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Location of IPFC for congestion Management Lines In Electricity Market Restructured Using PSO Algorithm

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Abstract: Of 1980, many efforts to change the structure of power industry with the aim of fair competition and improve economic efficiency have been conducted in different countries. One of the most important and most sensitive network functions exploiter, planning to reduce production costs in planning systems is power utilization. A different method of providing cost management is carried. FACTS devices using one of the most commonly used equipment to reduce production costs and reduce the power density line systems is considered. In this paper, location optimal IPFC on the system IEEE 14 bus and IEEE 30 bus based on PSO algorithm for congestion management market power transmission lines is used.

Key words: location optimization, FACTS devices, congestion management, UPFC, PSO

INTRODUCTION

One of the most important issues restructured systems, network density is transferred. In dealing with this problem various methods from basic researchers and those involved give power industry. And include that the contract path method and critical factors, and cost transfer pricing method, method of using FACTS devices, etc. could be mentioned. The purpose of these procedures under the proposed congestion management are the first information to create mechanisms for attracting participation subscribers and prevent the occurrence of network congestion or density, and then resolve potential network densities using the methods are fair and transparent.

Restructuring of power systems in many countries following income had an important and has led to the use of common equipment to be more FACTS day. Since the power transmission network limitations essentially controlled flow removable or network is reduced, so use of these elements density for the management seems very useful. The application issues FACTS, a place for the true and accurate to maximize profits FACTS expensive equipment and management is optimum density lines.

The most important studies done in the field of FACTS devices for the management, density, UPFC can be used in different ways to manage the density. These methods based on market and generally are used in Europe. Based method, divided into geographic market and the use of FACTS elements between areas divided according to specific methods of density management. These methods include using mutual exchange, share market and auction market in the border area between the two is dense. But the most important issues in these field placement FACTS devices are optimized. Placement for problem solving many optimization methods FACTS devices such as linear and nonlinear programming, neural networks, fuzzy logic, steel plating and intelligent algorithms are used. Intelligent algorithms such as genetic algorithms (Saguan, M., 2004; Reddy, K., 2006; Nabavi, S.M.H., 2006) and PSO algorithm due to the inherent characteristics of natural and simple to understand, be understood, using knowledge of human and living, etc. them to make appropriate problem solving discussion.

Algorithm PSO, for the first time in 1995 by Eberhart and Kennedy as an optimization method was introduced. This algorithm is a social search algorithm that models the social behavior of birds has clubs and governing in order to discover patterns and sudden change in flight path of birds at the same time they change and shape optimization is applied to categories. The work of PSO is based on the principle that every moment of each particle in your location search space the best place so far has been the best of his neighborhood where there is total, is set .

In Reference (Chen, Z.X., 2005) of the PSO method for solving OPF market for shared congestion management is used. The main purpose of this reference for managing congestion at least cost and demand on active buying power with system reliability is preserved. In reference (Meena, T., K. Selvi, 2005) with the presence of TCSC, PSO algorithm for optimized playback on with the aim to minimize the congestion charge has been used. In this reference, TCSC in line performance and high-density installation of the two models (without the data-sharing market and bilateral market-sharing with mutual agreement) is analyzed. The results show that presented method can effectively change in density with the minimum production cost and minimum density, improve. The results also indicate that in some cases due to TCSC line installation cost, cost, density is increased.

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Effective in congestion management, optimal placement FACTS devices in the network is the power of reference (Gitizadeh, M., M. Kalantar, 2008) placement optimal TCSC and SVC in a IEEE 14 bus standard system evaluated the results shows the line density to eliminate condensation and voltage profile is improved. Also in Reference (Barati, H., 2006) the optimal placement UPFC using genetic algorithm evaluated the results of UPFC placement showed reduced production cost, cost, density, improved density lines and Profiles is the voltage. The reference genetic algorithm placement UPFC for congestion management market is shared use. In reference (Kazemi, A., R. Sharifi, 2006) the optimal placement TCPS using criteria based on real power in the market for the management of shared and mutual density is taken into consideration. In this reference system as the standard IEEE 30 bus system used and studied by MATLAB7.0 Programming was conducted and the maximum social welfare for selecting the best location of TCPS is considered.

