EFFECT OF DG TYPES & SEASONAL MIXED LOAD MODELS IN DISTRIBUTED GENERATION PLANNING

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Abstract: A combination of public policy, incentives and economics is driving a rapid growth of distributed generation in the electric power system. The majority of states/provinces now have renewable portfolio standards, with many requiring that over 20 percent of electricity sales by generated by renewable energy sources within the next five to fifteen years. The majority of these requirements will be addressed by adding significant amounts of wind energy and growing amounts of solar energy to the bulk power system.

Wind and solar power plants possess more variability and uncertainty because of the nature of their "fuel" sources. Optimization is one of the technique that can be used to address concerns and costs around this variability and uncertainty. This paper discusses Effect of types of DG & Seasonal mixed Load Models in Distributed Generation Planning, provides background on what can be realistically expected from distributed generation power-output.

Distributed generation can enhance energy efficiency, postpone the construction investment of distribution network, and reduce environmental costs. On the contrary, DG may also disturb the system stability. The model can reflect the DG environment-friendly features. Considering load growth, the planning problem is divided into different periods which can be solved by using the dynamic programming method, and the planning result of next period has effects on the previous one. Taking the Genetic algorithm (GA) and IEEE38-bus system as the example, the results show that the proposed method can effectively resolve the DG planning problem in smart grid and get the DG optimum sizing & type.

Index Terms—Distributed Generation (DG), Genetic Algorithm (GA), Distributed generation Planning,Load Models

I. INTRODUCTION

As the deepening reform of the electricity market and the global depletion of fossil energy worldwide, a modern smart grid that can be energy-saving, environmental friendly, efficient, reliable and stable will be the main trends of the development of power grid. Distributed generation is an important part of the smart grid, and will be a high percentage of smart grid in the future. Distributed generation which is included in the smart grid will improve energy efficiency, delay transmission line upgrade, and can also reduce greenhouse gas emissions, increase the quality of the environment. Access of distributed power in the distribution network will impact node voltage, feeder load and system reliability. Therefore, the difficult problem of distribution network planning is to determine the capacity and access point of DG.

The pressure to consider DG options for capacity addition comes from a number of sources, including: Investment risk in competitive power markets, Regulatory agencies that require due diligence before approving major vestments such as new substations, and Availability of more cost-effective DG technologies. This Paper presents a planning process that considers DG as well as conventional and other nonconventional options. The basic process has its roots in utility generation planning and was adapted for smaller generators connected to utility distribution systems for an EPRI engineering handbook on DG and related planning software. The methodology continues to evolve with additional economic and engineering analyses to address such issues as power quality and system dynamics during islanding. There are many other planning frameworks that may address this problem. The method described in this paper here is a relatively straightforward extension of familiar distribution planning concepts.

Electric utilities are now continuously searching upcoming new technologies to provide acceptable power quality and higher reliability to valuable customers. Non-conventional generation is growing more rapidly around the world due to its low size, low cost and less environmental impact with high potentiality. Investment in distributed generation (DG) enhances environmental benefits particularly in combined heat and power applications

A. Distributed generation

The distributed generation uses smaller-sized generators than dose the typical central station plant. They are distributed throughout the power system closer to the loads. The normal distribution system delivers electric energy through wires from a single source of power to a multiple of loads. Thus, several power quality issues arise when there are multiple sources. Will Distributed Generation improve the quality or will it degrade the service end users have come to expect.

The electrical power system, consisting of relatively small generators configured in isolated, used Distribution Generation. That model gave way to present centralized system largely because of economies of scale. Also, there was the desire to sequester electricity generation facilities away from population centre for environmental reasons to locate them closer to the source of fuel and water.

So we can say that Distributed generation is:

- Use of small generating units installed close to load centers
- Other terms:
  - ➢ Decentralized generation

  - Embedded generation
  - Disperse generation
- Trend: generators sized from kW to MW at load sites renewed interest for DG IEA lists five major factors
  - developments in distributed generation technologies,
  - constraints on the construction of new transmission lines,
  - increased customer demand for highly reliable electricity,
  - the electricity market liberalization and
  - Concerns about climate change.

