

Optimal Distributed Generation Allocation and Sizing for Minimizing losses and Cost Function

Niloofer Ghanbari, H. Mokhtari[#], and S. Bhattacharya

Department of Electrical and Computer engineering

North Carolina State University

Raleigh, North Carolina, USA

Email: nghanba@ncsu.edu

[#]Department of Electrical Engineering

[#]Sharif University of Technology

[#]Tehran, Iran

Abstract— The need for independent power generation has been increased in recent years specially with the growing demand in micro grid systems. In distribution networks with several DGs of different types and with all kinds of loads of variable nature, an optimal power balance in the system has to be achieved. This optimal objective, which results in minimal energy losses over a specific period of time, requires an optimal location and sizing of the DGs in a distribution network. This paper proposes a new optimization method in which both optimal location of the DGs and their generation profile according to the load demand profile are determined. The method is based on minimizing simultaneously the cost of investment and operation of the DGs, the cost of power delivered by the external grid as well as the cost of power losses in the network. The proposed method is tested on the IEEE standard radial distribution network considering time-varying loads.

Keywords—Distributed Generation (DG), Time-varying loads, Optimal placement, Load profile, Energy losses

I. INTRODUCTION

There has been a growing demand for a more flexible and independent electrical energy in power networks. Dependence only on the grid as a source of electricity may lead to blackout in case of grid failure. On the other hand, the regulatory and economic scenarios are changing due to the restructured power systems. In restructured power systems, DGs play an important role in supplying the loads. If a DG is rightly planned and operated, it will provide some benefits to the network among which the reduction of losses is the most important one. Therefore, in a distribution system, the DGs can provide an alternative power generation solution if they are optimally used. [1]

In [2], the authors have proposed a method in which optimal sizing and siting of the DGs are achieved based on minimizing the DGs investment and operational costs. But the sizes of the DGs are the same during the planning period. In [3], the technological limitations faced by the DGs are explained, and a new method is given using linear programming to find the best and optimal location of the DGs based on some constraints. This methodology does not determine the optimal sizes of the DGs and only specifies their location. In [4], optimum locations for the DGs are determined. This reference also assumes that the

loads are time-varying. However, the objective function in this paper is based on the reliability indices and some economic concerns without considering the system power losses.

There are many methods for DG planning which use different algorithms for optimization. In [5], some experiences of DGs placement and planning in the west of America are reported. In [6] a method is presented for DG placement based on Genetic Algorithm. The goal function for this paper is the cost evaluation and reliability indices for both utility and consumers. Some algorithms for DG planning considering distribution automation and management and control are proposed in [7]. Some guidelines for optimal placement and sizing of the DGs are proposed in [8]. However, these works show that in a restructured power system, each company tries to optimize the costs and benefits of the DGs planning based on different concerns and objective functions.

In recent researches, some approaches are highlighted regarding the minimization of cost function. In [9], cost of losses besides reliability indices are investigated, but the cost of external grid is neglected. In [10], all DGs are considered to generate equal power during the period of study. In other words, the output power of the DGs do not vary in different time intervals. Effect of environmental factors and solar radiation on renewable resources have been discussed in detail in [15-23].

In this paper, a new strategy is proposed which determines optimal location and sizing of the DGs in a radial distribution system considering investment and operation costs of the DGs. The method, at the same time and during the optimization process, tries to minimize the energy losses when the loads are time-varying by determining their generation capacity at different instants. The paper shows that working all the DGs at their full capacity will not necessarily result in an optimal operation from power losses point of view.

The structure of this paper is as follows. In section II, the proposed technique is presented. Load modelling, objective functions, loss modelling, system constraints and the optimization algorithm are explained. Section III presents the simulation results, and section IV summarizes the paper results.

II. PROPOSED METHOD

As mentioned earlier, in most of the existing DG placement and sizing techniques, loads are considered constant, and therefore, the allocation procedure is based on load power demand. However, in practice, loads change by time, and therefore, it is required to consider energy indices instead of power indices during the optimization process.

This strategy implies that the DGs output power must change according to the load demand. To minimize the total power losses, the losses must also be included in the objective function of the optimization algorithm.

