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Optimal Power Flow Of Integrated Energy System With Solar And Wind Using Tcsc And Grey Wolf Algorithm Considering Uncertainties

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Abstract*:. *The continuous enlargement and up-gradation of transmission network have become very important to satisfy ever mounting power demand due to the insufficient energy sources and severity evaluation is necessary. In this study, optimal placement of Thyristor controlled series converter is carried using the combination of two indices and sized using Grey wolf algorithm for improvement of power flow as well as the voltage stability and reliability of the integrated system. The formulated Fast voltage stability index determines the power flow of the line and Line Utilization factor estimates the percentage of the line being utilized. The TCSC is placed at the maximum value of the joint severe indicator composite severity index. To validate the proposed methodology it in the absence presence TCSC are compared for normal and 110% loading.

Index Terms*: *Grey Wolf optimization, Solar, Wind, Generator reallocation, distribution functions, TCSC

I. INTRODUCTION

Highlight a section that Around the globe, the existing electrical power network has a multitude of social aids besides that the system also agonizes from network complexity, environmental constraints, increase with size, technical and economic issues which affects the sustainability and reliability. These problems encourage the planners to employ the new and pollution free renewable energy sources. As a appropriate choice, solar and wind generations are observed and more attracted renewable energy sources in the past decade for the reduction of transmission losses, emissions and fuel cost. The unpredictable nature of wind and solar connected to the conventional system has given more challenges to the planners and researchers for the improvement voltage stability and sustainability. Electrical engineers are looking for better methods to use maximum power with the existing integrated energy system. Optimization is one of the good techniques to get the optimal power flow solution with generation reallocation within the specified conditions. The further refinement can be done by connecting shunt devices and maintains the voltages within the limits in general. They are different conventional methods transfer maximum. In recent years development of power electronic devices provides control and flexible for signal transmission. FACT devices can be used to control different in the effective way. The capability of these devices can be used in proper way if it is properly tuned and placed at a particular location of the system thereby reducing the active power loss and maintains the stability. In the literature renewable energy sources could give a better solution to many of the issues [1-3] and can be accomplished with the conventional thermal generators. Carpentier [4] explained the scheduling of generators considering the economic criteria in the OPF frame. B. Khan [5] have discussed and reviewed different techniques used in OPF under conventional and renewable constraints. Atwa [6] proposed a probabilistic planning method to reduce the losses in wind-based energy distribution systems. S. Sichilalu [7] have tried to incorporate a water heater based on heat pump which is delivered and considering minimization and electricity tariff as objective function. A. Panda [8-9] have considered three thermal generators replaced with three equivalent wind farms in IEEE 30 bus system for obtaining OPF solution. The authors included under and over estimation cost corresponding to the reactive power limits of the double fed induction generators in the objective function and obtained the solution by using modified bacteria foraging algorithm. The authors also solved the same problem by using STATCOM. H. T. Jadhav [10] have formulated the objective function comprises of electric vehicles and offshore wind farm where the reactive power capability of DFIG connected to HVDC link has been considered using artificial bee colony. P. P. Biswas [11] have demonstrated the modeling of uncertainties of solar and wind, where the constraints are included with conventional generators for estimated cost energies also taken into account for solving the OPF problem. S. S. Reddy [12] proposed to include the storage system along with solar and wind generation systems to overcome the scheduled period similar to the conventional systems. A. E. Chaib [13] proposed backtracking search technique to determine the OPF solution comprises carbon emissions and valve point loading effect along with cost function and transmission line losses.

