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Economic Load Dispatch of Distributed Generation – A comparison on IEEE- 30 bus system and IEEE- 118 bus system

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***Abstract*—** The scheduling of load to the thermal power units and solar photovoltaic units of distributed generation so as to obtain the most economic operating cost and minimizing the emissions is proposed in this paper. The tests are carried out on IEEE-30 bus system and IEEE-118 bus system integrating them with solar photo voltaic units distributed at uniform locations in the state of Telangana, India is discussed. The thermal generating units usually have unique cost-per-hour characteristic for its output operating range, have emissions which pollute the air and also their cost of operation is more.To supply for the ever increasing load requirements, for reliable, sustainable power supply and for most economic operation, solar power plants have to be installed evenly across various geographical locations in addition to the already existing ones and integrate them with the grid. In this paper, the allocation of the load demand to the various generating units, both SPP and TPP i.e the Load Dispatch considering the various limits and constraints of the units of standard IEEE-30 bus and IEEE-118 bus test systems for different load demands in the state of Telangana to obtain the most economical operating costs are evaluated using Non-linear Generalized reduced gradient (GRG) algorithm, Evolutionary algorithm(EA) and Moth flame algorithm (MFA) and the results are compared.

ELD is evaluated by considering multiple parameters of thermal power units such as the fuel cost coefficients, valve point loading effects, penalty due to emissions, transmission losses, minimum and maximum capacities, ramp rate limits and prohibited operating zones and the parameters such as the minimum, maximum and average capacities which depend on the solar irradiance values for the peak solar hours in an year and a factor of overestimation, underestimation of available solar power of PV units.

With the integration of PV units at evenly distributed locations, the transmission line losses and cost of load dispatch is greatly decreased more so in case of IEEE-118 bus system compared to IEEE-30 bus system. Also MFA gives better results compared to Evolutionary algorithm and GRG algorithm, GRG and Evolutionary algorithm are easier and consume less time for evaluating.

Index Terms—**Cost of dispatch ,Evolutionary algorithm, GRG Algorithm Load demand, Moth flame algorithm , Photo-voltaic.**

I.INTRODUCTION

The load demand is increasing globally at the rate of 2.1% per annum as thegrowth is linked to the increasing digitalization and is largely offset by energy efficiency improvements. The power consumption in the state of Telangana, India is increasing rapidly more so the agri sector has a steep rise of 62% since 2013and the peak demand has crossed 13,500 MW. The installed capacity of Thermal power is 6682.5MW from various units belonging to Kakatiya TPP(1100MW),KothagudemTPP(2460MW), Ramagundam(62.5MW & 2600MW),Singereni (1200MW) and 7780 MW is under construction. The installed capacity of solar PV plants is 173 MW distributed at Palwal village (**Lat, Lon: 17.55, 77.45**) near Gadwal(12+12 MW)from Telangana –I & II Solar power plants(SPP), Dharmaraopet SPP (143MW) near Kamareddy**(Lat, Lon: 18.45, 78.25)**, Ramagundam (**Lat, Lon: 18.75, 79.45)**SPP(10MW), Jalar SPP(1MW).

As the raw material for conventional sources like coal for TPP which is the major source of power generation in all countries is fast depleting, ,they have to be integrated with other nonconventional sources for minimizing their utility, preserving them for future generations and to reduce pollution. Also because of high solar irradiance index of solar power in Indiaand its free availability.Hence installation of various solar power plants of 12MW capacity each in addition to the already existing SPPs are to be proposed and placed evenly across various geographical locations in Telangana such as Hyderabad(17.35^0 N, 78.45^{0}E), Adilabad(**Lat, Lon: 19.65, 78.55)**, Nalgonda(**Lat, Lon: 17.05, 79.25)**, Warangal(17.95^{0}N, 79.65^{0}E), Siddipet(**Lat, Lon: 18.15, 78.85)** and Vikarabad(**Lat, Lon: 17.35, 77.95)**.From the solar irradiance data obtained from https://pvwatts.nrel.gov/pvwatts.php, the average output power of the units is calculated based on the solar radiance values of every month considering only the peak sun hours in a day (though the solar radiation is from 7.00am to 05.00pm on any average day) .For solar PV units, the transmission line losses are not considered as they are placed at the distribution end. All the PV units are of Modular, standard, fixed (open rack) type with arrays tilted by 20^0 and with an azimuth angle of 180^0. System losses are taken as 14.08%. The most important task is to interconnect all generating units in parallel, synchronizing them with the grid, scheduling them and thereby meeting the load demand economically. For this reason, optimized and timely switching of generating units is to be made possible to ensure maximum cost savings without affecting the load. Hence in this paper, Standard test systems such as IEEE -30 bus systemconsisting of 6 thermal units integrated with 10 PV units of 107MW for the load demand of 1263 MW and IEEE-118 bus system consisting of 15 thermal units integrated with 11 PV units of 250MW for a load demand of2630MW are considered. IEEE-30 bus system consists of 6 Thermal units, 26 buses,46 transmission lines and base capacity of 100MVA.