B. Types of DG:

The different types of traditional and non-traditional DGs are classified from the constructional, technological, size, and power time duration point of view. The DGs may also be grouped into four major types based on terminal characteristics in terms of real and reactive power delivering capability. Four major types are considered for comparative studies which are described as follows:

Type 1: This type DG is capable of delivering only active power such as photovoltaic, micro turbines, fuel cells, which are integrated to the main grid with the help of converters/inverters. However, according to current situation and grid codes the photovoltaic can and in sometimes are required to provide reactive power as well.

Type 2: DG capable of delivering both active and reactive power, DG units based on synchronous machines (cogeneration, gas turbine, etc.) come under this type.

Type 3: DG capable of delivering only reactive power, Synchronous compensators such as gas turbines are the example of this type and operate at zero power factors.

Type 4: DG capable of delivering active power but consuming reactive power, mainly induction generators, which are used in wind farms, comes under this category. However, doubly fed induction generator (DFIG) systems may consume or produce reactive power i.e. operates similar to synchronous generator.

II. IMPACT OF DISTRIBUTED GENERATION ON DISTRIBUTION SYSTEM

Distributed generation is an approach that employs small-scale technologies to produce electricity close to the end users of power. DG technologies often consist of modular (and sometimes renewable-energy) generators, and they offer a number of potential benefits. In many cases, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences than can traditional power generators. Distributed generation, also called on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy, generates electricity from many small energy sources. Distributed generation reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used, perhaps even in the same building. This also reduces the size and number of power lines that must be constructed. In contrast to the use of a few large-scale generating stations located far from load centers-the approach used in the traditional electric power paradigm-DG systems employ numerous, but small plants and can provide power onsite with little reliance on the distribution and transmission grid. DG technologies yield power in capacities that range from a fraction of a kilowatt [kW] to about 100 megawatts [MW]. Utility-scale generation units generate power in capacities that often reach beyond 1,000 MW. Distributed generation takes place on two-levels: the local level and the end-point level. Local level power generation plants often include renewable energy technologies that are site specific, such as wind turbines, geothermal energy production, solar systems (photovoltaic and combustion), and some hydro-thermal plants. These plants tend to be smaller and less centralized than the traditional model plants. They also are frequently more energy and cost efficient and more reliable. Since these local level DG producers often take into account the local context, the usually produce less environmentally damaging or disrupting energy than the larger central model plants.

III. OPTIMAL LOCATION& SIZE OF DGS

A. Optimal Location:

Placement of DGs is an interesting research area due to economical reason. Distributed generation systems (such as fuel cells, combustion engines, micro turbines, etc) can reduce the system loss and defer investment on transmission and distribution expansion. Appropriate size and optimal locations are the keys to achieve it optimal placement of DG (OPDG) in distribution network is an optimization problem with continuous and discrete variables. Many researchers have used evolutionary methods for finding the optimal DG placement.
In fact, three types of DG are considered which are as follows:

Type 1: DG is capable of supplying only real power
Type 2: DG is capable of supplying only reactive power
Type 3: DG is capable of supplying real power but consuming proportionately reactive power

In a Newton-Raphson algorithm based load flow program is used to solve the load flow problem. The methodology for optimal placement of only one DG type1 is proposed. Moreover, the heuristic search requires exhaustive search for all possible locations which may not be applicable to more than one DG.

There have been number of studies to define the optimum location of DG. The mathematical approaches on the optimum DG placement for minimum power losses are as follows:

Optimal load flow with second order algorithm method genetic algorithm and Hereford Ranch algorithm which can find optimum. Fuzzy-GA method, tabu search approach, the algorithm to determine the near optimal, 2/3 rule, which is often used in capacitor placement studies, and analytical approach in radial as well as networked systems. Particularly, reference demonstrates an analytical approach to determine exclusively the optimal location to place a DG in radial systems to minimize the total loss of the system. This study takes the size of DG as total load size and in respect of the size of DG obtains the optimal location of DG in radial systems without optimizing size of DG.