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Hingorani [14] explained and analyzed various fact devices for different types of electrical power system issues. Mishra [15] proposed distinct line usage factor for optimal placement of IPFC based on determination of line flows using fire fly algorithm. Bali, S.K. [16] proposed combined index based optimal generation reallocation using harmony search algorithm. Rao BV [17] proposed optimal placement for SVC using firefly and Bat algorithm. This paper mainly concentrates on optimal power flow based generation reallocation in the absence and presence of TCSC using Grey Wolf optimization.The point severity indicator is resultant best position of Fast voltage Line utilization factor framed to achieve the TCSC device and is also used to attain an accurate measurement of overall disturbance. FVSI is utilized for the assessment of line loads in terms of line parameters and reactive power. LUF is utilized for the determination of overloaded line in terms of real power.CSI is calculated for the lines of the power system to find the weak lines connected to the buses. All the lines are ranked in the descending order based on composite severity index. The line pairs which have the highest value of CSI is considered to be optimal placement for TCSC to reduce the carbon emission, losses and fuel cost with valve point effect in the electrical system.. The cost function considering power loss, carbon emission, voltage distortion and fuel cost for valve point has been formulated for optimum tuning of TCSC using Grey wolf optimization. A detailed assessment of the results has been compared on standard bus system to mark the effectiveness of the proposed model. It is also verified for different conditions like normal loading, 110% of loading and 10 percent uncertainty in solar and wind generation.

II. PROBLEM FORMULATION

The main aim is to find out reallocation of generation and optimal parameters of integrated power system.

Chief objective function can be as the following equations

MinF

=Min(w1*FC+w2*FPL+w3*FVD+w4*FCE+w5*FVPE)

(1)

w1+w2+w3+w4+w5 =1 and w1=w2=w3=w4=w5 =0.2

Where w1,w2,w3,w4,w5 are the weighting factors for objective functions. Weightage of individual objective function has given equal priority and sum is equal to one.

A. Real power generation cost:

The reduction of real power generation cost is given by

$$F_C = \min(\sum_{i=1}^{N_{TG}} a_i + b_i P_{TGI} + C_i P_{TGI}^2) \quad (2)$$

$$C_{wj}(P_{wj}) = x_j P_{wj} \quad (3)$$

$$C_{sk}(P_{sk}) = y_k P_{sk} \quad (4)$$

Where P_{wj} is the wind from jth i.e wind farm in MW, the K th solar PV plant (MW), x_j co-efficient jth wind farm, and yk co-efficient (MW).

B. Real power generation cost with valve-point effect

$$C_{TD}(P_{TG}) = \sum_{i=1}^{N_{TG}} a_i + b_i P_{TGI} + C_i P_{TGI}^2 + \left| d_i \times \sin(e_i \times (P_{TGI}^{\min} - P_{TGI})) \right| \quad (5)$$

where di and ei are the co-efficients that extracted to loading of valve point $P_{TGI}^{\min}$ ith . The considered into account to have a more effective and realistic modeling of cost functions. By considering the effect of multi valve turbines the power systems exhibits greater variation in the generating -cost functions and sinusoidal function is supplemented to the fuel cost.

C. Active

The aim is to minimizing real power loss in transmission lines.

$$F_{PLoss} = \min(P_{Loss}) = \min(\sum_{k=1}^{ntl} real(S_{ij}^k + S_{ji}^k)) \quad (6)$$

Where ntl gives no. of transmission lines, Sij gives complex power flow.i is the sending end and j is the receiving end.

D. Voltage Deviation:

For good voltage performance, the deviation at each bus should be as less as possible. This Voltage Deviation (VD) is given as:

$$F_{VD} = \min(VD) = \min\left(\sum_{k=1}^{Nbus} :V_k - V_k^{ref}:^2\right) \quad (7)$$

V_k represents voltage level for bus k, Vk_{ref} is the reference level. Apparent power is Sk and Sk_{max} is the maximum apparent power.

E. Emission

As the environment is polluted, it is expected to determine the emission for adjusting optimal power. Emission of pollutants caused by thermal units is given by

$$E = \sum_{i=1}^{N_{TG}} [(\alpha_i + \beta_i P_{TGi} + \gamma_i P_{TGI}^2) \times 0.01 + \omega_i e^{(\mu_i P_{TGi})}] \quad (8)$$

α_i β_i, γ_i, ω_i ,µi are all emission coefficients corresponding to the ith thermal generator

Modelling of installed TCSC

The active and reactive power equations at bus t are

Pt = VtVmBtm sin (θt- θm) (9)

Qt = -Vt2Btt -VtVmBtmcos(θt- θm) (10)

Equality constraints:

$$\sum_{i=1}^{N} P_{Gi} = \sum_{i=1}^{N} P_{Di} + P_L \quad (11)$$

Where i=1,2,3,.......,N and N = no. of. Buses

$$\sum_{i=1}^{N} Q_{Gi} = \sum_{i=1}^{N} Q_{Di} + Q_L \quad (12)$$

Where i=1,2,3,.......,N representing bus number.Active power is represented by PL.Reactive power by QL.Active power generation is termed as PGi. PDi is the power demand at bus i.