In TPPs, the input output characteristic curves of all the generators connected in parallel are not similar or identical to each other, as they belong to different brands and have varied efficiencies, hence the load cannot be divided symmetrically on all of them. Also fuel cost curves at differ at different power outputs.The objective of ELD is to schedule the power output of all the generating units within the designed limits of each individual unit and to meet load demand with optimal fuel and operating cost.

The Load demands are very complex and irregular in nature. Hence A number of optimizing techniques, Computational techniques based on Modern BIA (Biologically Inspired Algorithms)MATLAB programming methods, Lambda iterationmethodand mathematical programming methodsare employed to solve Economic Load Dispatch problem.

A number of Modern BIA (Biologically Inspired Algorithms) classified as Evolutionary based, Ecology based, Swarm based algorithms find their applications to solve ELD. The **Evolutionary based algorithms** aim at solving the problem based on the collective phenomena in adaptive populations comprising growth, development, reproduction, selection, and survival. EAs are nature inspired, classical, non-deterministiccost-based optimization algorithms and mimic the strategies of living organisms to interact with each otherperforming with best-to-survive criteria. A family of EAs comprises of genetic algorithm (GA), genetic programming (GP), Differential Evolution, evolutionary strategy (ES) and Paddy Field Algorithm. The EA are all population-based stochastic search algorithms. They commence by creating an initial population of feasible solutions and evolve iteratively from generation to generation towards a best solution. In successive iterations of the algorithm, fitness-based selection takes place within the population. Better solutions are selected to fit into the next generation of iterations.

The **Ecology based Algorithms** are also bio inspired algorithms in which the living organisms interact with abiotic environment such as air, soil, water etc. The interactions can be among the species of ecosystem which can occur between the species or within the species and can be cooperative or competitive. These are PS2O, Invasive weed colony Algorithm (IWCA), Biogeography based Optimization (BBO).

Another type of bio inspired algorithms **Swarm based Algorithms**which are an extension of EC. While EAs are based on **genetic adaptation** of organisms, Swarm Intelligence (**SI**) is based on collective **social behavior** of organisms**. SI**implements the collective intelligence of groups of simple agents based on the behavior of real-world insect swarms, as a problem-solving tool. The family of SI which can solve ELD problem comprises of Particle swarm optimization(PSO), Ant colony optimization(ACO),Artificial Bee colony optimization(ABC) , Fish Swarm optimization(FSO), Intelligent Water Drops optimization(IWDO), Bat Algorithm(BA), Krill -Herd Algorithm(KHA), Bacterial Foraging Optimization Algorithm(BFOA), Firefly Algorithm (FFA), Artificial Immune system Algorithm(AISA), Group research Algorithm(GRA), Shuffled Frog Leap Algorithm(SFLA) etc.

Solver an **add**-in has found its application in what-if analysis and to find an optimal (maximum or minimum) value for a formula in the objective cell in Excel — subjected to constraints, or limits, on the values of other formula cells in any worksheet.The Non-linear Generalized Reduced Gradient (GRG) Algorithm present in the Solver tool in the additional settings in Data menu of Micosoft Excel Add-ins is the most popular method of optimization used to solve problems with active inequalities. The GRG Nonlinear Solving Method uses the Generalized Reduced Gradient (GRG2) code for solving nonlinear optimization problems.The variables are separated into a set of dependent variables and independent variables. Then, the reduced gradient is computed in order to find the optimum value in the search direction. This process is repeated until the convergence is obtained.

It is easy to install run and execute solver in any system having MSOffice and the time taken for execution is also very less compared to various methods of solving ELD. The personal working in Load dispatch centres can work on this for effectively scheduling the load instantly and economically and need not have any programming knowledge.

Hence in this paper, ELD is computed on IEEE -30 bus system and IEEEE-118 bus system without and with integration of PV units for the load demand of 1263 MW and 2630MW respectively using GRG algorithm, Evolutionary algorithm and Moth flame algorithm and the results are compared with respect to efficiency and economy.