In reference (Saravanan, M., 2006) one of the applications of PSO to identify the best location of FACTS devices to install minimum cost of FACTS devices has been paid. The temperature limit reference voltage lines and limit bus is considered. In reference 3 type FACTS devices the SVC, TCSC and UPFC used on the system IEEE 30 bus, IEEE 118 bus and IEEE 6 bus tested is. The results show that UPFC capacity is on the system but the high installation costs. TCSC installed in the minimum cost recovery system load capacity is better.

In reference (Shaheen, H.I., 2008) the best location of UPFC with the optimization parameters is analyzed. The reference PSO and genetic algorithms for achieving this goal has been used. Simulation system for the IEEE 6 bus and IEEE 14 bus is used. The results show that both algorithms for solving the problem of high quality, specifications and performance integration constant calculation, well have. The results also show that the PSO technique at the beginning of GA optimization is faster, but with increased production, genetic algorithm, the PSO is better. In terms of computing time of the PSO technique is faster than GA.

In reference (Barati, H., 2006) with the placement of power lines and congestion management as one of the newest generations of IPFC devices FACTS, IPFC has been done in the reference model and to simulate the injection of IEEE 6 bus is used. Results from the density of transmission lines, reducing active losses and congestion management in line are desirable.

Because of economic issues related to the IPFC as initial investment and operating costs, it is the best place to install it on the power grid to its ability to meet multiple objectives, maximum use. So in this article IPFC Placement Optimization using PSO algorithm on the IEEE 14 bus and IEEE 30 bus (Zimmermann, R.D., D. Gan, 2005) for Transmission congestion management in restructured power systems has been used.

Algorithm Method Birds Community:

Birds in the community position algorithm to record the motion of particles and their neighbors will change. Each particle is a position that we show with $\vec{x}_i(t)$ Shows that this position P_i st particle is the time t. In this algorithm each particle addition to the speed of a location is required:

$$\vec{v}_i(t) = \vec{x}_i(t) - \vec{x}_i(t-1) \tag{1}$$

Algorithm community with a group of birds random answers to start, then answer the problem by optimization problem with space to make deals to search generations. Each particle as multidimensional with two values that x_{id} and v_{id} respectively Referrals location and speed to the situation after d_{st} of my i are particle is defined.

At each stage of the population moves every particle with two values is the best to date. The first value, the best answer so far is in terms of competence for each particle separately obtained and this value is called p_best . Another best value by the algorithm is obtained social birds; the best value so far by all particles in the population has obtained the best overall value and g_best is called. After p_best and g_best by the amount and speed of each particle according to its new location in relationship to that:

$$\begin{aligned} v_{id}(t+1) = w.v_{id}(t) + c_1.rand(p\_best_{id} - x_{id}) + \\ c_2.rand(g\_best_d - x_{id}) \end{aligned} \tag{2}$$

$$x_{id}(t+1) = x_{id}(t) + v_{id}(t+1) \tag{3}$$

Top w in the relationship, weight, c_1 and c_2 factors, learning, and $rand$ a random number in the range (1, 0) is. To prevent algorithm divergence, the final value of each particle velocity is limited.

$$v_{id} \in [-v_{\max} \ , v_{\min}] \tag{4}$$

w, c_1 and c_2 of the algorithm parameters are social birds. And convergence is dependent value for this parameter. Here, the procedure is usually equal to c_1 and c_2 and the number 2.05 is assumed. Convergence strongly depends on the amount of w is better dynamic and must be defined. Thus, the linear trend in the evolution of population 0.4 to 0.9 decreases. Initially this number must be large as possible by good answers to provide early and late stages Small w causes a better convergence. This reduction in the related form can be defined.

$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{iter_{\max}} \times iter \tag{5}$$

This algorithm is the corresponding topology on. In this algorithm each particle movement relying on its experience and knowledge of all other particles is performed. Therefore, it is clear that the integrity of the community is many and complete communication is established between the particles.

The algorithm steps are:

1 - Basic population is formed randomly.
2 - Determine the competence of particles with their present position.
3 - Comparison of current competence and the best experiences of particles and their necessary replacement.
4 - Comparison of current competence of each particle's best previous result of all particles.
5 - Set the speed vector for each particle using the relationship 2.
6 - Move with their new positions related to particle 3.
7 - Return to step 2 and repeat the algorithm to reach convergence.

