Hybrid Intelligent Technique (SFLA-PSO) for Control and Intellectual Process of Power System with Huge Penetration of Non-Conventional Energy Sources

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Abstract: Due to the pressure of decreasing the carbon emission and inadequate sources of fossil fuels being a major reason, Renewable Energy is being incorporated rapidly throughout the globe. Smart grids have a substantial prospective towards tapping the non-conventional energy sources in their grid-connected mode or stand-alone mode [2]. Such limited systems across the sectarian domains of distributed generation systems despite the fact of tapping non-conventional energy sources, stay expected to be the advanced networks which may assist in transmuting the power and energy segment through not only delivering energy to distant and isolated communities, but also through better safekeeping and dependability of electrical energy resource in the urban zones [2][3].

Predominantly, due to a very large or bulk dispersion of non-conventional energy, the system units are expected to practice substantial encounters in sheltered and steady state process, very prominently on advanced stages of inconstant and spasmodic non-conventional sources (solar and wind).

This paper is aimed to investigate the influence of the distributed generation like Wind and PV on the power system due to the large diffusion of non-conventional sources.

Keywords: Non-Conventional Energy Sources, Uncertainty, penetration level, optimization techniques, Constraints, Optimal location.

I. INTRODUCTION

In the preceding few years, electrical energy resource and the quality of power supply has accomplished collective attention as they are the vital centers for modern-day life. Currently mentioned to as a product with a defined quality, electrical energy supply is rather an irreplaceable invention because of its intangible and transient character [3].

Through the liberalization of electrical energy marketplaces and the accumulative dissemination of Distributed Generation from Renewable Energy Sources (RES) determined by promising ecological guidelines and supervisory backgrounds, apprehensions have been raised up concerning the influences on the quality of resource [2].

II. DISTRIBUTED GENERATION AND ITS IMPACT

Distributed Generation is an adequate production or storing of electrical energy at the consumer end, that certificates the choice of transferring and importing energy to the utility system and vice versa, however captivating benefit of the Extreme productivity of electrical power production [10]. Basically, the capability range of dispersed generation is between 100 kW to 10 MW. Figure 1.1 shows the various DG Technologies that are in use.

The interface of DG with the grid can be categorized into two types [14]:

a. **Direct grid-connected DGs**- Direct-connected DGs are attained with the help of induction or synchronous generator. The prime mover functions at a consistent speed to drive the generators.

b. **Indirect grid-connected DGs** - Indirect grid connection is used when the output of the source is DC (for example PV systems and fuel-cells), high frequency AC (for example micro-turbines) and variable frequency (such as WECS).

Even though the incorporation of the DG into electric power systems has assorted benefits, they increase the complication [15]. As a result, the DGs affect the system performance such as voltage characteristics, system power flow, losses in the system, power quality, steady state stability, reliability, and protection.

III. POWER SYSTEM OPTIMIZATION TECHNIQUES:

A. Shuffled Frog Leap Algorithm :

SFLA is a Meta heuristic optimisation technique which imitates the memetic progression of a set of frogs while looking out for the locality which contains extreme volume of accessible foodstuff. The SFLA comprises components of local and global search and interchange of information [10].

Retrieval Number: C6046029320/2020©BEIESP
DOI: 10.35940/ijeat.C6046.029320
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

3064

The SFLA comprises a populace of potential results which are defined by a number of virtual frogs (set) which are divided into smaller number of frogs(sub sets) referred to as memeplexes. Inside every memeplex, the specific frog has an idea that can be affected by the ideas of other frogs, and these ideas can develop by means of memetic evolution.