II.PROBLEM FORMULATION

A. Full-Sized Camera-Ready (CR) Copy

Economic Load Dispatch of Thermal power interconnected with Solar power:

Economic load dispatch is calculated to find out the operating cost of power system through the strategic Dispatch of various generating units both TPP and SPP taking into account the fuel costs, valve-point loading effects, penalty due to emissions, transmission line losses while considering the minimum and maximum capacities, prohibited operating zones, ramp-rates limits of all the thermal units and the operating costs, the reserve cost factor, the penalty cost factor for overestimation and underestimation of available solar power while consideringthe minimum and maximum capacities for PV unitswhile fulfilling load demand. Transmission line losses are negligible for PV as PV units are considered to be placed near the load end.In general only real power generated is considered for solving ELD.

A.Parameters of Thermal Power Units:

I)*Operating Cost equation considering fuel cost coefficients* :

The cost of thermal power generation is the summation of the fixed costs which are independent of the amount of power generated and variable costs which depends on the scheduled load of each unit.

The cost function is given as:

$$\boldsymbol{Cost_{gen}} = \sum_{i=1}^{n} \boldsymbol{C_i P_i} = \sum_{i=1}^{n} \boldsymbol{a_i P_i^2} + \boldsymbol{b_i P_i} + \boldsymbol{c_i} . (1)$$

For n number of units

Where *Ci* is the fuel cost of generating *Pi* amount of output power.

ai, *bi* and *ci* are the fuel cost coefficients for *Pi*.

a_i = coefficient to measure of losses in the ith generator.

b_i = coefficient which represents the fuel cost in the ith generator.

c_i = constant coefficient includes salary , wages, interest and depreciation of the ith generator and is independent of the amount of power generated.

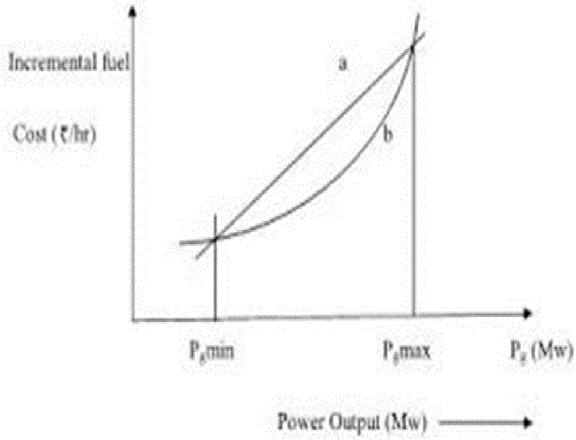

Fig.1: Cost function curve of Thermal power plant

II*) Effects due to Valve point Loading*

Considering the effects due to the changes in steam admission through various nozzles i.e., valve point loading effects which in turn depend on the power to be generated by a particular unit, P_i thereby causing rippling effect because of variation in speed of the turbine,

$$\boldsymbol{Cost_{gen}} = \sum_{i=1}^{n} \boldsymbol{C_i P_i} = \sum_{i=1}^{n} \boldsymbol{a_i P_i^2} + \boldsymbol{b_i P_i} + \boldsymbol{c_i} + \left| \boldsymbol{d_i} \sin(\boldsymbol{e_i}(\boldsymbol{p_i^{min}} - \boldsymbol{p_i}) \right| \ldots \mathbf{(2)}$$

Where d_i and e_i are the coeffients reflecting valve point loading of ith generator.

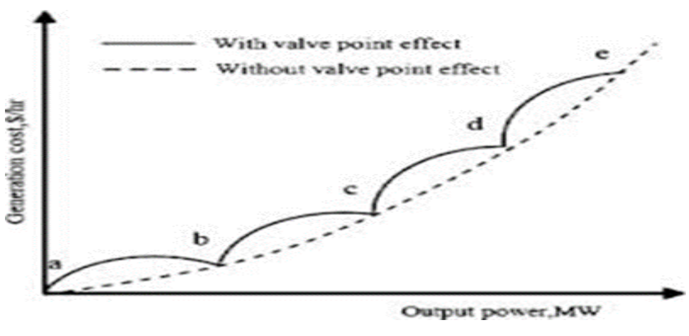

Fig.2: Operating cost curve considering valve point loading effect.

III)*Transmission Losses*:

The losses in the transmission network can be calculated using the formula

$$\boldsymbol{P_{loss}} = \sum_{i}^{n} \sum_{j}^{n} \boldsymbol{P_i B_{ij} P_j} + \sum_{i}^{n} \boldsymbol{B_{0i} P_i} + \boldsymbol{B_{00}} \ldots (3)$$

Where B_{ij}, B_{0i}, and $B_{00}$are the loss coefficient

matrices.

The total Real power to be generated is the sum of load demand P_D and losses due to transmission, where only real power losses P_{loss} are considered and is given by

$P_{T\ total} = \sum_{i=1}^{N_g} P_i = P_D + P_{loss}$……(4)

For efficient operation of the units ,their power generation must lie within their minimum and maximum capacities.