A. Load Modelling

Most of the loads in a power network vary with time. In addition to the daily variation of loads, load profile also depends on the seasons and weather conditions during a year. Thus, daily load profile should be considered variable for each season of a year. As the weather condition does not change that much in a season, the load demand and consequently, the daily load profile can also be considered identical during a season. Fig. 1 shows an average of the daily load variation for different seasons [8]. It should be noted that these amounts are the average of the load for week days and weekends.

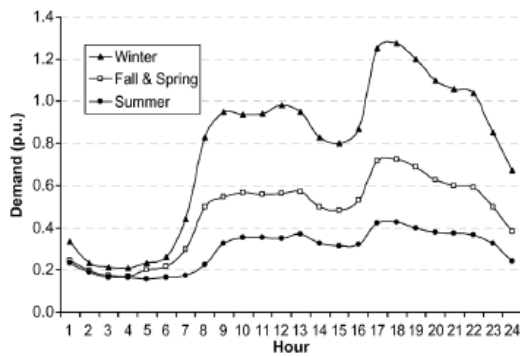


Fig. 1. Daily load profile for different seasons [8]

As Fig. 1 indicates and for simplicity, the daily load profile can be divided into some intervals over which the load variations are small. This constant value is calculated from the load curve by averaging using the Trapezoidal method. For the loading showing in Fig. 1, 7 time intervals seem appropriate. Table 1 summarizes the load averaging model for different seasons. In some references, an hourly load model is considered. This consideration needs 24 time intervals, but in this method, 7 time interval is sufficient.

TABLE I. AVERAGE LOAD FOR DIFFERENT SEASONS

Time Intervals (hrs)	Different Seasons		
	Winter (p.u.)	Fall & Spring (p.u.)	Summer (p.u.)
0-7	0.25	0.2	0.19
7-9	0.6	0.4	0.25
9-14	0.95	0.55	0.35

Time Intervals (hrs)	Different Seasons		
	Winter (p.u.)	Fall & Spring (p.u.)	Summer (p.u.)
14-17	0.85	0.5	0.3
17-20	1.25	0.7	0.4
20-22	1.1	0.65	0.38
22-24	0.85	0.5	0.35

B. Objective Function

As mentioned in the previous section, the objective function should consist of the cost of investment, operation and maintenance (O&M), and also the energy losses in the power network. Losses have thermal effects on the lines of a network and are measured in Watts. However, the costs of investment and O&M of DGs are measured in dollars and are based on monetary units. Therefore, it is required to change the losses model into monetary units.

The cost function is generally as follows:

$$\text{Objective function} = \sum_j I_j * \text{capacity of the } j^{\text{th}} \text{ DG} + \sum_i \sum_j (O\&M)_j * (\text{power generated by DG})_{i,j} * T_i + \lambda_{\text{grid}} * x_{\text{grid}} * T + F(\text{losses}) \quad (1)$$

Where, I_j is the investment cost of the j^{th} DG in $\$/_{kW}$, $(O\&M)_j$ is the operation and maintenance cost of the j^{th} DG in $\$/_{kWh}$, $(\text{power generated by DG})_{i,j}$ is the power produced by the j^{th} DG at the i^{th} time interval. T_i is the duration of the i^{th} time interval. λ_{grid} is the price of buying electricity from the external grid. x_{grid} is the power supplied by the external grid. In the planning stage, load maximum demand is normally considered in order to supplying the demand. In this paper, at every time interval, the exact amount of load will be considered and for supplying extra power required, electricity will be bought from external grid. T is the total duration of the period of planning which in this case is 8760 hours, and $F(\text{losses})$ is the losses cost function.

If there is no DG in a power system, the cost of losses would be equal to the cost of buying electricity from the external grid. This is the result of the assumption that all of the losses in the network is supplied by the grid. However, by installing DGs in the network, the losses may be supplied by the DGs, and thus, the cost of grid losses would be different.

It should be noted that in some cases, the output power of the DGs may be greater than the total demand at that moment. In such cases, the external grid absorbs the extra power. In other words, in some time intervals, power may be sold to the grid. If this condition occurs, x_{grid} will be negative to minimize the cost function.

The constraint is that the total power generated by the DGs should be as close as possible to the total demand at every moment. This constraint leads to less power absorption from the external grid. Thus, in the case of outage, dependence on the external grid would be minimum. To formulate this limitation,

the difference between the total demand and total power generated is set to 5% of the total load.