To make sure the global investigation, after a definite number of memeplex development phases (local hunt), where the virtual frogs are scuffled and restructured to form fresh memeplexes [11]
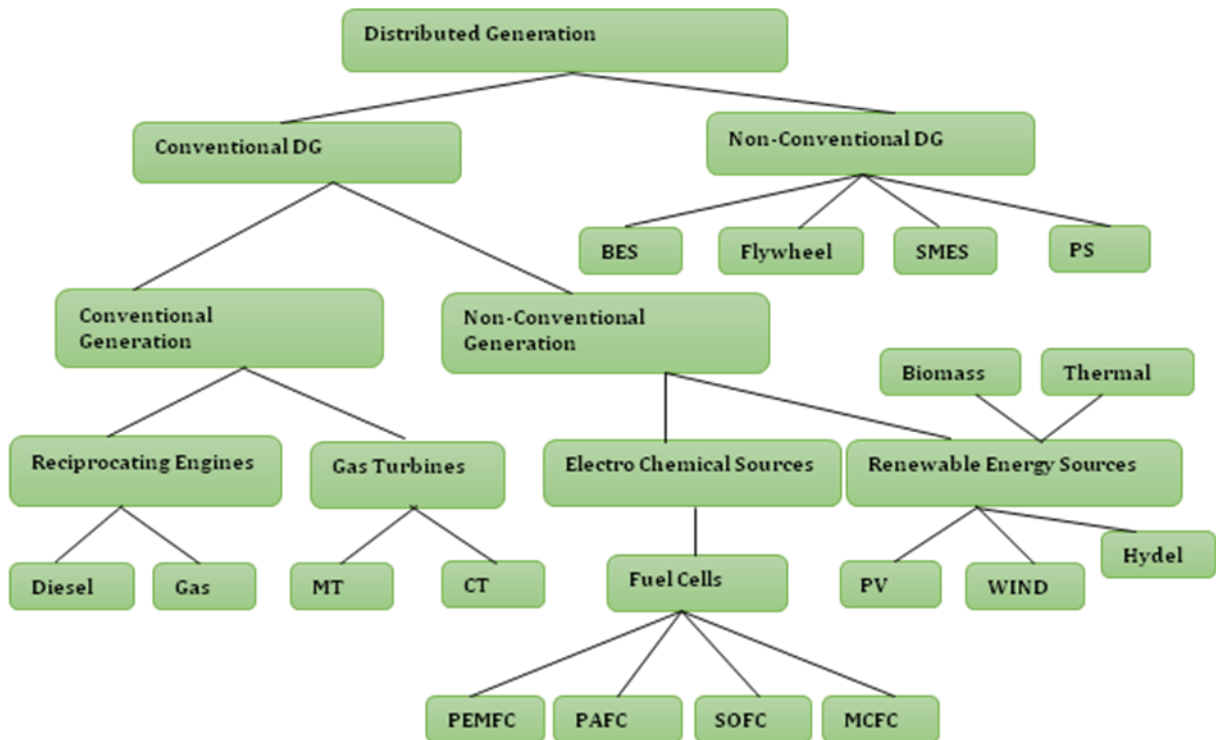

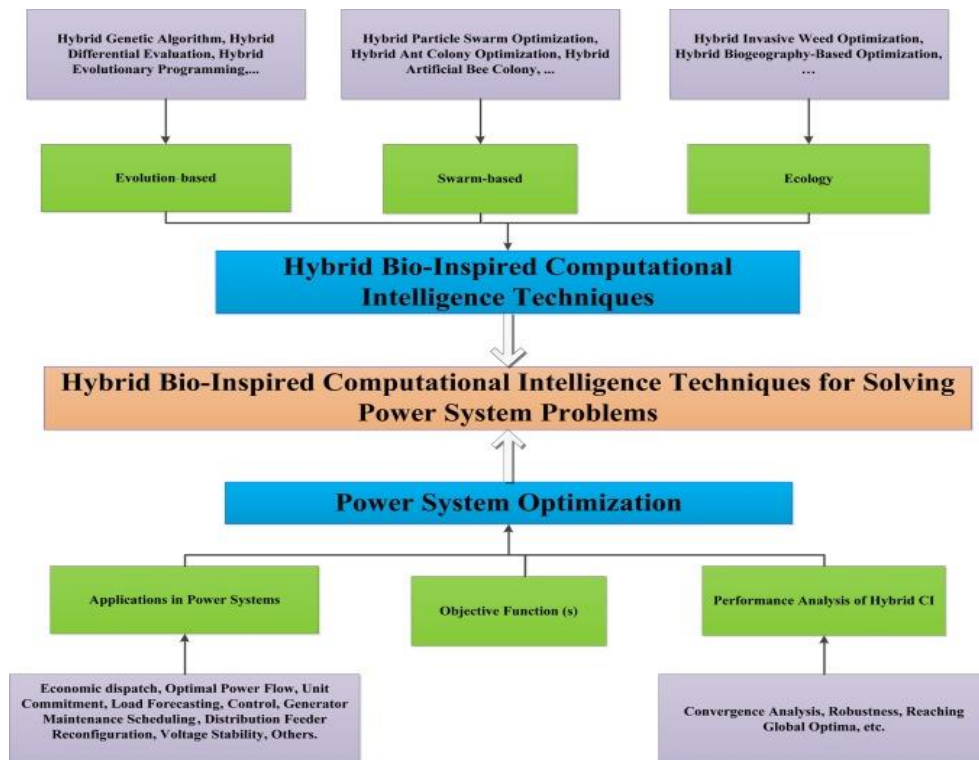**Figure 1.1: Different types of DG Technologies**