The Proposed Method Problem Solving:

FACTS devices include installation has two stages. First location in the network equipment should be specified and then control the device parameters for the desired goal should be optimal. Method first proposed standard system IEEE 14 bus to test on it and share the load chosen regardless of UPFC on the values and passing power lines we calculated. Then the effect of IPFC in all different places, IPFC based on the desired sensitivity Replacement and doing calculations, density lines with and without IPFC gain. Calculations performed with IPFC Replacement in many different places and algorithm PSO continued and finally the most optimal location of IPFC installation, we manage specific density. The above steps are performed on the system IEEE 30 bus.

To determine the best relationship 6 is a multiple function and define it as we choose the objective function. Therefore, the aim of obtaining the minimum objective function and the implementation of the algorithm is to remove congestion.In this regard, V_i , $\cos t$, $loss$ and TCC , respectively, bus voltage, the production cost, total mortality is density and cost. Coefficients α , β and γ coefficients also are coordinating with the $\cos t$ so:

$$\alpha = 36000,\ \beta = 900,\ \gamma = 16$$

$$f = \alpha \sum_{i=2}^{i=14} \left| (1.05 - V_i) - (0.95 - V_i) \right| + \cos t + \beta.loss + \gamma.TCC \tag{6}$$

$$C_i = \sum_{i=1}^{N_g} C_{gi}.P_{gi} \tag{7}$$

$$TCC = \sum_{i-1}^{Nb} P_i^D \lambda_i - \sum_{i=1}^{Nb} P_i^G \lambda_i \tag{8}$$

Ties 7 and 8 respectively to relations of production and total cost of congestion costs are (Barati, H., 2006). In addition to the above relations, limitations and constraints related to the bus voltage and active power productions as well as nine are defined relationship.

$$P_{gi}^{\min} \le P_{gi} \le P_{gi}^{\max}\ ,\ V_i^{\min} \le V_i \le V_i^{\max} \tag{9}$$

The constraints and limitations of the IPFC control parameters are considered as follows:

$$\begin{aligned} V_{se1}^{\min} \le V_{se1} \le V_{se1}^{\max} \quad &, \quad \delta_{se1}^{\min} \le \delta_{se1} \le \delta_{se1}^{\max} \\ V_{se2}^{\min} \le V_{se2} \le V_{se2}^{\max} \quad &, \quad \delta_{se2}^{\min} \le \delta_{se2} \le \delta_{se2}^{\max} \end{aligned} \tag{10}$$

IPFC Model Used In The Algorithm Implementation:

IPFC combinations of two or more static synchronous series, which is compensated by a dc interface pair are together, the real power flow between the terminals of the SSSC are easy.

Independent control of reactive power to compensate for real power flow in each line, and set the optimal distribution of the lines is preserved. Figure 1 Schematic IPFC, based on two VSC converters and interface with a DC voltage that a capacitor can be shown (Barati, H., 2006). Injection model of IPFC is shown in Figure 2 can be used extensively in research and studies on the impact of the IPFC is in the system. Therefore this model to simulate the performance of the algorithm is used.

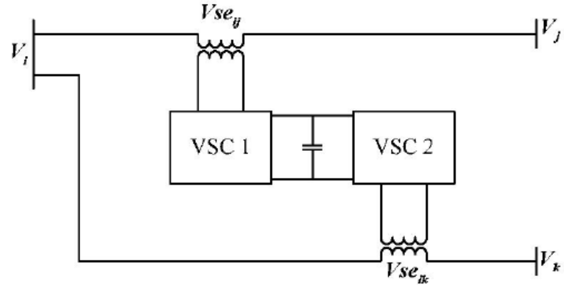

Fig. 1: Schematic IPFC with two converters.

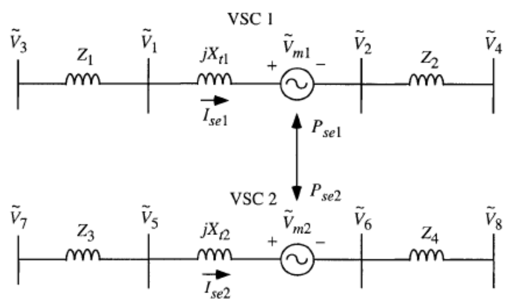

Fig. 2: Power injection model of IPFC.