In all of the studies, cited above the loads are the loads are generally modelled as constant power or constant current types of loads. Since most of the distribution system loads are uncontrolled, effects of this type of load models on optimum sizing and location s should be questioned.

a) *DG Location:*

The optimal location of the distributed generation unit is determined based on the value of the stability index. The stability index is calculated using at every node in the system. The DG is installed at the bus with the highest stability index. The size of the DG is determined using an optimization technique which can be implemented for stability index minimization or system losses minimization as given below.

b) *Minimum stability index:*

The branch corresponding to the maximum value of the stability index Lis called the weakest branch where the voltage collapse normally starts from it. The margin of voltage stability can be obtained according to the deviation between 0.0 at no load and the critical value of 1.0 when the system collapses.

c) *Genetic Algorithm:*

A powerful class of optimization methods is the family of GA. The GA become particularly suitable for the problem posed here. GA based energy loss optimization technique is proposed for finding size and site for DG to place in power systems. For a given distribution system network wherein all branches between nodes are known and therefore evaluation of the objective function depends only on the size and location of DG units.

- The GA is employed to designate optimization algorithms that perform a kind of approximate global search such that: They rely on the information obtained by the evaluation of several points in the search space. Each “current point” is called an individual, and the set of “current point” is called the population. The algorithm keeps this set of “current points”, instead of keeping a single “current point” as would be the case of in most optimization algorithms.
- The population is expected to coverage to optimum (or near optimum) through sequential applications, at each iteration, of genetic operators.

Preparatory steps are the basic version of genetic programming. The human user communicates the high levels statement of the problem to the genetic programming system by performing certain well-defined preparatory steps. The preparatory steps are the human supplied input to the genetic programming system. The computer program is the output of genetic programming system. Genetic algorithm that yields good results in many practical problems is composed of three operators:

a) *Crossover:* The individuals, randomly organized pair-wise, have their space locations combined, in such a way that each former pair of individuals gives rise to a new pair.
b) *Mutation:* Some individuals are randomly modified, in order to reach other points of the search space.
c) *Selection:* The individuals, after mutation and crossover, are evaluated. They are chosen or not chosen for being inserted in the new population through a probalistic rule that gives a greater probability of selection to the “better” individuals.

The advantages in using GA are that they require no knowledge or gradient information about the response surface; they are resistant to becoming trapped in local optima and they can be employed for a wide variety of optimization problems. A GA search is done by examining at the same time a set of possible solutions, instead of a single one. This strategy allows a better exploration of the solution space during the search for the global optimum. Also, it reduces the probability of being stuck in a local optimum. The success of the optimization process depends on the appropriate design of a fitness function for the problem. The fitness values of individuals in a given population are employed to drive the evolution process. These characteristics enable the GAs to present excellent results even when optimizing complex or discontinuous functions. In most of the cases, it is very difficult to achieve analytic relationship between sensitivity of simulated power system and the parameters values to be optimized. GA don’t need this kind of information, hence it is suitable in our optimization task. An evolutionary strategy needs to be adopted in order to generate individuals for the next generation. The individuals are arranged by their fitness and only the best of them are taken unchanged into the next generation. In this way good individuals are not lost during a run. Other children come from crossover and mutation. The aim of the fitness function is to numerically represent the performance of an individual. In order to end the evolution of the population we choose certain termination criterion. The final result of the GA optimization is the best individual of the last iteration.

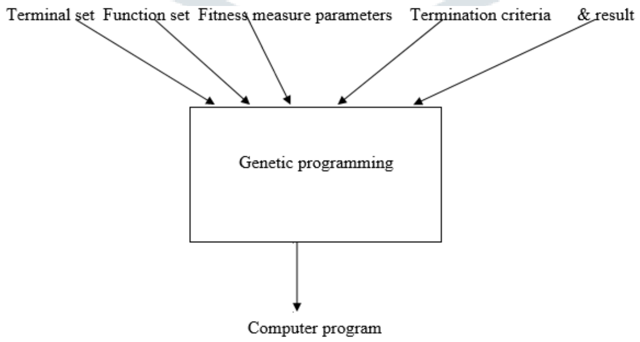

Fig.1. Preparatory Steps of Genetic Algorithms

d) *Problem formulation:*

DG sources are normally placed close to load centres and are added mostly at the distribution level. They are relatively small in size (relative to the power capacity of the system in which they are placed) and modular in structure A Common strategy for sizing and placement of DG is to minimize system energy loss of the power systems. The voltage at each bus is in the acceptable range and the line flows are within the limits. These limits are important so that integration of DG into the system does not increase the cost for voltage control or replacement of existing lines. The formulation to determining the optimal size and location of DG in a system is as follows:

Formulation for system energy saving

Min. [E_{loss}]