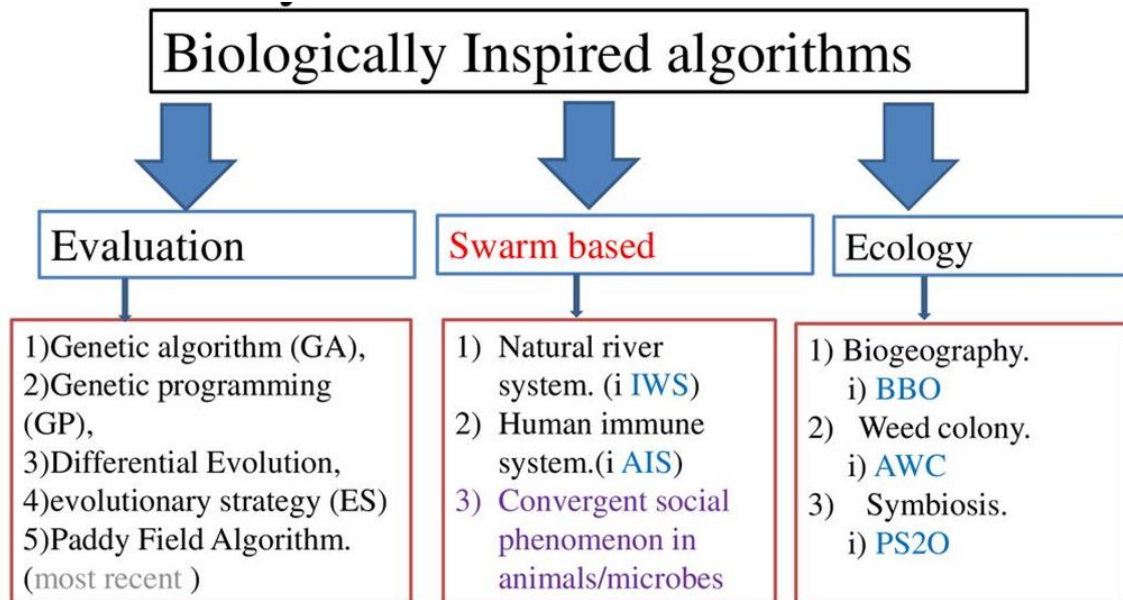**Figure 1.2: Types of Power system optimization techniques**

Figure 1.3: Types of biologically inspired Power system optimization techniques

Also along with this, in order to afford chance for random generation of better statistics, random virtual frogs are created and replaced in the populace if the local search fails to obtain better solutions.

The local hunt and the shuffling procedure will carry on till a definite convergence condition is fulfilled. After a definite quantity of memetic evolution stages, the ideas are handed over to the other memeplexes in a scuffling procedure. Figure 1.4 illustrates the flow chart of SFLA[11]

Possible Solutions $F = m * n$ are randomly separated or divided into numerous memeplexes (m), every memeplex comprising of equivalent amount of results ( ).

All memeplexes will be evolved independently. Firstly, a primary populace of F frogs is formed arbitrarily amongst the possible region. For a problem with R variables, the ith frog is denoted as $Xi = (xi1, xi2… xiR)$. Later, the frogs are organized according to descendent order with respect to their fitness. Later, the whole populace (F) will be divided into m memeplexes, totally containing n frogs. In this process, the 1st frog travels to the 1st memeplex, the 2nd frog travels to the 2nd memeplex, mth frog travels to the mth memeplex, and frog $m+1$ travels back to the 1st memeplex, etc[09] .