The inequality constraint considering the generation limits is given by Eq.(5)

$P_{imin} \leq P_I \leq P_{imax}$ ……….(5)

Where *Pimin* is the minimum generation capacity limit and *Pimax* is the maximum capacity limit of i^{th} generator.

IV) Cost occurred due to Emissions:

The emissions in the form of COX, SOX and NOX to the atmosphere are subjected to penalty

Further the emissions mostly depend upon the amount of power generated. The load dispatch involves generation of required power for serving the system load with minimum emissions so as to reduce the penalty costs. The emission dispatch function for a particular power generation is given by

$EmissionCost = \sum_{i=1}^{n} \alpha_i \boldsymbol{P_i^2} + \beta_i \boldsymbol{P_i} + \gamma_i$**…..(8)**

Where αi, βi, γi are emission coefficients of the ith generating unit

The Objective function considering valve point loading and emission is given as

$\text{Min}(\boldsymbol{Cost_{gen}}) = \boldsymbol{Min}\ (\sum_{i=1}^{n}((\boldsymbol{a_i P_i^2} + \boldsymbol{b_i P_i} + \boldsymbol{c_i} + |\boldsymbol{d_i} \sin(\boldsymbol{e_i}(\boldsymbol{p_i^{min}} - \boldsymbol{p_i})\ | + \boldsymbol{h_i}(\boldsymbol{\alpha_i P_i^2} + \boldsymbol{\beta_i P_i} + \gamma_i)))$ **……(9)**

Where $\boldsymbol{h_i} = \frac{a_i P_{imax}^2 + b_i P_{imax} + c_i}{\alpha_i P_{imax}^2 + \beta_i P_{imax} + \gamma_i}$ **…..(10)**

Where P_{imax} is the maximum capacity of generation i^{th} generator

h_i is the price penalty factor of emissions for i^{th} generator.

h_i for a particular load demand is obtained by calculating the value of h_i for each generating unit, arranging these values$of\, h_i$ in assending order along with the corresponding P_{max} of the units and finding the cumulative values of maximum power generation. The value of h_i for a particular load demand is the value of h_i corresponding to the cumulative P_{max}.

V) *Ramp rate limits:*

For balancing the net load, providing flexibility and reliability of operation, the difference in power generated by a particular generator (P_i) in a certain interval and that of in the previous interval P_{i0} must not exceed by more than a certain amount called the up-ramp rate limit URi and must not decrease by less than certain amount called the downramp rate limit DRi of that generator .

These constraints are given as

As generation increases Pi–Pi0 ≤ URi

As generation decreases Pi0–Pi≤ DRi   and

max (Pi min ,Pi0 -DRi) ≤ Pi ≤ min(Pi max , Pi0+ URi)….(11)

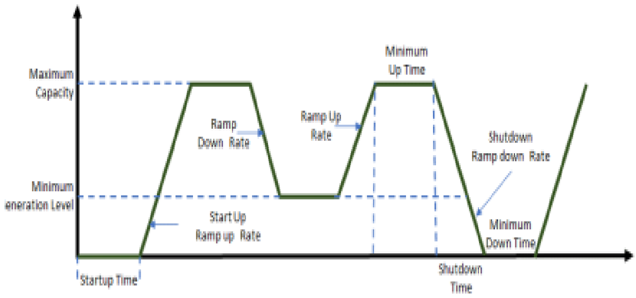

Fig.3. Ramp Rate Limits

VI) *Prohibited Operating Zones:*

In some operating Zones, the efficiency of the machine falls below the acceptable level , so the units are not put into operation in those ranges or zones. These zones are called Prohibited operating zones.There can be multiple such zones for any machine , which makes the problem of ELD still more complex. For unit i with POZs, the feasible operating zones can be described as follows:

Pi min <=Pi<= Pl i,1

P u i,j-1 <= Pi <= P l i,j j=2,3,…….ni

P l i,ni <= Pi <= Pi max …………… (12)

Where

j is the number of prohibited operating zone of unit i.

Pli,j is the lower limit of jth prohibited operating zone and

Pui,j-1 is the upper limit of (j-1)th prohibited operating zone of ith unit.

ni is the total number of POZs of ith unit.

B.: The operating cost Solar PV units is given by

A proper estimation of solar probability density function should be made to determine actual probability of solar power generation. This is obtained from the solar radiance values at various locations during various seasons as given by NREL.