Annual system energy loss

$$\left[E_{loss}\right]=\left[\Sigma P_{loss}\left\{DG\left(i,size\right)\right\}*t\right]*D\ (1)$$

System power loss

$$P_{loss} = \sum_{line(i,j)=1}^{m} P_{line(i,j)}\ (2)$$

Line power loss

$$P_{line}\left(i,j\right)=P_i-P_j\ (3)$$

Subject to

Real power injected at j_{th}bus is the difference of total real power generated with DG of a particular size and real power load at I_{th} bus. i.e

$$P_i = DG\left(i,size\right)-P_{di} = |V_i|\sum|V_k|\left[G_{ik}\cos\left(\theta_i-\theta_k\right)+B_{ik}\sin\left(\theta_i-\theta_k\right)\right]\ (4)$$

Reactive power injected at I_{th} bus is the difference of total reactive power generated with DG of a particular size and reactive power load at I_{th}bus but reactive power generation is zero in DG. i.e

$$Q_i = -QD_i = |V_i|\sum|V_k|\left[G_{ik}\sin\left(\theta_i-\theta_k\right)+B_{ik}\cos\left(\theta_i-\theta_k\right)\right](5)$$

$$V_i \max \geq V_i \geq V_i \min\ (6)$$

$$P_{line}(i,j)\min \leq P_{line}(i,j) \leq P_{line}(i,j)\max\ (7)$$

The important operational constraints are addressed by Eqns. (6) and (7).

Annual system energy saving is the difference of annual system energy loss without penetration of DG and annual system energy loss with DG. i.e.

$$E_{saving} = \left[E_{loss}\left(noDG\right)-E_{loss}\left(withDG\right)\right](8)$$

In the above formulation the location which ranges from bus 2 to *n*, bus 1 being the slack node or the feeder node and n being the total number of buses in the system. DG size is also considered as variable that varies from 0 to 0.63 p. u. An operating time for particular load t ranges from 0 to T hours in any day. D is number of days in a year. The variables P_i, Q_i, V_i and θ_i are real power, reactive power, bus voltage and power angle at i_{th} bus. G_{ik} And B_{ik} are the shunt branch conductance and shunt branch susceptance between the bus *i*and *k*. They are usual terms in power flow studies. *PDi*and *QDi*are the real and reactive load at bus *i*. The eqns. (4) and (5) are the real and reactive power balance equations for a particular bus *i*. The saving in energy given in eqn. (8) is the difference in losses of the system with and without DG.

e) Sizing & placement of DG using GA:

The problem related to the placement and size of a DG can be formulated on the basis of energy loss minimization approach. The optimal placement of a DG requires finding the strategic locations for it according to the minimum energy loss so that overall system operation may be economical. Penetration level of the DG is the percentage of total demand supplied economically by it. The problem statement is to find the economically viable location and corresponding size for various types of DGs like reciprocating engine, mini gas turbine, fuel cell, etc. Proper placement of DG in power system is important for obtaining their maximum potential benefits. The goal is to find out proper size and optimal location for a DG in distribution systems and assure that the voltage Vi in every bus are in the acceptable range, 1 + 0.05 or 1-0.05 p. u. and transmission lines are loaded under specified MVA limits.

i). Algorithm for system annual energy loss minimization:

Step 1: Randomly generate size-location pairs of distributed generation system in a predefined range of sizes and the buses. Set k = 1. Enter the maximum number of iteration m.

Step 2: Run power flow and calculate system annual energy loss of the system for each size-location pair under time-varying loading condition, and record the system annual energy loss and its corresponding size location pairs.

Step 3: Check whether the voltage limits and transmission line MVA limits are satisfied for all the buses for each of the size-location pairs.

Step 4: If all the voltages and MVA limits are in acceptable range for a particular size-location pair, accept that pair for next generation population. Else reject the size-location pair which does not satisfy criteria given in step 3 in the next generation. Obtain the size-location pair with minimum annual energy loss (min E_{loss} size location (k)). If min E_{loss} size location (k) has not changed for last m iteration STOP. Else, If k = m, the corresponding size and location pair is the optimum-size location pair. STOP and END the program.

Step 5: Use the available population of size-location pair (parent population) for cross-over and mutation for obtaining new generation of (offspring) population. If population size after step 4 is zero go to step 1.