Inequality constraints:

Voltage limits for generator buses:

$$V_{Gi}^{\min} \le V_{Gi} \le V_{Gi}^{\max} \quad (13)$$

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Where Gi=1, 2, 3,.......,ng and ng = no. of. Generator buses

Real power generation limits:

$$P_{Gi}^{\min} \le P_{Gi} \le P_{Gi}^{\max} \tag{14}$$

Reactive Power generation limits:

$$Q_{Gi}^{\min} \le Q_{Gi} \le Q_{Gi}^{\max} \tag{15}$$

TCSC Limits

$$X_{TCSC}^{\min} \le X_{TCSC} \le V_{TCSC}^{\max} \tag{16}$$

III. Optimal Placement of TCSC Using Indices

Fast Voltage Stability Index (FVSI)

Indices of voltage with S manifest and capacity for collapse and voltage. Moreover, system encourages shown by Vinduced.

$$FVSI_{ij} = 4\frac{z^2 Q_j}{V_i^2 X} \tag{17}$$

Where Z = ZdX represent line impedance line reactance in ohms, Qj = the reactive power at bus j (receiving end bus), Vi = the voltage magnitude at bus i (sending end bus), FVSIij = FVSI for line connected between bus i and bus j. The line being heavily loaded is shown when any line in the system that has FVSI magnitude close to unity. Hence, FVSI values are required to be kept at less than unity for ensuring system stability.

Line utilization factor (LUF)

Line Utilization Factor is an index used for determining the congestion of the transmission lines and how well the capacity of the line is being utilized. LUF is given by equation

$$LUF = \frac{MVApq}{MVApq^{\max}} \tag{18}$$

MVApq (max) is the maximum rating line linked to p + q been activated MVA value indirectly the percentage utilized.

IV. Weibull and Lognormal for Wind/PV

To evaluate the output power of wind, the weibull PDF is utilized. In the weibull analysis, the frequency, probability and cumulative probability are calculated.

A.Weibull PDF

The wind speed pattern is determined by weibull distribution function which uses two parameters. The statistical analysis data is utilized. The weibull distribution formula is denoted as the following equation,

$$f(v) = \frac{k}{c} * \left(\frac{v}{c}\right)^{k-1} * e^{-\left(\frac{v}{c}\right)^k} \tag{19}$$

Where, C and K denoted as the wind speed characteristics, If the C value is high the wind speed is also high. If the C value is low, the wind speed is also low. The wind speed stability is denoted by the parameter K. After that, the cumulative weibull distribution is determined by the equation

$$F(v) = 1 - e^{-\left(\frac{v}{c}\right)^k}$$

Where the relation between wind speed and power delivered is existing can be considered by the equation (20)

$$P(v) = \begin{cases} 0 & v < v_{ci} \ \ or \ \ v > v_{co} \\ q(v) & v_{ci} \le v \le v_r \\ P_r & v_r < v < v_{co} \end{cases} \tag{21}$$

From the above equations ,the $P(v)$, v_{ci}, v_{co}, v_r, P_r ,and $q(v)$ is the electric power ,wind speeds related to cut-in, cut-out, rated wind speed and rated values of wind speed and power. There is a nonlinear relationship between power and wind speed.