As per the PPA of the state, the cost of each unit is Rs.6.49 with a penalty of Rs.0.50 per unit if the deviations are > 15% but <=25%, For deviations > 25%, Rs.0.50 per unit upto 25% and Rs.1.0 per unit for deviations >25% and <=35%. For deviations > 35%,Rs.0.50 per unit upto 25% , Rs.1.0 per unit from 25%to 35% and Rs.1.50 per unit for deviations are > 35% in 15 minute duration,

The total cost solar power of i th unit is given by

$$\textbf{Cost (PV)} = \sum_{i=0}^{m} \textbf{Cost}\,(\textbf{PVij}\,) = \sum_{i=0}^{n} (\textbf{C pvi}\,(\textbf{pv ij}) + \textbf{Cp.pvi}\,(\textbf{PVi.av} - \textbf{pvij}\,) + \textbf{C rpvi}\,(\textbf{pv ij} - \textbf{PVav}\,)\,) \;\ldots.(13)$$

Where C_{pvi} is the cost coefficient of the generated output solar power which is the scheduled power,$C_{p,pvi}$is the penalty cost coefficient for under estimation i.e., for not using all the available PV generated power and$C_{r,pvi}$is the reserve cost coefficient for over estimation of PV power i.e the reserves which is due to that the actualsolar power generated is less than the scheduled power,*pvij* is the power committed by *ith* PV unit during *jth* hour. *PVi,av* is the available amount of energy of *ith* PV unit, adding the factor of overestimation and underestimation of available solar power.

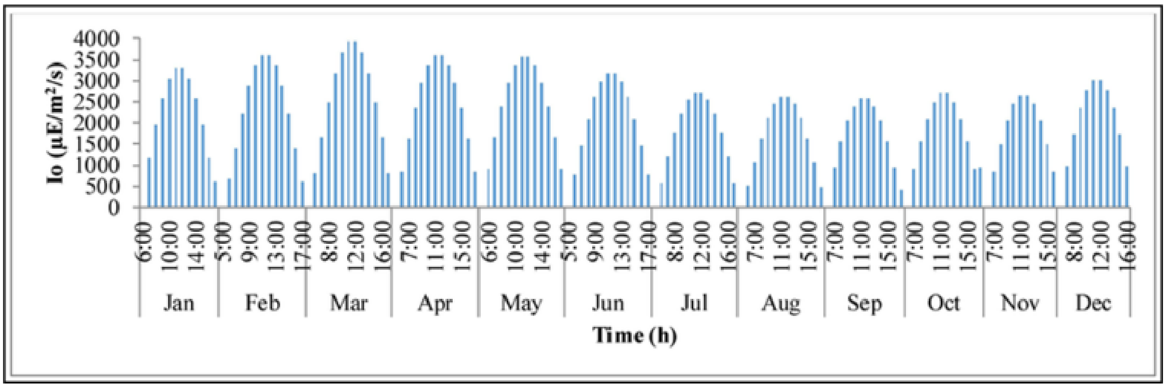

Fig.4.Annual Solar Irradiance Profile in Hyderabad.

C:The Objective Function

The objective function of this study is to minimize the operating cost of power system when PV units are used along with Thermal units for Economic distribution of load among the units.

The total operating cost is calculated by summing Eq. (1) and eq. (13),

$$\textbf{Cost}_{\textbf{total}} = \sum_{i=1}^{n} (C_i P_i) + \sum_{i=1}^{m} cost(PV_{ij}) \;\ldots\ldots\ldots\ldots\ldots.(14)$$

The Equation (14) is evaluated considering the fuel co-efficients and minimum and maximum loading capacities for thermal units and minimum, maximum and average capacities of Solar PV units.

III.METHODOLOGY

To find the Most economical total operational cost of the power dispatch without integration of PV units and with integration of PV units on IEEE-30 bus system and IEEE-118 bus system, comparing the results and thereby proposing the best combination of units in the distributed generation.

- Nonlinear GRG Algorithm
- Evolutionary Algorithm
- Moth Flame Algorithm

A) GRG non linear Algorithm:

GRG non linear Algorithm isapplicable for non-smooth and most difficult type of optimization problemswhere best decision is needed. In this work, it is used to evaluate the most economical value of cost function satisfying all the conditions and constraints of TPPs and SPPs to meet the load demand in accordance with the scheduled load. This is computed in the solver tool which is an add-in in Excel in advanced options of MSOffice10 or above versions. **Excel Solver** is a What-if Analysis Tool used in a number of engineering and business models for the purpose of simulation and optimization. The algorithms used in Excel solver are **GRG non linear Algorithm**, SimplexLP and Evolutionary Algorithms. SimplexLP is used for linear problems and hence is not applicable to find ELD.