C. Loss Modelling

Network losses in a system depend on the grid configuration, DGs' location, and grid node connection. Due to the investment and operational costs, it becomes important to know what percentage of the network power losses is supplied by the DGs and grid. One simple method to use is the postage stamp method to consider the power loss shares in a distribution system which is explained in [11]. Based on this method, one can write:

$$loss_{DG} = Total\ loss * \frac{P_{DG}}{\sum P_{DG} + P_{grid}} \quad (2)$$

$$loss_{grid} = Total\ loss * \frac{P_{grid}}{\sum P_{DG} + P_{grid}} \quad (3)$$

Where P_{DG} is the active power generated by the DGs and P_{grid} is the active power generated by the external grid.

Based on Eqs. (2) and (3), the cost of losses can be computed as follows:

$$F(losses) = loss_{DG} * \lambda_{DG} * T + loss_{grid} * \lambda_{grid} * T \quad (4)$$

Where, λ_{grid} is the price of buying electricity from the external grid, and λ_{DG} is the price of buying electricity from each DG. T is the total duration of the planning period, and λ_{DG} is calculated from Eqs. (5) to (7):

$$i_{eq} = i + f + i * f \quad (5)$$

$$A = \frac{(1 + i_{eq})^n - 1}{i_{eq} * (1 + i_{eq})^n} \quad (6)$$

$$\lambda_{DG} = \frac{I}{A * 8760} + \frac{O\&M}{8760} \quad (7)$$

Where, i is the rate of return, f is the inflation rate and n is the average lifetime of DGs. i_{eq} shows the equal rate of return of a system which includes the inflation rate [12].

It should be noted that the O&M cost is in \$/MW/year. Thus, this cost should be divided by 8760 in order to be in \$/MWh. Eq. (6) and Eq. (7) convert the O&M cost into the price of buying electricity from each DG [12].

In case of inflation rate, the equal rate of return should be defined which is obtained from (5). In (6), the investment cost is converted to the annual payment in each year, and then, the total annual payment is divided by 8760, and therefore, λ_{DG} is obtained in \$/kWh.

It should be noted that the DG could be different with various lifetime averages and investment costs. Thus, λ_{DG} changes according to the type of the DG.

D. Constraints

Every optimization function has some constraints which restrict the feasible answers. In a power network, there are two major constraints:

1. limits of bus voltages: The voltage of all of the busses in a power network should remain within a standard range. This range is defined by IEEE or IEC standards and is assumed to be $\pm 5\%$. In other words, all bus voltages must be between 0.95 and 1.05 per unit, i.e.,

$$0.95^{p.u.} < V_i < 1.05^{p.u.} \quad i \in \{all\ of\ the\ busses\} \quad (8)$$

2. limits of line loadings: all of the lines of a power network have some intrinsic parameters. One of them is the capacity of the current flowing in the lines. This limitation is due to the thermal effects of flowing currents in the lines. For optimization, this line limit is assumed to be 105%.

E. PSO Algorithm

There are many algorithms for optimizing customized objective functions which are based on a natural phenomenon. One of the most common and useful methods is the Particle Swarm Optimization (PSO) algorithm. This algorithm models the objective function as the particle swarm movement. Based on PSO, in order to optimize the objective function, some particles should be considered. These particles are initialized randomly, and after computing the objective function for each particle, the best particle which minimizes the objective function is selected. Then, the particle is updated, and this procedure is repeated until the optimal answer is reached. Now, the array of the particle should be determined.

In this paper, the goal is to find the best location of the DGs in the network such that the cost function is minimized, and all of the constraints are satisfied. Moreover, the output of the DGs should be determined in each time interval for each season. Thus, the desired particle is as follows:

$$\{first\ place\ of\ the\ DG\ | \ output\ power\ for\ (3 * T)\ time\ intervals\ | \ second\ place\ of\ the\ DG\ | \dots\} \quad (9)$$

The first place of the particle array is the number of the bus at which the first DG must be placed. In the next bits of the array, the power generated by that DG at every time interval will be found. T is the number of time intervals in each day. 3 is the number of seasons in the year (considering that fall and spring seasons modellings are the same).