Step 6: Use the newly generated population size i.e. off springs and parents as new generation. Go to step 2. A data file having all the previously searched options is created and is used in step 1, thus the new populations generated is checked and if already searched are excluded from the population. It can be seen from the algorithm that if the objective function do not change for large number of iteration the solution is taken as optimum otherwise algorithm allowed to run for maximum of m iteration and the results obtained are taken as minimum. The problem posed here is a combinational one wherein large numbers of combination of size-location pairs are to be solved using non-linear power flow equations.

f) Loss sensitivity factor method

The loss sensitivity factor method is based on the principle of linearization of the original nonlinear equation (loss equation) around the initial operating point, which helps to reduce the amount of solution space. The loss sensitivity factor method has been widely used to solve the capacitor allocation problem. Its application in DG allocation is new in the field and has been reported in Loss Sensitivity. The real power loss in a system is given by Equation:

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N}\left[\alpha_{ij}(PiPj+QiQj)+\beta ij(QiPj-PiQj)\right] \quad (9)$$

$$\alpha_{ij} = \frac{r_{ij}}{ViVj}\cos(\delta i-\delta j), \beta_{ij} = \frac{r_{ij}}{ViVj}\sin(\delta i-\delta j)$$

Where $r_{ij} + jx_{ij} = z_{ij}$ are the ij_{th} element of Z_{bus} .The sensitivity factor of real power loss with respect to real power injection from DG is given by

$$\alpha_i = \frac{\partial PL}{\partial Pi} = 2\sum_{i=1}^{N}(\alpha_{ij}Pj-\beta_{ij}Qj) \quad (10)$$

Sensitivity factors are evaluated at each bus, firstly, using the value obtained from the base case power flow.

g) Indices:

There are various technical issues that need to be addressed when considering the presence of distributed generators in distribution systems. Computed several indices in order to describe the impacts on the distribution system due to presence of distributed generation during maximum power generation

- Real Power Loss Indices (PLI)
- Reactive Power Loss Indices (QLI)
- Voltage Profile Indices (VPI)
- Line capacity indices (LCI)

i). Real and Reactive Power Loss Indices (PLI and QLI):

The real and reactive power loss indices are defined as

$$PL1 = \frac{[P_{LDG}]}{[P_L]} \quad (11)$$

$$QL1 = \frac{[Q_{LDG}]}{[Q_L]} \quad (12)$$

Where P_{LDG} and Q_{LDG} are the total real and reactive power losses of the distribution system after inclusion of DG. P_L And Q_L are the total real and reactive system losses without DG in the distribution system.

ii). Voltage Profile Index (VPI):

One of the advantage of proper location and size of the DG is the improvement in voltage profile. This index penalizes the size-location pair which gives higher voltage deviations from the nominal (V_1=1.03 p .u). In this way, closer the index to zero better is the network performance. The VPI can be defined as follows*:*

$$VP1 = \max_{i=2}^{n}\left(\frac{V_1 - Vi}{V_1}\right) \quad (13)$$

iii). Line Capacity Index (LCI):

As a consequence of supplying power near to loads, MVA flows may diminish in some sections of the network, thus releasing more capacity, but in other sections they may also increase to levels beyond distribution line limits (if line limits are not taken as constraints). The index (LCI) gives important information about the level of MVA flow/currents through the network regarding the maximum capacity of conductors. This gives the information about need of system line upgrades. Values higher than unity (calculated MVA flow values higher than the MVA capacity) of the index give the amount of capacity violation in term of line flows, whereas the lower values indicate the capacity available. It is define as $LCI = \max_{i=1}^{m}\left(\frac{\bar{S}_{ij}}{\bar{CS}_{ij}}\right)$

IV VOLTAGE STEP CONSTRAINT

Voltage step constraints are included in a similar way to the familiar line outage security constraints. A set of power flow equations is added as extra constraints in the OPF for each generator outage contingency (these differ from the base case only in that the power injection from this generator is zero, and of course in the use of contingency voltage and flow variables.) As the new generation is not run in voltage control mode, the DG connection buses are (P, Q) nodes in the contingency power flows. The voltage step limit itself is enforced for each generator outage by placing bounds on the deviation of the contingency bus voltages from the base case values.