Inside every memeplex, location of frogs with the finest (best) and poorest (worst) finesses is identified as *Xb* and *Xw*, correspondingly. Along with this the location of a frog with the universal (global) fitness is identified as *Xg*. Later, in every memeplex, a specific method is used to improve the frog with the lowest fitness in every sequence as shown:

$$D_i = Rand() \times (X_b - X_W)$$
$$Xw_{NEW} = X_W + D_i$$

Where R_{and} ( ) is some arbitrary numeral between 0 and 1. Once this procedure produces a improved result, the worst frog will be switched.
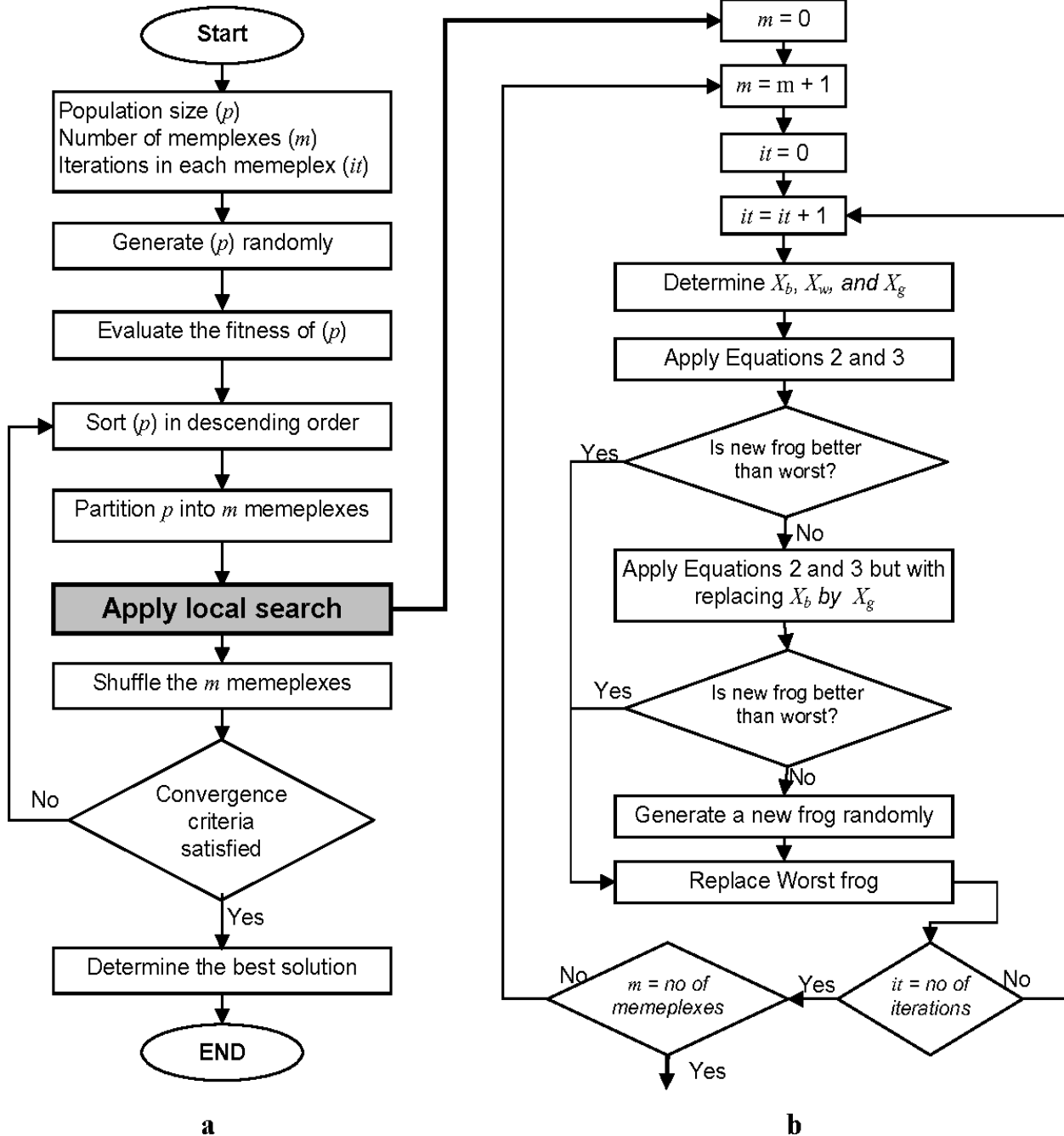