The various parameters like cost coefficients, emission coefficients, different load demands, transmission losses and the constraints like minimum, maximum values, limits of ramp rate for either increase or decrease in the scheduled generation, prohibited operating zones of thermal power plants for TPPs and the minimum, average and maximum capacities for SPPs are placed in a spread sheet. The optimum(minimum) value of cost is set as objective function of the system, the load scheduling for various units will be the changing variable cells which in turn is equal to the sum of allocated load demand and transmission losses at a particular load. The cost of power plants subjected to various constraints can be defined in the algorithm. The GRG Nonlinear Algorithm in solver is used to solve ELD and arrives at a locally optimal solution and also globally optimal solution. In this method the gradient or slope of the objective function is taken as the decision variables and are then are separated as basic variables which are dependent variables and non basic variables which are independent variables. In order to obtain optimum value, the reduced gradient is computed in the search direction till it reaches convergence. The population size is taken as 100 and the number of iterations as 100. It gives the solution at a very fast rate. GRG solver results in better solutions, escaping locally optimal solutions in favor of globally optimal ones.

B) *Evolutionary Algorithm:*

The Evolutionary method uses genetic algorithms to find its solutions and is applicable for non-smooth problems and looks at randomness, population, mutation, crossover and selection to solve the problem with population size of 100, mutation rate of 0.75, convergence at 0.00001for 100 iterations. This is also computed in Solver add-in of Excel. It gives a feasible solution satisfying all the conditions and constraints. This method consumes more time compared to GRG but arrives at a better result.

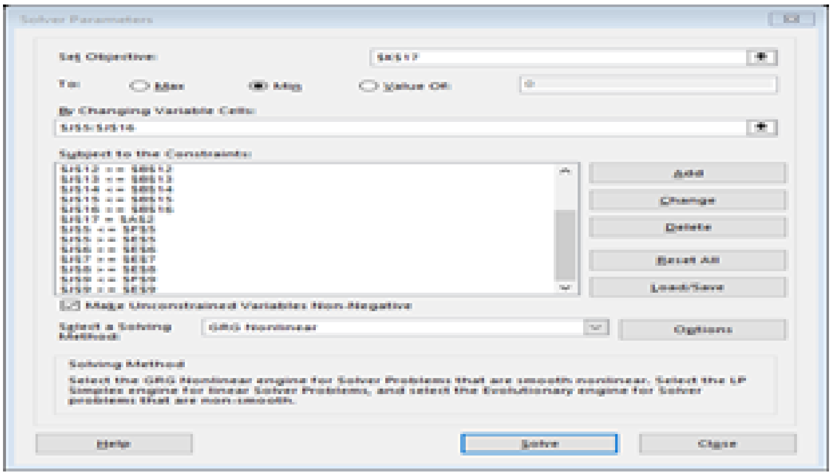

Fig.5: The screen shot of solver configuration

C) Moth Flame Algorithm

Moths are fancy insects, which are similar to the family of butterflies. Basically, they have two main milestones in their lifetime: larvae and adult. The larvae are converted to moth by cocoons. Their special navigation methods in nights is the most interesting fact about moths. They have been evolved to fly in night using the moon light. The mechanism utilized for navigation is called transverse orientation. In this method, a moth flies by maintaining a fixed angle with respect to the moon, a very effective mechanism for travelling long distances in a straight path. Since the moon is far away from the moth, this mechanism guarantees flying in straight line. When moths see an artificial light, they try to maintain a similar angle with the light to fly in straight line. Since such a light is extremely close compared to the moon, maintaining a similar angle to the light source causes a useless or deadly spiral fly path for moth and the moth eventually converges toward the light. The mathematical model this behaviour can be proposed as an optimizer called Moth-Flame Optimization (MFO) algorithm