3.10 VOLTAGE REGULATION MODEL

Transformer tap settings are used in distribution networks to keep the bus voltages as close to nominal as possible. In this work, therefore, the secondary buses of all transformers are constrained to exactly nominal voltage (a continuous range of tap settings is used in order to retain the continuous optimization problem.

3.11 IEEE 37 Bus Test Systems and its Data

Planning of DGs for different load Models, a IEEE 38 distribution bus system is adopted. In this thesis the line impedances, load data and line power limits are expressed in p.u. at the base voltage of 12.66 kV and base MVA of 10 MVA. The IEEE 37 bus (38 Node) test system and its data are given in figure and table respectively.

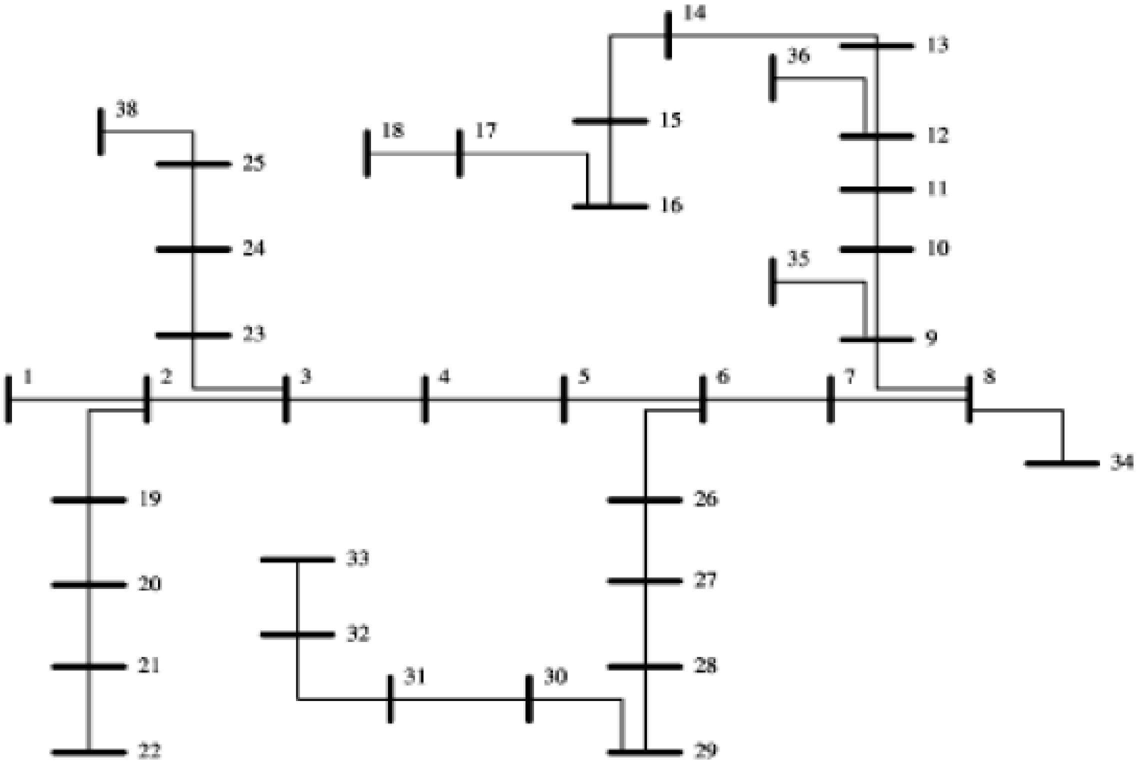

Fig. 2. IEEE 37 Bus (38 Node) test system

IV. RESULTS& DISCUSSIONS

In this Paper, the summary of results obtained for various test cases are presented. The quantities PDG, QDG, PFDG, Sint, Pint, Qint, Ssys, PL & QL corresponding to minimum PL are presented in different tables from Table 4.1 to 4.5. The indices corresponding to minimum PL and minimum Sint configuration are depicted from Figure 4.1 to 4.8. This analysis is presented on the basis of data depicted in Table 3.1 (For Exponent Values for Typical Load Models), Table 3.2 (Exponent Values for Typical Load Scenario) & Table 3.3 (Value of Relevant Factors of load Models)for various seasonal mixed load models as well as constant power load model. The various types of distributed Generation are considered for each case.

Case 1: Constant Power Load Model (CP): The summary of results obtained for Constant Power Load model is tabulated as per below details & results are discussed.