a   **b**

Figure 1.4 : SFLA Algorithm with steps

Else, the above steps with calculations are repeated with exchange of X_b by X_g. If there is no improvement in this step, then a fresh result is arbitrarily produced inside the possible space to change the worst frog. Later, the same steps will carry on for a certain number of iterations To make sure the global exploration; after a certain number of memetic evolution steps inside each memeplex, the ideas that were passed within memeplexes will be pooled up in the scuffling process [17]
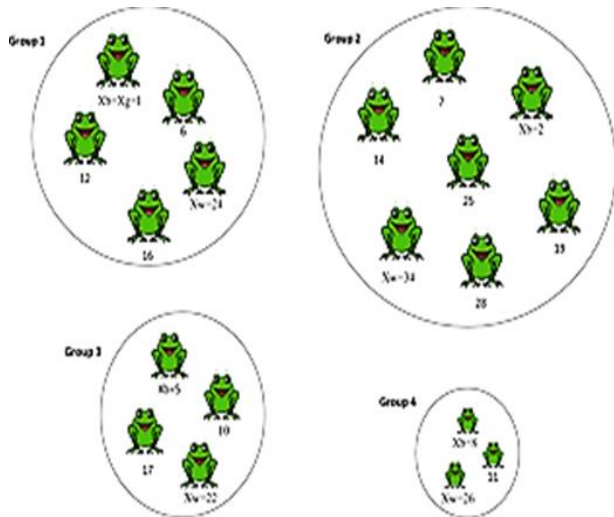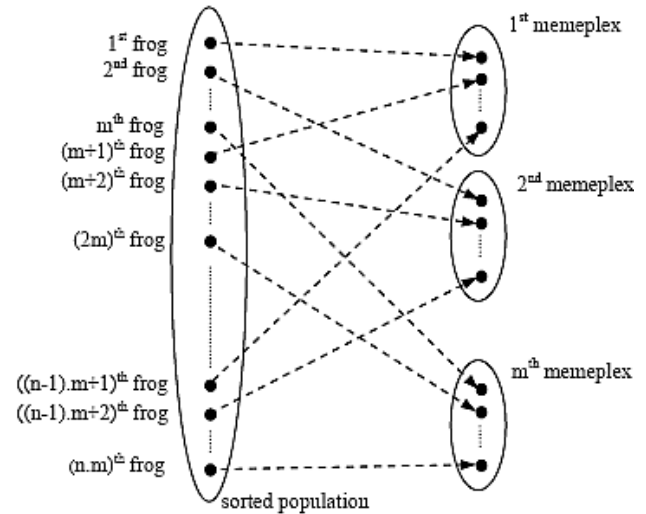
Figure 1.5: Memeplexes and grouping of frogs

B. Particle Swarm Optimization Technique:

PSO is an extensively used optimization technique that is based on swarm intelligence, where in the hunt is made on the basis of the speed of particle. The PSO is a populace based searching process that utilizes the particles to adjust their location in the problem space, which is as shown below:[13]

$$V_i^{k+1} \omega^k V_i^k + a_1 r_1 \times \left(P_{bi}^k - X_i^k\right) + a_2 r_2 \times \left(G_{bi}^k - X_i^k\right)$$

Where P_{bi} signifies the local best particle, G_{bi} designates the global best particle, ω designates the inertia weight function, a_1 and a_2 denote the acceleration constants and r_1 and r_2 are the arbitrary random values that lie between 0 and 1.

The particle's location is reorganized as given:

$$X_i = X_i + v_i.$$

The procedure of PSO is given as below

Step 1: Input the system parameters such as wind specification, voltage limit, line data, bus data and line limits;

Step 2: Initialize the PSO settings;

Step 3: Set the iteration counter c = 0, where the population of particles is initialized with random positions and velocities on dimensions;

Step 4: For each particle, the objective function is calculated and compared with the individual best value. Based on this, the best P_b value is modified with the higher value, and the current position of the particle is recorded;

Step 5: Choose the particle that associated with the individual best P_b of all particles, and set the value of P_b as the overall G_b;

Step 6: Update the velocity and position of each particle;

Step 7: If the number of iterations reach the maximum limit, go to Step 8; otherwise, set the iteration index as c = c + 1 and go to Step 4;