In other words, the array which shows the power generated by each DG looks like Eq. (10):

$$\{Winter\ | \ Fall/Spring\ | \ Summer\} \quad (10)$$

Based on the number of DGs needed in the network, this particle will be extended and repeated in the same manner. By considering this particle and after some iterations, the final result

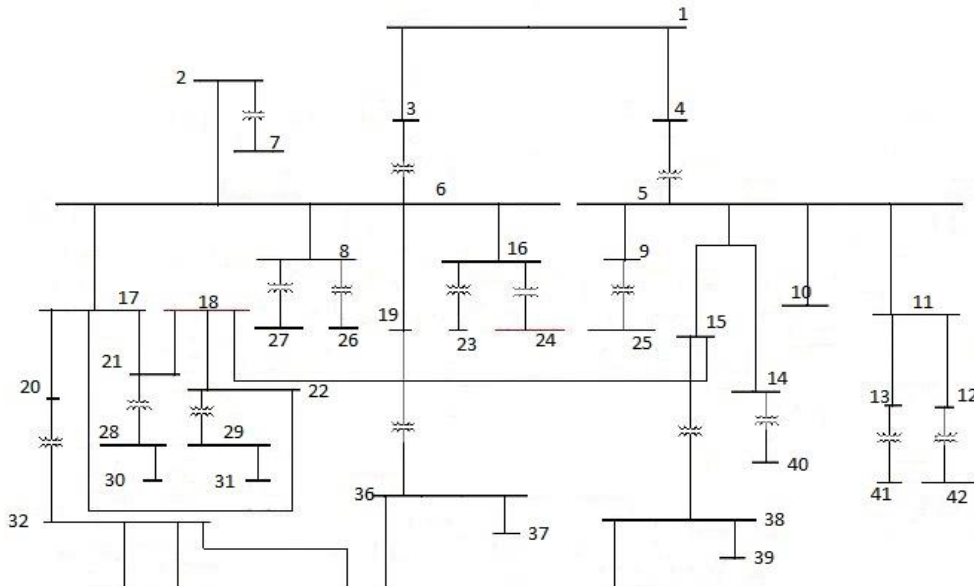


Fig. 2. Single line diagram of the network [13]

will be obtained. This result will represent the locations and sizes of all the DGs.

III. SIMULATION

To evaluate the performance of the proposed method, an IEEE std 399 network is selected as the test system. This sample network is a distribution system with 42 buses. Buses 1 to 4 have a voltage level of 69 kV, buses 5 to 22 have a voltage level of 13.8 kV, buses 23 to 26 have a voltage level of 2.4 kV, and the other busses have a voltage level of 480V. The external grid is connected to one of the 69kV busses, and all of the loads are connected to the 480V and 2.4kV busses. It is supposed that the DGs are to be placed at the 13.8kV and 2.4kV busses. The general topology of the network is shown in Fig. 2. The specifications of the lines could be found in [13].

It is assumed that 5 DGs are to be placed in the network. In other words, 5 busses should be selected for the DGs. This number comes from the assumption that 12% of the total number of busses is considered for allocating the DGs. More than this number yields to unstable and uncontrollable system [9]. By this assumption and considering 42 busses in the standard system, the best number of busses for allocating DGs is 5. In the array of a particle, the amount of the power produced by each DG is considered to be between 0 and 1 MW. Then, this number is multiplied by the capacity of the DGs. The capacity of each DG depends on the voltage of the bus to which the DG is connected. In other words, if the DG is connected to one of the 13.8kV busses, it is assumed that it could produce 5.75 times more power than the one connected to a 2.4kV bus. The number 5.75 is computed by the division of 13.8 by 2.4. This number shows the importance of busses with a voltage of 13.8 kV. By this assumption, the DGs at the busses with higher voltage levels could produce more power than the other DGs.

Now, the amount of the energy produced by the DGs at the 13.8kV busses and at the 2.4kV busses is given by the following equations, respectively.

$$P_{DGij} = P_{ij} * 5.75 * \frac{TL_i}{\sum_j^5 5.75 * a_j + \sum_j^5 b_j} \quad (11)$$

$$P_{DGij} = P_{ij} * \frac{TL_i}{\sum_j^5 5.75 * a_j + \sum_j^5 b_j} \quad (12)$$

In these equations, P_{ij} is the size of the j^{th} DG at the i^{th} time interval, which is appeared in the array of the particle and is between 0 and 1. TL_i is the total load at the i^{th} time interval. a_j is the location of the j^{th} DG, which is a binary number and represents if the DG is placed at 13.8kV busses or not. b_j is the same as a_j except for the 2.4kV busses.