B. Lognormal PDF

In the section, the lognormal PDF function is utilized for the analysis of power in PV

The variable x,which is random variable of complex type has a lognormal distribution if the random variable has mean and standard deviation.

$$f(x:\mu,\beta) = \begin{cases} \frac{1}{\beta x\sqrt{2\Pi}} e^{\frac{-1}{2\beta^2}[\ln(x)-\mu]^2} & x \ge 0 \\ 0 & Otherwise \end{cases}$$

(22)

The density function for the analysis is represented as

$$r(x) = \frac{1}{x\beta\sqrt{2\Pi}} e^{\frac{[\ln(x)-\mu]^2}{2\beta^2}} \tag{23}$$

The parameters of the lognormal distribution is calculated as the following equation,

$$\mu = e^{\mu + \frac{\beta^2}{2}} \tag{24}$$

$$\beta^2 = e^{2\mu+\beta^2}\left(e^{\beta^2} - 1\right)$$

(25)

The lognormal distribution is used for a wide variety of applications. It applies and evaluated the output power of PV. Based on that, the frequency and probability of PV are analyzed. Here, the mean and variance values are changed, the corresponding values are evaluated. In the paper, the lognormal based PV is utilized to analyze the output power. After that, the variation of the mean and co-variance parameters, the output power is determined and achieves the optimal power flow solutions.

V. Optimal Tuning of TCSC by Using Grey Wolf Optimization

In 2014 S. Mirjalilli presented the Grey Wolf Optimizer (GWO. This technique is totally designed based upon on searching prey and individual hunting characteristics of grey wolves. In this optimization four different levels of hierarchies are assumed. Grey wolves involving 'p' being first then followed by second one 'q' then third one 'r' and the last level 's'. Grey wolves are more interested to live in a group. The pack size may be on average of around 5-12 wolves. 'P' wolves are generally the group leaders are responsible for different activities like decision making for hunting, walking,

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attacking, sleeping, wake up etc and need not be a strong wolf in the pack but needs to manage the other wolves. Allthe grey wolves gives the respect and acknowledges the leader wolf by keeping their tails down in gatherings. The second order in the pack of wolves is ‘q’ which is better than the other wolves and next to the ‘p’ grey wolf. It can be a either female or male. The responsibility for ‘q’ wolf is to give the feedback collected from the remaining wolves and it should help the ‘p’ while taking decisions of other activities conducted in the group. This wolf should lead the remaining wolves in the absence of leader wolf. The next level of hierarchy is ‘r’ wolves which commands the lower hierarchy grey wolves and gives respect to the higher level wolves. The last one ‘s’ wolves are not that much important but it is observed that the whole group has fighting if one ‘r’ wolf is loosed. These are mainly responsible for caring, integrity and safety in the wolves group/pack.

VI. RESULTS AND DISCUSSIONS

The actual output power of wind turbine is determined by consideration of probablilites and its variations of speed is noted. The wind speed is assumed as the miles per hour (m/h) and then it is converted into m/sec. Based on the weibull PDF,. Here, the resultant power of PV is considered with the help of lognormal PDF functions. One PV is employed and the 24hours PV data is noted. Based on the data, the irradiance level is noted. The average wind farm related power and solar is assumed for solving the OPF and the proposed Grey wolf algorithm has been execution on IEEE 30 Bus system including and excluding TCSC.

For IEEE 30bus system

. The modified IEEE 30 bus test system comprises of six generators , among them slack bus is placed at bus 1 and 3 thermal generators are placed at bus no 2,5,8 solar system is located at bus 11 and wind system is located at bus no 13 and the remaining 24 buses are treated as load buses(PQ-Bus).This configuration is having 41 interconnected lines. Only Load buses (PQ buses) are assumed for the optimal placement of TCSC. TCSC improves the line power transfer capability which contains series capacitor in parallel with a TCR to give a smooth variable compensation of the power transmission system. Grey wolf optimization is utilized for obtaining the optimal power flow including and excluding TCSC and program is executed in MATLAB software and Salient features are tabulated. The obtained results are illustrated. Equal weights of 0.2 have been considered for all objectives. The results are carried out for different objective function

Table –1: Salient features of GWO method

S.No	Features	Quantity
1	Grey wolf size	20
2	Iterations	50
3	a vector	2

Table 2: Top-20 CSI-index values including and excluding TCSC.