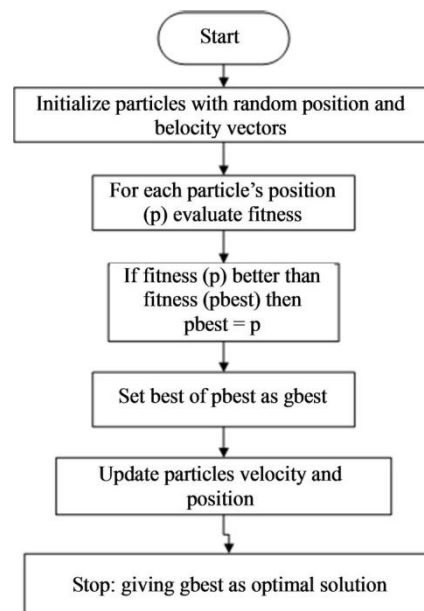*Step 8: The best particle denoted by G_b provides the optimal solution for the problem;*

Figure 1.6: Flowchart of PSO [13]

The rapidity and locations of particles are updated using the below Equations:

$$v_i = wv_i + c_1 \cdot r_1 \cdot (P_i - X_i) + c_2 \cdot r_2 \cdot (P_g - X_i),$$

$$w = \frac{2}{\varphi - 2 + \sqrt{\varphi^2 - 4\varphi}}$$
$$\varphi = \varphi_1 + \varphi_2$$
$$c_1 = w\varphi_1$$
$$c_2 = w\varphi_2$$

Here, v_i is the speed of the ith particle; r_1 and r_2 are two arbitrary quantities which assures an identical dispersal in 0–1; X_i and P_i are existing location and particular top location, correspondingly[23];
P_g is the global best location; and ϕ_1 and ϕ_2 both are set as 2.05. The flight speed of the particles is restricted by v_{max}, which is given by:

$$v_{max} = (X_{max} - X_{min})/10,$$

Where X_{min} and X_{max} are the minimum and maximum constraints
The restructured speed is further combined with the existing location n order to attain a fresh location

IV. CASE STUDY:

The hybrid SFLA-PSO algorithm technique is applied to the standard IEEE 33 bus system which is operated at 12.6kV voltage level and contains 33 busses with 32 branches. 3715kW and 2300kVar is the total active and reactive power of the system. Fig 1.7 shows the network considered.
In this case, the results obtained after the execution of a new shuffled frog leap algorithm and particle swarm optimization algorithm is done on the IEEE 33 bus system in MATLAB. For the test system, the following circumstances are considered:
Case -1 : Allocation of Hybrid (Solar and Wind) DG unit
Scenario 1 : 10 % Penetration of DG
Scenario 2 : 30 % Penetration of DG
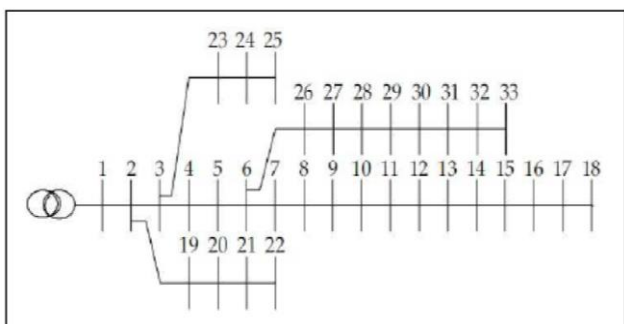Scenario 3 : 50 % Penetration of DG

Fig 1.7 : Single line diagram of IEEE 33 bus

V. RESULTS AND DISCUSSIONS:

A. Scenario-1: 10 % Integration Of SOLAR, WIND Hybrid DG

The results obtained from SFA-PSO algorithm for allocation of Hybrid DG unit for scenario-1 are tabulated in table 1.1. The system losses reduced to 105.76 KW from 201.98 KW and losses in percentage are reduced to 47.95%. Figure 1.8 shows the deviation of voltage and power losses at all the buses before and after integration of 10% of hybrid DG.