Table 1.1 Constant Power Load Model (CP)

Load Models	W/WO DG	DG Type	P_{DG} (p.u.)	Q_{DG} (p.u.)	PF_{DG}	DG bus	P_{int} (p.u.)	Q_{int} (p.u.)	S_{int} (p.u.)	S_{sys} (p.u.)	P_L (Min.) (p.u.)	Q_L (p.u.)
CP	WODG	-	-	-	-	-	3.900	2.426	4.596	4.596	0.188	0.126
	WDG	T1	2.570	0.0	1.0	6	1.242	2.370	2.675	4.489	0.097	0.070
		T2	2.460	1.717	0.8	6	1.312	1.455	1.455	4.442	**0.057**	**0.045**
		T3	0.000	1.265	0.0	30	3.849	4.010	4.010	4.530	0.134	0.090
		T4	2.296	-0.32	0.9	6	1.533	3.112	3.112	4.509	0.115	0.081

In minimum P_L configuration, it is observed that the P_L with T2 is 0.0577 p.u. which is less compared to with other types of DGs and without DG. The P_{DG} is 2.46 p.u., at 0.82 leading power factor, which is less than with T1 and greater than with T4. The S_{int} with T2 is 1.4552 p.u. which is less than with other type of DGs and without DG. The location of T1, T2, and T4 is at bus 6 whereas of T3 is at bus 3.

Case 2: Summer day Mixed load model (SDM): The summary of results obtained for Summer day Mix load model is tabulated as per below details & results are discussed.

Table 1.2 Summer day Mixed load model (SDM)

Load Models	W/WO DG	DG Type	P_{DG} (p.u.)	Q_{DG} (p.u.)	PF_{DG}	DG bus	P_{int} (p.u.)	Q_{int} (p.u.)	S_{int} (p.u.)	S_{sys} (p.u.)	P_L (Min.) (p.u.)	Q_L (p.u.)
	WODG	-	-	-	-	-	3.800	4.596	4.596	4.596	0.188	0.126
		T1	1.370	0.000	1.0	11	1.142	2.675	2.675	4.469	0.097	0.070

SDM	**WDG**	T2	1.260	1.315	0.8	30	1.212	1.455	1.152	4.422	**0.089**	**0.060**
		T3	0.000	1.164	0.0	30	3.649	4.010	4.080	4.410	0.134	0.090
		T4	1.222	- 0.23	0.9	9	1.413	3.112	2.122	4.509	0.115	0.081

In minimum P_L configuration, the P_L and Q_L with T2 is 0.089 p.u. and 0.060 p.u. respectively, whereas with other type of DGs and without DG are more. The value of P_{DG} with T2 is 0.7440 p.u. at 0.8 leading power factor, which is less than with T1 and T4. The location of T1 is 11, T2 and T3 is 30 and T4 is 9.

Case 3: Summer Night mixed load model (SNM): The summary of results obtained for Summer Day Mix load model is tabulated as per below details & results are discussed.

Table 1.3: Summer Night Mixed load model (SNM)

Load Models	**W/WO DG**	**DG Type**	**P_{DG}** (p.u.)	**Q_{DG}** (p.u.)	**PF_{DG}**	**DG bus**	**P_{int}** (p.u.)	**Q_{int}** (p.u.)	**S_{int}** (p.u.)	**S_{sys}** (p.u.)	**P_L** (Min.) (p.u.)	**Q_L** (p.u.)
SNM	**WODG**	-	-	-	-	-	3.833	2.379	4.007	4.466	0.129	0.086
	WDG	T1	0.735	0.0	1.0	13	3.082	2.270	4.430	4.434	0.165	0.109
		T2	0.536	0.402	0.8	31	3.269	1.900	3.828	4.417	**0.104**	**0.069**
		T3	0.000	1.110	0.0	30	3.825	1.194	3.781	4.447	0.118	0.069
		T4	0.792	-0.11	0.9	12	3.027	2.279	4.107	4.266	0.229	0.066

In minimum P_L configuration, The P_L and Q_L with T2 is 0.104 p.u. and 0.069 p.u. respectively whereas with other DGs and without DG are more. The P_{DG} of T2 is 0.536 p.u. , at 0.80 leading power factor, which is less than other type of DGs. The location of T1, T2, T3, and T4 are 13, 31, 30, and 12 respectively.