LINE Numbers	SEB Number	REB Number	FVSI without TCSC	LUF without TCSC	CSI without TCSC
1	1	2	0.0951	0.7068	0.4009
13	9	11	0.361	0.1209	0.2838
5	2	5	0.1944	0.2928	0.2711
2	1	3	0.17	0.3525	0.2612
6	2	6	0.2098	0.2436	0.2267
14	9	10	0.1404	0.1001	0.1862
4	3	4	0.0429	0.3185	0.1807
7	4	6	0.0391	0.232	0.166
15	4	12	0.1539	0.0946	0.1501
9	6	7	0.0704	0.2066	0.1403
3	2	4	0.1132	0.3477	0.1387
36	28	27	0.1225	0.0188	0.1085
10	6	8	0.0521	0.1641	0.0974
27	10	21	0.0621	0.0381	0.0915
12	6	10	0.101	0.1428	0.0819
18	12	15	0.0237	0.0754	0.0571
41	6	28	0.0305	0.0048	0.055
11	6	9	0.0384	0.1462	0.0545
8	5	7	0.033	0.2102	0.0542
25	10	20	0.0548	0.0387	0.0528

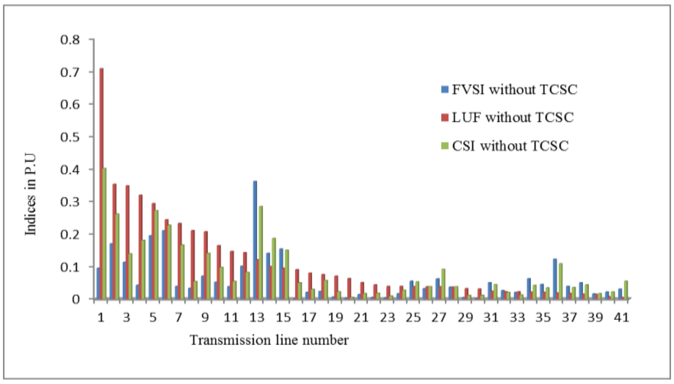

FIGURE 1 Values of different indices for transmission lines

Table 3: Avg, Worst, Best Multi objective values

MULTI objective	G=20 a=1	G=20 a=1.5	G=20 a=2	G=20 a=2.5
AVG	247.71	243.6	242.33	242.6
WORST	255.35	252.34	242.34	243.52
BEST	242.59	242.38	242.32	242.42

Table 1 shows the parameters of Grey wolf algorithm. Top 20 CSI values along with FVSI and LUF values of all lines in IEEE-30-bus system are tabulated in Table 2. It is noticed from the Table 2 that the line connected between buses 9-11 has the highest CSI value which gives the optimal placement

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for the TCSC. Fig 1 shows the CSI, FVSI, LUF values of all lines in IEEE 30 bus system. Fig 2 displays and Table 3 shows the average, best, worst values of the multiobjective function for different values of constant 'a' (parameter of Grey Wolf algorithm). For a=2 provides the best value and it is employed in the further solving the problem.

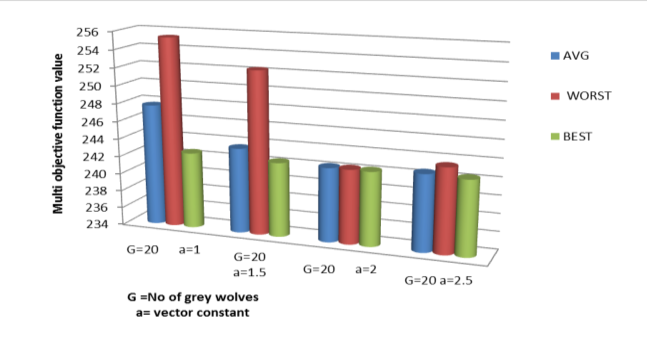

FIGURE 2:Avg, Worst and Best Multi objective values

Table -4 Analysis of Various parameters using Grey wolf algorithm.