Using Eqs. (11) and (12), the output power at each time interval is obtained, and the cost function is computed. The number of iterations is supposed to be 100 and the number of particles is 20.

The coefficients of the load curve is as shown in Fig. 1. According to this figure, considering 7 time intervals seems reasonable. The base amounts of the loads could be found in [13]. These numbers are multiplied by the numbers from Table 1, and the daily load curve is estimated.

The type of the DGs is assumed to be gas turbine. For this type of DG, the investment cost is 4000 \$/kW [14]. The O&M cost is considered to be 300 \$/kW per year [14]. By considering the lifetime average of this type of DG to be 10 years, the inflation rate of 15% and rate of return of 20%, λ_{DG} can be obtained from Eqs. (5) to (7). The result is 0.18 \$/kWh. λ_{grid} is supposed to be 0.25 \$/kWh [14].

IV. RESULTS

By applying the proposed method to the IEEE standard network, the best placement of the DGs and the amount of power

production of each of unit is shown in Table III. The numbers of production in Table III is in per unit. For converting these values to the power generated by each DG, Eqs. (11) and (12) can be used. By considering this profile of generation, the amount of the cost function is given in detail in Table IV.

TABLE II. POWER GENERATION PROFILE AND THE PLACEMENT OF DGs

	Location(bus number)				
	11	19	19	7	9
The amount of production for each time interval during the year which appeared in the particle array (p.u.)	0.71	0.77	0.39	0.81	0.25
	0.68	0.4	0.2	0.91	0.6
	0.44	0.9	0.22	0.15	0.96
	0.94	0.72	0.57	0.11	0.65
	0.27	0.95	0.45	0.44	0.28
	0.62	0.14	0.88	0.89	0.56
	0.73	0.18	0.76	0.15	0.61
	0.2	0.56	0.55	0.39	0.89
	0.25	0.39	0.43	0.30	0.4
	0.25	0.24	0.18	0.7	0.67
	0.15	0.17	0.53	0.6	0.38
	0.5	0.4	0.7	0.3	0.71
	0.14	1	0.55	0.4	0.19
	0.18	0.96	0.64	0.38	0.23
	0.64	0.2	0.12	0.92	0.74
	0.22	0.2	0.11	0.28	0.96
	0.3	0.2	0.81	0.24	0.4
	0.89	0.96	0.93	0.27	0.74

TABLE III. COSTS RESULTS IN DETAIL PER YEAR

Total Cost	138171944 \$
Investment Cost	134433280 \$
O&M Cost	3459739 \$
Loss Cost	25936 \$
Grid Cost	252988 \$
Loss(kW)	417.35 kW

If the placement of the DGs was only based on minimizing the energy losses, the cost function and the best locations would be as those given in Tables V and VI.

TABLE IV. COSTS RESULTS IN DETAIL BASED ON MINIMIZING THE ENERGY LOSSES

Total Cost	153464433 \$
Investment Cost	149684576 \$
O&M Cost	3569789 \$
Loss Cost	16406 \$
Grid Cost	303712 \$
Loss(kW)	269.32 kW

TABLE V. POWER GENERATION PROFILE AND THE LOCATION OF THE DGs BASED ON ONLY MINIMIZING THE ENERGY LOSSES

	Location(bus number)				
	8	16	7	21	19
The amount of production for each time interval during the year which appeared in the particle array (p.u.)	0.39	0.29	0.82	0.39	0.15
	0.45	0.78	0.43	0.76	0.8
	0.29	0.16	0.52	0.07	0.27
	0.47	0.85	0.3	0.44	0.41
	0.84	0.79	0.89	0.23	0.51
	0.29	0.56	0.12	0.89	0.64
	0.52	0.0011	0.95	0.38	0.02
	0.11	0.29	0.5	0.7	0.16
	0.8	0.83	0.64	0.3	0.87
	0.44	0.77	0.37	0.35	0.71
	0.74	0.91	0.92	0.79	0.74
	0.3	0.19	0.43	0.7	0.67
	0.9	0.61	0.73	0.6	0.28
	0.44	0.73	0.27	0.74	0.15
	0.16	0.61	0.72	0.6	0.09
	0.31	0.2	0.19	0.93	0.39
	0.92	0.24	0.59	0.18	0.72
	0.998	0.07	0.3	0.72	0.53
	0.739	0.14	0.7	0.2	0.88
	0.65	0.22	0.96	0.98	0.35
	0.049	0.42	0.98	0.08	0.16