In the analysis of power systems is usually lines are simulations with the model π . Circuit transmission lines with IPFC are shown in Figure 3. Also in Figure 4, the injection lines embedded with IPFC is shown.

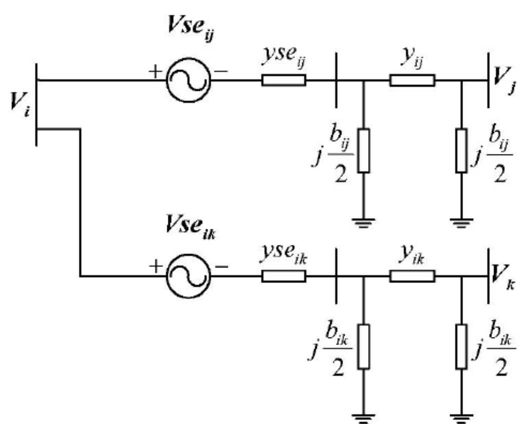

Fig. 3: Equivalent circuit transmission lines with IPFC.

Relations used in the model according to Figure 2 are:

$$P_{sh} = -V_i V_{sh} \sin(\theta_i - \delta_{sh}) / X_{t1} \tag{11}$$

$$Q_{sh} = V_i \left(V_{sh} \cos(\theta_i - \delta_{sh}) - V_i\right) / X_{t1} \tag{12}$$

$$P_{to} = V_j \left(V_{se} \sin(\theta_j - \delta_{se}) - V_i \sin(\theta_j - \theta_i)\right) / X_{t2} \tag{13}$$

$$Q_{to} = -V_j\left(V_j - V_i\cos(\theta_j - \theta_i)\right) + V_{se}\cos(\theta_j - \delta_{se}) / X_{t2} \quad (14)$$

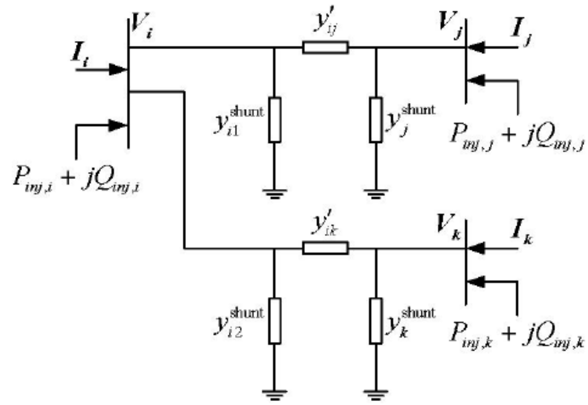

Fig. 4: The injection lines Transmission with IPFC.

On the linear series voltage sources are connected to it, be active and reactive to reach the second bus, from 15 to 18 are achieved through relationships.

$$P_{to1} = V_2\left(V_{m1}\sin(\theta_2 - \alpha_1) - V_1\sin(\theta_2 - \theta_1)\right) / X_{t1} \quad (15)$$

$$Q_{to1} = -V_2\left(V_2 - V_1\cos(\theta_2 - \theta_1) + V_{m1}\cos(\theta_2 - \alpha_1)\right) / X_{t1} \quad (16)$$

$$P_{to2} = V_6\left(V_{m2}\sin(\theta_6 - \alpha_2) - V_5\sin(\theta_6 - \theta_5)\right) / X_{t2} \quad (17)$$

$$Q_{to2} = -V_6\left(V_6 - V_5\cos(\theta_6 - \theta_5) + V_{m2}\cos(\theta_6 - \alpha_6)\right) / X_{t2} \quad (18)$$

Any population structure in the implementation of the PSO algorithm is shown in Figure 5. Based on the length of a population that is 7 Location IPFC placement represent and also show parameters IPFC.

bus_i	bus_{j1}	bus_{j2}	V_{se1}	V_{se2}	δ_{se1}	δ_{se2}

Fig. 5: Structure of each population.

LMP in the calculation to this point is that the buses that the generator is installed if the cost is $P^{\min}\langle P\langle P^{\max}$ generators operating in the proposed set of LMP but when $P \geq P^{\max}$ or $P \leq P^{\min}$ is LMP is determined by the system. So the buses 1, 2, 3 and 8 are $P^{\min}\langle P\langle P^{\max}$. The proposed cost of generators is the decisive factor LMP (LMP1=35, LMP2=35, LMP3=38 and LMP8=45). But because there is no production in the generator $G_6\,.\,(P_{G6} = 0)$ and $P_6 \leq P_6^{\min}$. Thus, the system will determine the amount of LMP (In the first case $LMP_6 = 39.734$ and in the second case $LMP_6 = 35.759$).