Parameter		Base case	With TCSC	GWA Tuned without TCSC	GWA Tuned with TCSC
Real power generation (MW)	PG1(MW)	195.3	193.01	150.52	149.11
	PG2(MW)	20	20	42.25	46.931
	PG5(MW)	20	20	23.299	19.997
	PG8(MW)	20	20	11.58	10
	PGS11(MW)	20	20	35	35
	PGW13(MW)	20	20	30	30
Total real power generation (MW)		295.3	293.0	292.64	291.03
Active power Loss (MW)		11.83	9.61	9.15	7.63
Reactive power Loss(MVar)		33.33	46.81	24.71	39.17
Voltage deviation (p.u.)		2.429	1.307	2.127	1.2983

Table 4 gives the comparison of different parameters like individual generators, active power loss, effective power and voltage distortion have been compared with and without TCSC and also tuned with grey wolf algorithm. Table 5 displays a noticeable improvement in voltage profile and Fig 3 represents the contrast of voltage profile of buses without and with tuned TCSC. Table 6 shows that active power generation and losses are reduced after the placement and optimal tuning of TCSC using grey wolf optimization. Table 6 represents different cases with different objective functions consisting of the Total generation cost, valve-point loading effect, Voltage deviation, carbon-emission and recommended power by

Table -5 Comparison of voltage profile for IEEE-30 Bus system

Bus number	Base case	Base case with TCSC	Base case with tuned	Optimal tuned with TCSC
1	1.06	1.06	1.06	1.06
2	1.0104	1.043	1.0189	1.043
3	0.9849	1.0389	0.9927	1.0404
4	0.9673	1.0339	0.9768	1.0357
5	0.9242	1.01	0.9345	1.01
6	0.9515	1.0294	0.9613	1.0305
7	0.9251	1.0076	0.9353	1.0083
8	0.9385	1.01	0.9473	1.01
9	0.9601	1.1327	0.9681	1.131
10	0.9243	1.0726	0.9333	1.072
11	1.0393	1.4096	1.0452	1.4031
12	0.9261	1.0546	0.9358	1.0552
13	0.9256	1.071	0.9347	1.071
14	0.9116	1.0453	0.9214	1.0457
15	0.9086	1.0456	0.9182	1.0457
16	0.917	1.0549	0.9264	1.0549
17	0.916	1.062	0.9252	1.0616
18	0.9002	1.0431	0.9097	1.043
19	0.8988	1.0448	0.9083	1.0445
20	0.9043	1.051	0.9136	1.0506
21	0.905	1.0515	0.9143	1.051
22	0.9121	1.0567	0.9212	1.0561
23	0.904	1.0492	0.9133	1.0487
24	0.8956	1.0357	0.9047	1.035
25	0.899	1.0185	0.9073	1.0172
26	0.8789	1.0008	0.8874	0.9996
27	0.911	1.0165	0.919	1.015
28	0.9438	1.024	0.9536	1.0248
29	0.8884	0.9965	0.8966	0.995
30	0.8754	0.9849	0.8837	0.9834
31		1.3516		1.3459

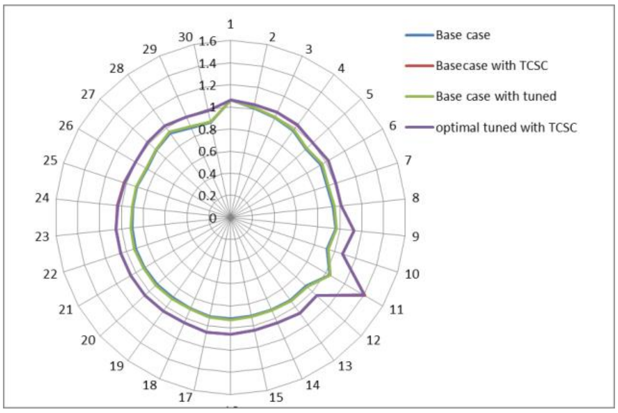

FIGURE 3: Voltage profile for IEEE-30bus system including and excluding TCSC

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Table -6 Comparison of Real power losses for IEEE30 bus system (TCSC placed in between bus no 9 and 11)