Table 1.1: Allocation of Hybrid DG for scenario 1

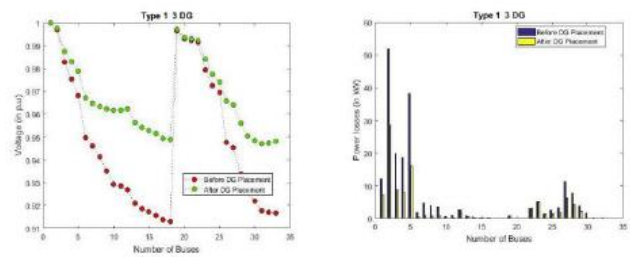|	Parameters	Hybrid Algorithm Result
1.	Optimal location	Bus 16, 32
2.	DG magnitude	752 KW, 382.6 KW, -69.12 KVAR
3.	Base case power loss	201.98 kW
4.	Power losses with DG	105.76 kW
5.	power loss reduction in %	47.95
6.	Minimum voltage without DG	0.90893 pu (Bus 18)
7.	Minimum voltage with DG	0.9382 pu (bus 33)

Figure 1.8: voltage and power losses at all the buses before and after integration of 10% of hybrid DG.

B. Scenario-2: 30 % Integration Of SOLAR, WIND Hybrid DG

The results obtained from SFA-PSO algorithm for allocation of Hybrid DG unit for scenario-2 are tabulated in table 1.1. The system losses reduced to 99.94 KW from 201.98 KW and losses in percentage are reduced to 59.46%. Figure 1.9 shows the deviation of voltage and power losses at all the buses before and after integration of 30% of hybrid DG. Table 1.2: Allocation of Hybrid DG for scenario 2

Table 1.2: Allocation of Hybrid DG for scenario 2

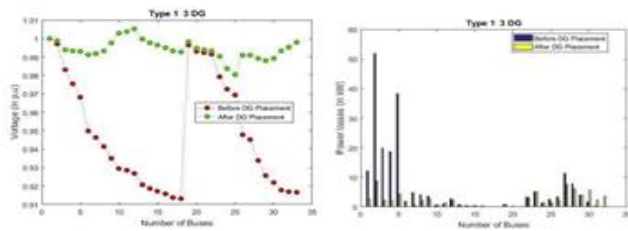| Parameters	Hybrid Algorithm Result
1: Optimal location	Bus 29, 32
2: DG magnitude	1394 KW, 1394 KW, -926.19 KVAR
3: Base case power losses	201.98 kW
4: Power losses with DG	99.94 kW
5: Power loss reduction in %	59.46
6: Minimum voltage without DG	0.90893 (Bus 18)
7: Minimum voltage with DG	0.9491 (Bus 33)

Figure 1.9: voltage and power losses at all the buses before and after integration of 30% of hybrid DG.

C. Scenario-3: 50 % Integration Of SOLAR, WIND Hybrid DG

The results obtained from SFA-PSO algorithm for allocation of Hybrid DG unit for scenario-3 are tabulated in table 1.3. The system losses reduced to 85.96 KW from 201.98 KW and losses in percentage are reduced to 62.84%. Figure 1.10 shows the deviation of voltage and power losses at all the buses before and after integration of 50% of hybrid DG.

Table 1.3: Allocation of Hybrid DG for scenario 3

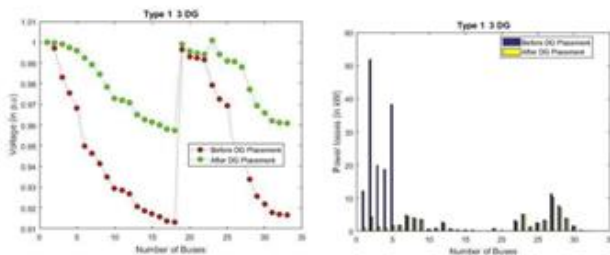| Parameters	Hybrid Algorithm Result
1: Optimal location	Bus 23, 06
2: DG magnitude	1675.6 KW, 1675.6 KW, -985.6 KVAR
3: Base case power losses	201.98
4: Power losses with DG	85.96
5: Power loss reduction in %	62.84
6: Minimum voltage without DG	0.90893 (Bus 18)
7: Minimum voltage with DG	0.95764 (Bus 33)

Figure 1.10: voltage and power losses at all the buses before and after integration of 50% of hybrid DG.

VI.   CONCLUSION:

In this paper a new hybrid algorithm is developed for outlining the optimal locations and penetration level based on various circumstances. The investigation is carried out for optimal position of DG for the corresponding penetration level assuming the normal operation of the system. The test system is investigated to decrease the real power losses in the system and to improve the voltage profile of the network. The process is coded in MATLAB software and the algorithms is tested on the standard IEEE 33 bus test system for hybrid solar/wind DG's

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