances from 0.9072 p.u to 0.9684 p.u from the base model to the BBO based adaptive scheme.

Figures 3 and 4 show real and reactive power loss comparison and Figure 5 shows the voltage profile comparison due to the optimal penetration RDG unit with BBO and PSO based adaptive scheme, with random RDG and without RDG. The BBO based adaptive scheme has generated promising results in

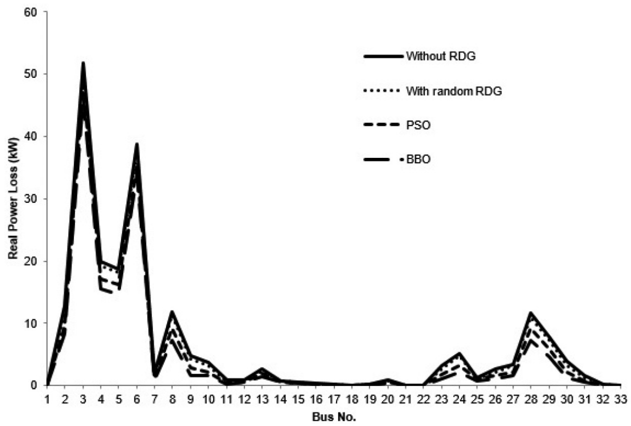

Figure 3: Real power loss (kW) comparison.

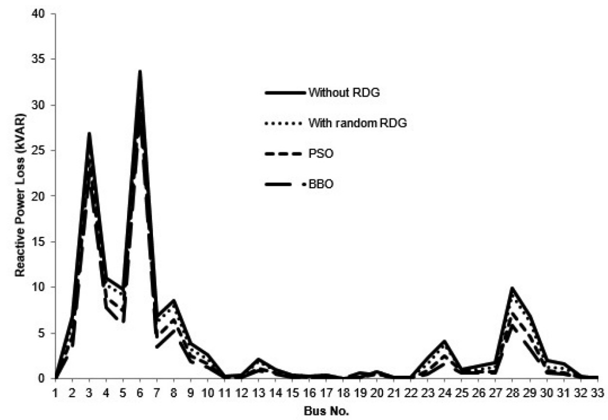

Figure 4: Reactive power loss (kVAR) comparison.

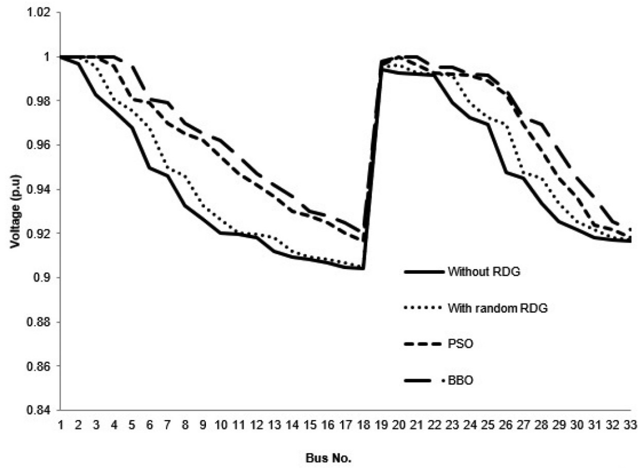

Figure 5: Voltage profile (p.u) comparison.

the context of optimal penetration of RDG in RDN. It has caused a maximum reduction of real and reactive power losses and improvement of the voltage profile.

Conclusion

All the constraints related to the optimal penetration of RDG like size, location, type, and PF have been considered. For clean and green energy, two PV type RDG units at unity PF are optimally penetrated in the IEEE 33 bus RDN. The use of adaptive schemes based on BBO and PSO has reduced the size of RDG units. The BBO and PSO have successfully performed the optimal penetration of RDG units based adaptive scheme for (real and reactive) power loss reduction and enhancing the voltage profile. BBO based adaptive scheme has better results than the PSO-based adaptive scheme, i.e. reduced more (real and reactive) power losses and better voltage profile.

References

Abbasi, F. and S.M. Hosseini (2016). Optimal DG allocation and sizing in presence of storage systems considering network configuration effects in distribution systems. *IET Transaction on Generation, Transmission and Distribution*, **10(3):** 617-624.

Ali, E.S., Elazim, S.M.A. and A.Y. Abdelaziz (2016). Ant Lion Optimization Algorithm for renewable Distributed Generations. *An International Journal of Energy*, **116(1):** 445-458.

Prabha, D.R. and T. Jayabarathi (2016). Optimal placement and sizing of multiple distributed generating units in distribution networks by invasive weed optimization algorithm. *Ain Shams Engineering Journal*, **7(2):** 683-694.

Moghaddam, M.J.H., Nowdeh, S.A., Bigdeli, M. and D. Azizian (2018). A multi-objective optimal sizing and siting of distributed generation using ant lion optimization technique. *Ain Shams Engineering Journal*, **9(4):** 2101-2109.

Gupta, A., Kumar, A. and D.K. Khatod (2019). Optimized Scheduling of Hydropower with increase in solar and wind installations. *Energy*, **183:** 716-732.

Gill, A, Yadav S.K. and P. Singh. (2019). A reverse power flow-based intelligent protection scheme for distributed generation system. *Journal of Advanced Research in Dynamical & Control Systems.* **11(7):** 17-25.

Devabalaji, K.R., Yuvraj, T. and K. Ravi (2018). An efficient method for solving the optimal sitting and sizing problem of capacitor banks based on cuckoo search algorithm. *Ain Shams Engineering Journal*, **9(4):** 589-597.

Brahma, S.M. (2011). Fault location in power distribution system with penetration of distributed generation. *IEEE Transactions on Power Delivery*, **26(3):** 1545-1553.

Hashemi, F., Ghadimi, N. and B. Sobhani (2013). Islanding detection for inverter-based DG coupled with using an adaptive neuro-fuzzy inference system. *An International Journal of Electrical Power and Energy Systems*, **45(1):** 443-455.

Hedayati, H., Nabaviniaki, S.A. and A. Akbarimajd (2008). A Method for Placement of DG Units in Distribution Networks', *IEEE Transactions on Power Delivery*, **23(3):** 1620-1628.

Ma, J., Zhang, W., Liu, J., and J.S. Thorp (2018). A novel adaptive distance protection scheme for DFIG wind farm collector lines. *An International Journal of Electrical Power and Energy Systems*, **94:** 234-244.

Basser, H., Karami, H., Shamshirband, S., Akib, S., Amirmojahedi, M., Ahmad, R., Jahangirzadeh, A. and H. Javidnia (2015). Hybrid ANFIS–PSO approach for predicting optimum parameters of a protective spur dike. *An International Journal of Applied Soft Computing*, **30:** 642-649.

Ghaffarzadeh, N. and H. Sadeghi (2016). A new efficient BBO based method for simultaneous placement of inverter-based DGs units and capacitors considering harmonic limits. *International Journal of Electrical Power & Energy Systems*, **80:** 37-45.

Sahoo, N.C. and K. Prasad (2006). A fuzzy genetic approach for network reconfiguration to enhance voltage stability in radial distribution systems. *Energy Conversion and Management*, **47(19):** 3288-3306.

Asian Journal of Water, Environment and Pollution

Volume 17 Number 2 **April – June, 2020**

Contents