Now considering the above relations, distribution of samples on the system and results based on the power lines crossing between then obtained by considering the density values using the algorithm lines PSO, placement optimal IPFC and optimized for playback on obtaining the best location of IPFC in terms of density delete lines continued.

Results And Discussions On The System Studied:

Two systems, IEEE 14 bus and IEEE 30 bus, the problem have been studied.

IEEE 14 Bus System:

IEEE 14 bus system (Figure 6), including 5 generators, 11 loads, 17 Transmission line and 3 lines is a Modifier. Method presented in two cases has been reviewed:

In the first case: the system without IPFC and the line density isn't limited.

Second case: In this mode density limit for 80MW lines there. The IPFC is added to the system.

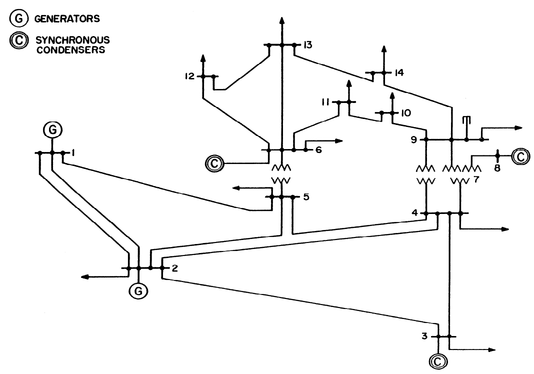

Fig. 6: Sample system used (IEEE 14 bus).

Cost function coefficients and proposed sale of energy is shown in Table 1. Value of each generator power production is given in Table 2 is noted as being expensive because of any purchase of generator 6 has been done. LMP values in Table 3 for all buses is given in Table 4 and the IPFC and linear parameters which must be exposed is shown in Table 5 of the algorithm implemented general information shown is.

Table 1: Cost function coefficients and proposed energy sales.

Bus No.	α	β	γ	Bid ($/MWh)	P_{max}	P_{min}
1	0	20	0.04743	36	332	0
2	0	20	0.2391	36	140	0
3	0	35.4	0.037	38	100	0
6	0	40	0.02	60	100	0
8	0	35	0.03	40	100	0

Table 2: The rate of production power generators.

Bus No.	The active powers generators in case 1	The active powers generators in case 2
1	194.33	190.64
2	36.72	36.720
3	28.74	29.42
6	0	0
8	8.5	8.45

Table 3: values of local price limit.

Bus No.	LMP in case 1	LMP in case 2
1	35	35
2	36	36
3	38	38
4	40.190	37.15
5	39.661	38.023
6	39.734	36.40
7	40.172	37.14
8	40	40
9	40.166	37.291
10	40.318	37.198
11	40.155	38.02
12	40.379	38.11
13	40.575	37.212
14	40.198	38.012

Table 4: parameters IPFC.

IPFC installed	Line 2-4 & Line 2-1
V_{se1}	0.23
V_{se2}	0.14
δ_{se1}	35
δ_{se2}	76

Table 5: General Information results from algorithm implementation.

General Information	Case 1	Case 2
Total loss	9.255	6.198
Total generation	268.255	265.21
Total congestion charge	527	329
Total generation cost	8081.10	7694.39
Numeric value function f	32120	30947
Power flow in line 1-2	129.524	78.441

According to Table 5 in the line density value of 1-2 MW 78.441 rate density has reached resolve this line indicates. Can have more lines are passing normal.

Total cost congestion charge mode 1, 527 Dollars per hour now and in the case of 2, 329 Dollars per hour is obtained on the density of spending reduction represents mode 2 is the total amount of production cost in case 1, 8081.1 Dollars per hour is the amount specified, but the IPFC mode 2 is used to value 7694.39 dollars per hour is reduced while the amount of total loss rate of 3 MW in case 2 is reduced. The best location of IPFC line 2-4 and 2-1 has been determined. According to Table 3, LMP has been a steady decrease in the latter. This shows that the increase in social welfare.