TABLE VI. COSTS IN DETAIL BASED ON ONLY MINIMIZING THE INVESTMENT AND O&M COSTS

Total Cost	178912821 \$
Investment Cost	175184614 \$
O&M Cost	3459739 \$
Loss Cost	20631 \$
Grid Cost	247837 \$
Loss(kW)	455.726 kW

TABLE VII. POWER GENERATION PROFILE AND THE LOCATION OF THE DGs BASED ON ONLY MINIMIZING THE INVESTMENT AND O&M COSTS

	Location(bus number)				
	2	6	19	19	3
The amount of production for each time interval during the year which appeared in the particle array (p.u.)	0.83	0.55	0.51	0.46	0.4
	0.5	0.13	0.85	0.45	0.12
	0.18	0.99	0.48	0.62	0.14
	0.18	0.31	0.10	0.61	0.24
	0.24	0.46	0.89	0.66	0.48

The amount of production for each time interval during the year which appeared in the particle array (p.u.)	Location(bus number)				
	0.66	0.46	0.75	0.09	0.99
	0.11	0.02	0.68	0.9	0.05
	0.64	0.63	0.62	0.03	0.9
	0.91	0.72	0.38	0.38	0.42
	0.42	0.25	0.17	0.78	0.65
	0.89	0.51	0.84	0.71	0.48
	0.4	0.86	0.81	0.36	0.51
	0.56	0.6	0.56	0.17	0.16
	0.7	0.12	0.04	0.25	0.82
	0.24	0.32	0.08	0.27	0.37
	0.02	0.95	0.47	0.74	0.69
	0.28	0.12	0.22	0.49	0.73
	0.91	0.76	0.13	0.53	0.01
	0.54	0.89	0.31	0.68	0.910
	0.65	0.64	0.53	0.86	0.3
0.67	0.42	0.74	0.53	0.3	

Comparing Tables IV with VI and VIII, clearly indicates that better results will be obtained when the optimization process is based on both energy losses and the cost function.

By analysing the above tables, it is obvious that bus 19 is very important in supplying demands and should be one of the candidates of installing DGs. Also, in the proposed method, there is no problem in repeating the bus number. That means in each buses of the network 1 or more DGs could be placed.

V. CONCLUSIONS

In this paper, a DG placement and sizing strategy is proposed which simultaneously optimizes system energy losses as well as the investment and O&M costs. For every DG, a power profile is obtained which represents the power produced by each DG at each time interval for a whole year. These numbers are based on minimizing a cost function which consists of the cost of investment and O&M of the DGs and also the cost of buying electricity from the external grid. Losses are modelled as a cost function and is included in the objective function.

The results show that the proposed method yields in a more economical planning for installing DGs in a radial distribution system.