	Total Power Generation in MW	Load in MW	Total Active Power losses in MW
NR method	295.33	283.4	11.83
NR with TCSC	293.01	283.4	9.61
GWO–OPF without TCSC	292.64	283.4	9.15
GWO-OPF with TCSC	291.0381	283.4	7.63

Table -7 Comparison of parameters of Multi objective function for Normal loading of IEEE30 bus system

	Tuned With out TCSC	Tuning of TCSC using GWO
Real power losses (MW)	9.38	7.63
Fuel cost ($/hr)	587	5.81E+02
Fuel cost with Value point effect($/hr)	612.96	6.06E+02
Emissions(ton/hr)	0.1221	0.1218
Voltage deviation(P.U)	2.1694	1.2983
Multi objective function value	242.32	239.13
Time of computation in secs	54.2	54.3

Table 7 shows the results for normal loading. It is observed that all the objective functions values are reduced after the placement of TCSC in the integrated system. Table 8 displays the results for 110% increase in the loadAs the load value increases all the objective functions are increased as compared to the normal loading. With the proper placement of TCSC it is noticed that there is improvement in the losses and voltage profile. Table 9 shows results for 10% uncertainty in solar and wind system. Here it is assumed that there is 10% reduction in the generation of solar and wind power. It is observed that losses, carbon emissions, valve point effect, voltage deviation are increased as compared to the normal loading and also noticed that after placement of TCSC all objective functions are decreased. Table 10 and Table 11 consist of different objective functions in the absence and presence of TCSC. As compared to the Table 10 the objectives present in the Table 11 gives better results with optimal placement of TCSC. Fig 4 illustrates the different objectives for normal loading, 110% of P load and 10% uncertainty in solar and wind

Table -8 Comparison of parameters of Multi objective function for 110% loading of IEEE30 bus system

	Tuned Without TCSC	Tuning of TCSC using GWO
Real power losses (MW)	41.56	10.177
Fuel cost ($/hr)	6.91E+02	680.53
Fuel cost with Value point effect($/hr)	7.26E+02	713.8667
Emissions(ton/hr)	0.179	0.176
Voltage deviation(P.U)	3.53	1.0139
Multi objective function value	2.92E+02	281.1547
Time of computation in secs	54	54.3

Table -9 Comparison of parameters of Multi objective function for 10% uncertainty in solar and wind of IEEE30 bus system

	Tuned Without TCSC	Tuning of TCSC using GWO
Real power losses (MW)	9.7617	8.04
Fuel cost ($/hr)	609	602
Fuel cost with Value point effect($/hr)	638	631
Emissions(ton/hr)	0.135	0.1347
Voltage deviation(P.U)	2.2121	1.3027
Multi objective function value	2.52E+02	2.49E+02
Time of computation in secs	53.46	57.24