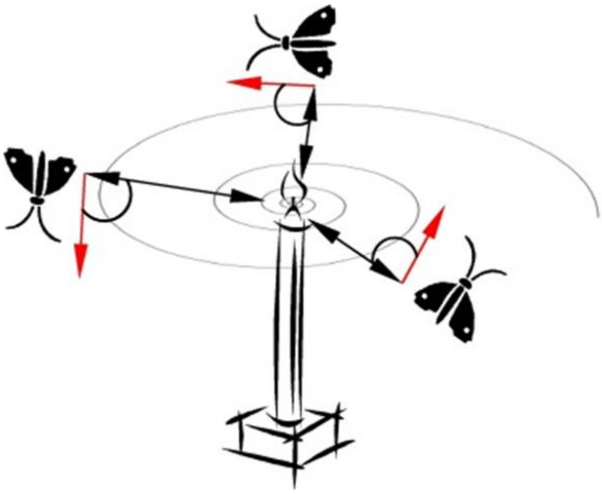

Fig.6: Spiral movement of moth towards flame

In this algorithm, the flame is taken as the best solution i.e., the most economical Load dispatch, while the position of moth with reference to flame is taken as the solution at a given time. The population of moths represents all possible solutions from which one best optimal solution is found. Moth Flame Optimization is reported to be the best algorithm for searching the search space (exploration) due to individual searching of moth around the flame which in turn avoids local stagnation. The first step is to generate a set of random initial solutions**.** Each of these solutions is considered as a candidate solution for a given problem, assessed by the objective function, and assigned an objective value. The algorithm then combines/moves/updates the candidate solutions based on their fitness values with the hope to improve them. The created solutions are again assessed by the objective function and assigned their relevant fitness values. This process is iterated until the satisfaction of an end condition. At the end of this process, the best solution obtained is reported as the best approximation for the global optimum. A logarithmic spiral as the main update mechanism of moths subject to the following conditions:

• Spiral's initial point should start from the moth

• Spiral's final point should be the position of the flame

• Fluctuation of the range of spiral should not exceed from the search space

The code for MFA is written in JAVA programming language it's executed and the results obtained are summarized in table:6.

IV.RESULTS AND DISCUSSIONS

The computational Analysis is carried out onIEEE-30 bus system with 6 thermal generators and IEEE-118 bus system with 15 thermal units considering their fuel costs, penalty due to emissions, valve point loading effects, power capacity constraints, ramp rate limits, prohibited operating zones, and transmission line losses with and without integrating them with uniformly distributed PV units at various loads.

Table 1: Result obtained from GRG Algorithm

IEEE-30 bus system with Load demand of 1263 MW				IEEE-118 bus system with Load demand of 2630MW			
System	Without PV	With PV	% Difference	System	Without PV	With PV	% Difference
Total Generation in MW	1083.754482	**1268**	17%	Total Generation in MW	**2642.61**	**2634.80649**	0%
Tr.Losses in MW	9.572896218	3.781434967	60%	Tr.Losses in MW	12.60658	4.806493755	62%
cost due to VPL	641.04	322.09	50%	cost due to VPL	**918.26**	**579.24**	37%
Total Cost	36281.91231	**23067.58146**	36%	Total Cost	**95276**	**61989.6397**	35%

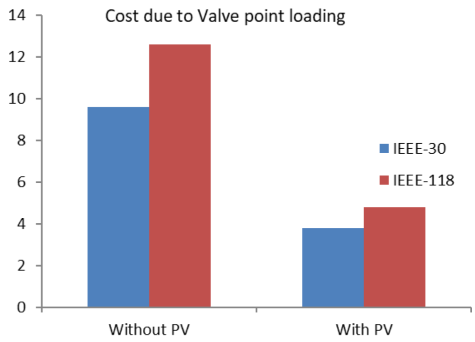

Fig.7: Comparison Cost graph due to GRG Algorithm

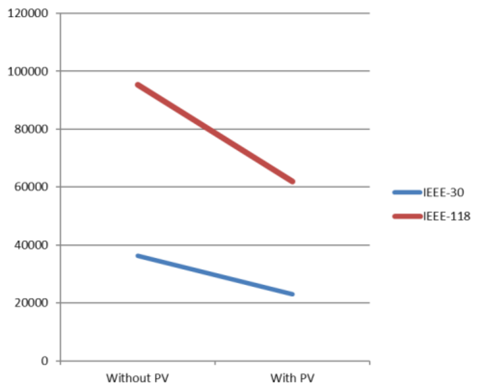

Fig.8 Comparison Cost curve of IEEE-30 & IEEE-118 Bus system.

Table 2: Result obtained from Evolutionary Algorithm

Consolidated result :EVO				
	IEEE-30 Bus system		IEEE-118 Bus system	
LOAD	TP	TP+PV	TP	TP+PV
600	21509.06	14665.04	21509.06	14665.0379
800	12166.81	14665.04	12166.81	14665.0379
1263	36541.67	18561.05	36541.67	18561.0475
1470	51731.71	23569.9	51731.71	23569.8977
2000	20035.96	56397.62	20035.96	56397.618

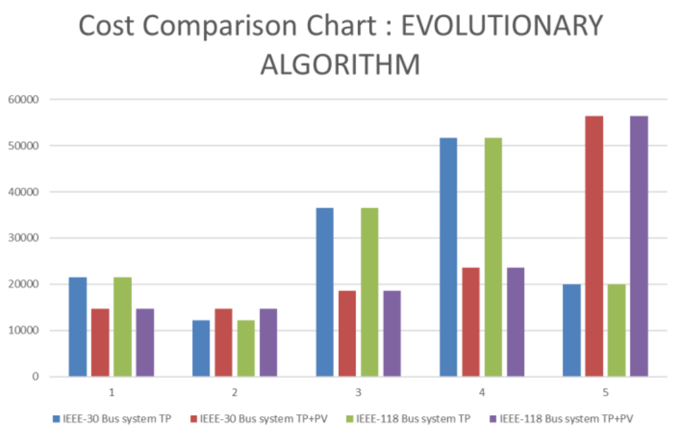

Fig.9: Comparison cost chart obtained from Evolutionary Algorithm at various loads.