REFERENCES

- [1] G. Celli, E. Ghiani, and F. Pilo, "A Multi Objective Evolutionary Algorithm for the Sizing and Siting of Distributed Generation" IEEE transaction on power systems, vol. 20, no. 2, pp. 75–757, May 2005.
- [2] W. El-Khattam, Y. G. Hegazy, and M. M. A. Salama, "An Integrated Distributed Generation Optimization Model for Distribution System Planning" IEEE transaction on power systems, vol. 20, no. 2, pp. 1158–1165, May 2005.
- [3] A. Keane, and M. O'Malley, "Optimal Allocation of Embedded Generation on Distribution Networks" IEEE transaction on power systems, vol. 20, no. 3, pp. 1640–1646, Aug. 2005.
- [4] D. Zhu, R. P. Broadwater, K. Tom, R. Seguin, and H. Asgeirsson, "Impact of DG Placement on Reliability and Efficiency With Time-Varying Loads" IEEE transaction on power systems, vol. 21, no. 1, pp. 419–427, Feb. 2006.
- [5] B. Maurhoff, and G. Wood, "Dispersed Generation Reduce Power Costs and Improve Service Reliability" IEEE rural electric power Conf. 2000, pp. 1-7.
- [6] A. Silvestri, A. Berizzi, and S. Buonanno, "Distributed Generation Planning Using Genetic Algorithms" IEEE powertech Budapest 1999, pp. 199-257.
- [7] R. Dugan, T. Mcdermott, and G. Ball, "Distribution Planning for Distribute Generation" IEEE rural electric power Conf. 2000, pp. 1-7.
- [8] G. Rackliffe, "Guidelines for Planning Distributed Generation Systems" IEEE PES Sum. 2000, pp. 3-7.
- [9] M. F. Shaaban, Y. M. Atwa, and E. F. El-Saadany, "DG allocation for benefit maximization in distribution networks," IEEE Trans. Power Syst., vol. 28, no. 2, pp. 639-649, May 2013.
- [10] E. Haesen, J. Driesen, and R. Belmans, "Robust planning methodology for integration of stochastic generators in distribution grids," IET Renew. Power Gener., vol. 1, no. 1, pp. 25–32, Mar. 2010.
- [11] M. Pipattanasomporn, M. Willingham, and S. Rahman, "Implications of Onsite Distributed Generation for Commercial/Industrial Facilities" IEEE Trans. Power Syst., vol. 20, Feb. 2005, pp. 206–212.
- [12] Delson, and Jerome. K, "Engineering Economics on Inflation." IEEE Trans. Power Syst. 1992, pp. 73–80.
- [13] IEEE std-399-1997: "IEEE recommended practice for industrial and commercial power system analysis", 1998
- [14] L. F. Ochao, A. Padilha-Feltrin, and G. P. Harison, "Evaluating Distributed Time-varying Generation Through a Multiobjective Index" IEEE transaction on power delivery, vol. 23, no. 2, pp. 1132-1138, April 2008.
- [15] Asadi, K., Ramshankar, H., Pullagurla, H., Bhandare, A., Shanbhag, S., Mehta, P., Kundu, S., Han, K., Lobaton, E., and Wu, T. (2018). "Building an integrated mobile robotic system for real-time applications in construction." arXiv preprint arXiv:1803.01745.
- [16] M. Taheri Andani, H. Pourgharibshahi, Z Ramezani, and H. Zargarzadeh, "Controller Design for Voltage-Source Converter Using LQG/LTR," in Power and Energy Conference (TPEC), IEEE Texas, 2018, pp. 1-6: IEEE.
- [17] T. Pourseif, et al., "Model Reference Adaptive Control for Robot Tracking Problem: Design & Performance Analysis," International Journal of Control Science and Engineering, vol. 7, pp. 18-23, 2017.
- [18] Yousefpour, Kamran, Seyyed Javad Hosseini Molla, and Seyyed Mehdi Hosseini. "A Dynamic Approach for Distribution System Planning Using Particle Swarm Optimization." International Journal of Control Science and Engineering 5.1 (2015): 10-17.
- [19] F. Safdarian, O. Ciftci, and A. Kargarian, "A Time Decomposition and Coordination Strategy for Power System Multi-Interval Operation", Arxiv, May 2018.
- [20] P. Shabestari, S. Ziaeinejad, and A. Mehrizi-Sani, "Reachability analysis for a grid-connected voltage-sourced converter (VSC)", IEEE Applied Power Electronics Conference and Exposition (APEC), pp. 2349-2354, TX, USA, March 2018.
- [21] N. Ghanbari, H. Golzari, H. Mokhtari, and M. Poshtan, "Optimum location for operation of small size distributed generators", IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA), Nov. 2017, pp. 300-303, San Diego, USA.
- [22] P. Shabestari, G. Gharehpetian, G. Riahy, and S. Mortazavian, "Voltage controllers for DC-DC boost converters in discontinuous current mode", International Energy and Sustainability Conference (IESC), pp. 1-7, NY USA, Nov. 2015.
- [23] N. Ghanbari, H. Mokhtari, and S. Bhattacharya, "Optimizing Operation Indices Considering Different Types of Distributed Generation in Microgrid Applications", Energies 2018, 11, 894.