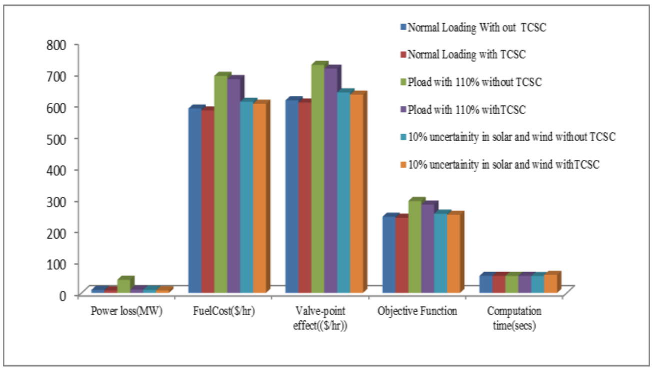

FIGURE 4. Comparison of parameters for different conditions

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Variables	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6
PG1(MW)	154.6976	138.8726	50.38	50	54.52	148.17
PG2(MW)	43.7753	58.261	80	80	62.44	48.51
PG5(MW)	19.6808	20.3499	50	50	50	21.08
PG8(MW)	10	10	60	60	55.567	10
PGS(MW)	35	35	35	35	35	35
PGw(MW)	30	30	12.22	30	30	30
Total real power generation (MW)	293.1537	292.4835	287.6	305	287.527	292.76
Total real power generation cost($/hr)	586.4983	590.98	793.41	792.5	710.15	587
Valve-PointEffect ($/hr)	613.6742	612.44	836.48	835.32	760.399	612.963
Active power Loss(MW)	9.7536	9.0835	4.2	21.6	4.245	9.38
Voltage deviation (p.u.)	2.128	2.128	1.2629	1.2071	1.2279	2.1694
Emissions(ton/hr)	0.1297	0.1111	0.0597	0.0595	0.053	0.1211
Objective function	586.4983	612.4457	4.2	1.2071	0.053	242.32
Computation time	45.45	45.66	41.07	46.14	33.2	47.67
TFVSI	2.5783	2.5063	2.3373	2.3583	2.3463	2.5683
Lmax	0.0917	0.0909	0.801	0.0816	0.0819	0.0913

Table-10:Comparison of OPF solution for 30 bus system using GWO-OPF Excluding TCSC

Table-11 Comparison of OPF solution for 30 bus system using GWO-OPF Including TCSC

Variables	Type-7	Type-8	Type-9	Type-10	Type-11	Type-12
PG1(MW)	153.86	139.0807	57.2207	201.6679	63.6996	149.1101
PG2(MW)	42.999	56.2478	80	20	73.5864	46.931
PG5(MW)	19.384	20.355	50	15	50	19.997
PG8(MW)	10	10	35	10	35	10
PGW(MW)	35	35	35	35	35	35
PGS(MW)	30	30	30	12	30	30
Total real power generation (MW)	291.24	290.6835	287.2207	293.6679	287.286	291.0381
Total real power generation cost($/hr)	580.28	584.0801	708.8873	660.24	696.321	580.5898
Valve-Point Effect($/hr)	606.58	605.4901	753.5322	671.4	747.1077	606.0276
Active power Loss(MW)	7.841	7.2835	3.8207	10.2679	3.886	7.63
Voltage deviation (p.u.)	1.2982	1.2992	1.3032	1.205	1.3029	1.2983
Carbon Emissions	0.128	0.1105	0.052	0.213	0.0518	0.1218
Objective function	580.29	605.4901	3.8207	1.205	0.0518	239.1352
Time of Computation	0.015	0.06	0.06	0.06	0.06	0.12
TFVSI	2.9511	2.9378	3.0804	3.0029	3.0728	2.9462
TLUF	5.0511	4.9577	4.085	5.376	4.1125	5.0179
TCSI	4.0011	3.9478	3.5827	4.1894	3.5926	3.982
Reactive losses	39.83	38.17	25.42	49.21	25.59	39.17

VII. CONCLUSION

Generator reallocation and voltage stability is an important prerequisite for successful operation of the integrated energy system reduction of losses, emission, generator reallocation ,voltage stability are primary issues. A composite performance index comprises of Fast voltage stability index and Line utilization factor for the optimal placement of TCSC for the reduction of losses and emissions is proposed. A multiobjective function consists of fuel cost with valve point effect, emissions, voltage deviation with the utilization of minimum value of TCSC is considered for the Optimal tuning of TCSC using Grey wolf optimization The proposed method is developed in MATLAB environment for optimal tuning of TCSC using GWO is supported. Composite severity index has been utilized for finding out the most stressed line of the Transmission system. The weak lines are identified based on the rank and arranged in descending order of composite severity index for the lines connected between the buses. Uncertainties of solar and wind are modeled as lognormal and weigh bull probabilistic distribution functions and interconnected to the conventional grid are explained.

The TCSC and output of Generators are further tuned by reducing function related to active power loss techniques for achieving must optimum global values. The best global optimum values.

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The system also tested for normal loading,110% loading and 10% uncertainty in solar and wind Results conveyed that the proposed approach reduces the losses, carbon emission up to a great extent and improves the voltage profile at every load bus respectively. The results also declare that the proposed approach relives the overloaded transmission lines in an efficient manner. Finally it can be concluded that the investigated method is more capable in decreasing the losses, carbon emission and improves the voltage profile.

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