Table 3: Consolidated result from GRG Algorithm, Evolutionary Algorithm and MFA for various loads

IEEE-30 BUS SYSTEM : CONSOLIDATED RESULTS: COST						
METHOD	GRG		EVO		MFA	
LOAD	TP	TP+PV	TP	TP+PV	TP	TP+PV
600	13874.289	16568.086	21509.06	14665.038	11150.74	7152.82
800	14809.405	16568.065	12166.813	14665.038	15158.66	9733.95
1263	36281.782	23067.581	36541.671	18561.048	32891.73	20602.19
1470	47480.587	32448.433	51731.71	23569.898	36383.39	22525.3
2000	47550.953	32448.433	20035.964	56397.618	60508.51	35551.37

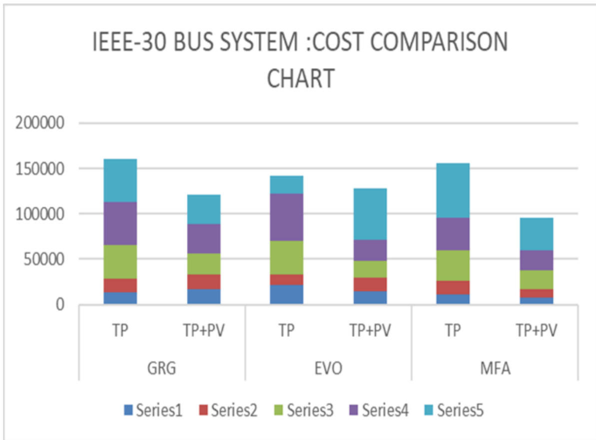

Fig10: Cost Comparison chart with and without PV

Table4: Consolidated result without and with PV on IEEE-30 bus system and IEEE-118 bus system.

Algorithm used	Generation and cost	IEEE-30 bus system with Load demand of 1263 MW			IEEE-118 bus system with Load demand of 2630MW		
		Without PV	With PV	% Difference	Without PV	With PV	% Difference
GRG	Total Generation in MW	1083.754	1268	17%	2642.6066	2634.8065	0%
	Total Cost	36281.91	23067.581	36%	95275.953	61989.64	35%
EVO	Total Generation in MW	1072.557	1252	-17%	2642.6066	2634.8065	0%
	Total Cost	36541.67	18561.048	49%	95275.953	61989.64	35%
MFA	Total Generation in MW	1272.72	1266.8	0%	2653	2645	0%
	Total Cost	31653.37	23142.8	27%	87422.37	57862.26	34%

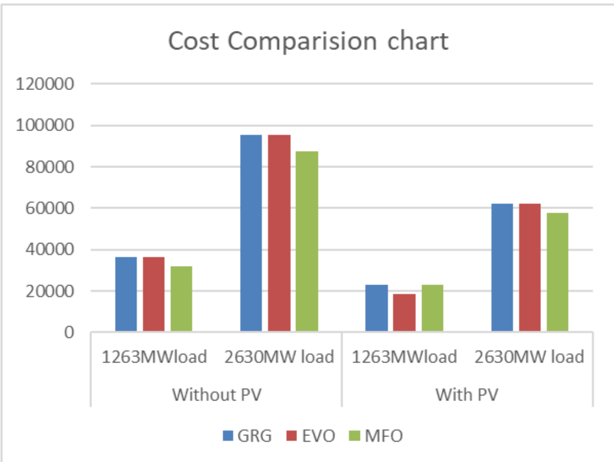

Fig11: Cost Comparison chart with and without PVon IEEE-30 bus system and IEEE-118 bus system.

V: CONCLUSIONS

By the distributing the generation by uniformly placing PV at various geographical locations and interconnecting them to the grid near distribution ends, the transmission losses and the cost of dispatch is greatly reduced compared to the ones without PV units. We also observe that the total cost and the transmission losses are reduced more so in the case of IEEE-118 bus system compared to IEEE-30 bus system. Hence it is proposed to place a greater number of PV units at uniform locations. Further it is noticed that MFA gives better results and is more cost effective compared to Evolutionary algorithm and Non-linear GRG algorithm.

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