Case 4 : Winter Day Mixed Load Model (WDM) : The summary of results obtained for Summer day Mix load model is tabulated as per below details & results are discussed.

Table 1.4: Winter Day Mixed load model (WDM)

Load Models	**W/WO DG**	**DG Type**	**P_{DG}** (p.u.)	**Q_{DG}** (p.u.)	**PF_{DG}**	**DG bus**	**P_{int}** (p.u.)	**Q_{int}** (p.u.)	**S_{int}** (p.u.)	**S_{sys}** (p.u.)	**P_L** (Min.) (p.u.)	**Q_L** (p.u.)
WDM	**WODG**	-	-	-	-	-	3.823	2.222	4.442	4.415	0.164	0.109
	WDG	T1	0.600	0.000	1.0	14	3.211	2.263	2.675	4.469	0.120	0.079
		T2	0.436	0.327	0.8	31	3.365	1.962	1.152	4.422	**0.112**	**0.075**
		T3	0.000	1.150	0.0	30	3.818	1.194	4.080	4.410	0.128	0.860
		T4	0.653	-0.93	0.9	14	3.161	2.358	2.122	4.158	0.124	0.082

In minimum P_L configuration, the P_L and Q_L with T2 are 0.112 p.u. and 0.075 p.u. respectively which are less than without DG and with other type of DGs. The P_{DG} is 0.436 p.u. at 0.8 leading power factor, which is less than T1 and T4. The location of T2 and T3 is same as in case of SNM load model i.e. bus 31 and 30 respectively. The location for T1 and T4 is bus 14.

Case 5. Winter Night Mixed load model (WNM): The summary of results obtained for Summer Day Mix load model is tabulated as per below details & results are discussed.

Table 1.5: Winter Night Mixed load model (WNM)

Load Models	**W/WO DG**	**DG Type**	**P_{DG}** (p.u.)	**Q_{DG}** (p.u.)	**PF_{DG}**	**DG bus**	**P_{int}** (p.u.)	**Q_{int}** (p.u.)	**S_{int}** (p.u.)	**S_{sys}** (p.u.)	**P_L** (Min.) (p.u.)	**Q_L** (p.u.)
WNM	**WODG**	-	-	-	-	-	3.818	2.217	4.415	4.415	0.163	0.108
	WDG	T1	0.450	0.0	1.0	15	3.359	2.248	4.042	4.423	0.127	0.083
		T2	0.328	0.246	0.8	32	3.474	2.022	4.020	4.428	**0.122**	**0.082**
		T3	0.000	1.115	0.0	30	4.000	1.193	4.000	4.462	0.128	0.086
		T4	0.485	-0.07	0.9	14	3.325	2.317	4.052	4.424	0.129	0.085

The P_L for T2 is 0.122 p.u. which is less than without DG (0.1636 p.u.), and with other type of DGs cases. P_{DG} of T2 is 0.3280 p.u. (at PF_{DG} = 0.80 leading) which is less than with other type of DGs cases. The location is different for each type of DG.

V. CONCLUSIONS

- It is found that type 2 DG has significant positive impact on DG planning compared to other types of DG. It is also found that DG planning based on constant power load model is different than the mixed load models which reveal that the assumption of constant power load model may not lead to proper DG planning.

- Type 2 DG, as compared to others, has significant influence on relevant quantities such as: Real and Reactive power loss reduction, DG size reduction & Power intake reduction.
- More efficient and environmentally-friendly generation technologies.

- These technologies are indeed considered to play a significant role for achieving the goals of enhanced security of energy supply.
- Improved system efficiency and reduced carbon dioxide emissions from the power sector.
- Penetration is rapidly growing throughout the world

V. FUTURESCOPE

The DG Planning with different types of load models under different loading condition leads to proper DG planning. The future scopes are as under.

- Two or more DG can be used in hybrid manner to improve the power system performances.
- In future the type of DG such as DG-1, DG-2, DG-3 and DG-4 can be used for reactive power supporter in power distribution system for enhancement of voltage profile.
- The different type of Artificial intelligence technique such as PSO, Tabu search, search algorithm, Ant bees colony algorithm, Simulated annealing algorithm etc. can be use in future for the optimal placement of DG in distribution power system for enhancement of power system performances.

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