IEEE 30 Bus System:

IEEE 14 bus system (Figure 7), including 6 generators, 20 loads, 41 Transmission line is.

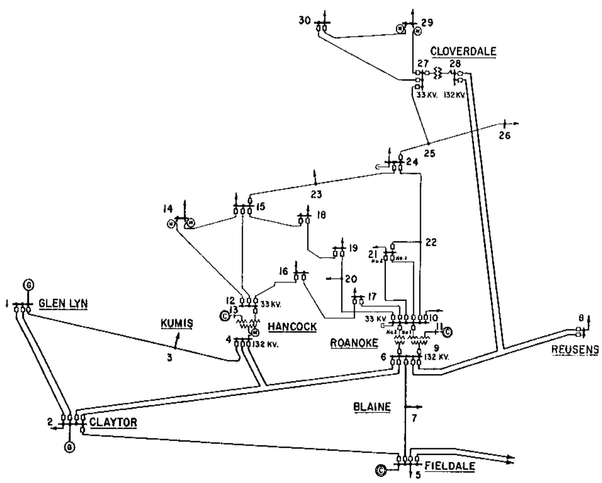

Fig. 7: Sample system used (IEEE 30 bus).

To demonstrate the effect of IPFC on congestion management, 2 are compared.

Mode 1: OPF without IPFC and No restrictions.

Mode 2: OPF with IPFC with 60 MW of power transfer limits.

To obtain the best performance of 50 independent parameters has been done. Problem results in tables 6 to 9 are shown.

Cost function coefficients and proposed sale of energy is shown in Table 6 Value of each generator power production is given in Table 7 is noted as being expensive because of any purchase of generator 2 has been done.

If the 60 MW power through transmission lines to be considered, Note that the line passing through the power of 1-2 MW 62/965 is calculated, so the congestion is created.

But after running the algorithm in case 2, the power transmission line 1-2 to reach the 54/86 MW that shows that the congestion in this line has been eliminated.

Table 6: Cost function coefficients and proposed energy sales.

Bus No.	α	β	γ	Bid ($/MWh)	P_{max}	P_{min}
1	100	2	0.02	4	90	0
2	100	10.75	0.0175	10	90	0
13	100	3	0.025	4	40	0
22	100	1	0.0625	6	50	0
23	100	3	0.025	4	30	0
27	100	3.25	0.00834	5	55	0

Table 7: The rate of production power generators.

Bus No.	The active powers generators in case 1	The active powers generators in case 2
1	85.00	86.58
2	00.00	00.00
13	40.00	40.00
22	45.98	47.432
23	30.00	27.119
27	55.00	54.42

Table 8: General Information results from algorithm implementation.

General Information	Case 1	Case 2
Total loss	5.026	4.620
Total generation	250.984	255.551
Total congestion charge	384	318
Total generation cost	1469.3	1402.9
Numeric value function f	5788	5721
Power flow in line 1-2	62.965	54.86

Table 9: parameters IPFC

IPFC installed	Line 1-4 & Line 1-2
V_{se1}	0.18
V_{se2}	0.36
δ_{se1}	38.54
δ_{se2}	29.86

According to Table 8 the total amount of production cost in case 1, 1469.3 Dollars per hour is the amount specified, but the IPFC mode 2 is used to value 1409.2 dollars per hour is reduced. Also Total cost congestion charge mode 1, 384 Dollars per hour now and in the case of 2, 318 Dollars per hour is obtained on the density of spending reduction represents mode 2 is. The losses amount to a 0.4 MW is reduced. The best location of IPFC line 1-4 and 1-2 has been determined. IPFC parameters are expressed in Table 9.

Conclusion:

The results of the PSO algorithm for IEEE 14 bus and IEEE 30 bus shows that After running the PSO, the voltage profile is improved And there is no congestion in the lines. Also After running the algorithm, the total production cost, total congestion cost and the objective function value is reduced.

As a result, the congestion management method using FACTS devices, despite being expensive, these elements, given that the optimal use of these elements in terms of what type of equipment used and what the best location in terms of installation, eventually reduced cost to the consumer is. Because the convergence rate and reduce production costs and congestion, the IPFC and PSO algorithm for solving congestion and increase social welfare is a good way.

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