Place Finding and Optimizing the Determination of Production Units Dynamically for Providing the Electricity and Heat in Industrial City

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Abstract

In this article the place and capacity of combined heat and power [CHP] prediction unit was determined dynamically with use of modified particle swarm optimization (MPSO). It was done in optimization palace and with a capacity of CHP as a production resource with the aim to increase the reliability capacity. Decrease the loss and provide the electrical and thermal energies of industrial city. The function of the optimization to the interest of CHP usage was described on its cost. It was considered as the cost of investments, operation, and Repair and keeping the CHP units in the function. It was proposed that load distribution and limits of CHP production be seen as units' condition as optimization issue condition. The problem was described as dynamic programming and it was used based on the interests of programming and inflation annually in the determined and thermal energies' price. The simulation results show the positive effects of CHP units in the electrical energy production of industrial city.

Keywords: optimize place finding, combined heat and power [CHP] prediction, the modified particle swarm optimization (MPSO), loss decrease, the interest to cost ratio.

1- Introduction

The reconstruction in electricity industry has led to the increase of interests to the use of diverse resources. These units are used with different aims such as the loss decrease, the improvement of voltage profile, the increase of trust, the procrastination of fceder's investments, and etc. The units have high yield. For example, one gas power plant has 30-37% thermal efficiency and 40-50% energy destruction that CHP unit can reduce this high energy destruction [1-2]. Nowadays, a lot of countries as Finland, Australia and Switzerland use the CHP as production system in their heat power plants. The use of CHP in the industrial, administrative and settlement units has a major role in providing clean and cheap energy. With notice to the country policies about the clean and cheap energy production, the CHP can have efficient role in this situation. In the past different researches were carried out in the CHP units. We have mentioned some of them here in this article.

In [3], the CHP effects on the reliability capacity increase in micro structures were studied. It was calculated the index of morality sensitivity for per bus and used for optimize place selection for CHP. Also it was calculated the interest to cost ratio of CHP for owners, in [4] it was the place selection for CHP units with purposes of voltage profile improvement and the decrease of short bridge level. In [5] It was determined the optimize capacity of CHP units with the use of cost to interest index. In this research it was considered as the improvement the environmental conditions with the CHP effect on the loss decrease, energy saving, and increasing the reliability capacity. In [6] the reliability capacity and availability of CHP was mentioned. The place finding the wind turbines with use of CHP units as a strong intelligent algorithm has advantages to PSO in some of the optimization problems [8].

The use of PSO algorithm in solving finding of CHP units was proposed in [9-10]. In this article the place finding of optimized CHP units dynamically was researched along with the use of MPSO algorithm in one of the industrial cities. It was considered that the target function is a maximization of the interest to the costs of CHP. These interests include improvement of reliability capacity, loss decrease, electrical energy saving and thermal (heat) energy saving. The costs of CHP include the installation costs, usage, repair, and keeping costs are considered important. In the calculation of these costs, the costs were considered annually.

2- Proposed Method

Place and capacity of CHP units were obtained with maximization of target function. The production limits of CHP units and the distribution conditions were taken into consideration. The problems included the propriety of providing the electrical energy. This work was done because the surplus electricity can be sold and lead to income, while the produced heat must be use locally. The installation of units programs was thought to occur in the first year. To obtain the optimized answer, an MPSO algorithm was used. Below, we will explain this algorithm briefly.

MPSO algorithm was proposed for solving some of the recent PSO problems and researchers were attracted to it to make the discrimination between MPSO and PSO.

$$X_i(t+1) = X_i(t) + X_i(t+1) \tag{1}$$

$$V_{ij}(t+1) = w\,V_{ij}(t+1) + c_1 r_{1j}(pb_{ij} - X_{ij}(t)) + c_2 r_{2j}(gb_j - X_{ij}(t)) \tag{2}$$

$$X_{i+\frac{n}{3},j} = X_{ij}(t) + r(X_{\max.j} - X_{ij}(t)) \tag{3}$$

$$X_{k+\frac{n}{3},j} = X_{kj}(t) - r(X_{k.j} - X_{\min j}(t)) \tag{4}$$

Is the control manner of divers' population capable to inhibit the unusual convergence? Let the PSO algorithm to be selected with n particles randomly. In MPSO algorithm the one third of these particles was selected and two third of them were determined with Equations (3,4). Equations (3,4) were used in the usual PSO algorithm. In equations (1-4) the $j \in 1,2,\dots,d$ show the particles' dimensions. $i \in 1,2,\dots,n/3$, $k \in 1,2,\dots,n/3$ show the two third of n, n ؛X_{minj} and X_{maxj} show the minimum and maximum scales of jth article and r is the optional scale in the [0,1] interval.

The produced population was evaluated by target function. Then, one third of them were used for the next produced population considering g b and pbi.

The location and speed of ith particle was selected in population with PSO equation e.i. equations (1,2) were updated. On the other hand, the locations of two third of produced population was updated on the basis of (3) and (4). In MPSO, place searcher was controlled with r and this parameter changed linearly in [0, 1] interval. With the increase of search place and diverse population control, the algorithm inhibited convergence. In other works, the efficiency of search place increased and consequently inhibited from convergence of minimum points (ED).

For this, we describe the bands' locations as it is shown in the follows:

$$X_1 = [x_1, \ldots, x_k] \tag{5}$$

$$X_2 = [x'_1, \ldots, x'_m] \tag{6}$$

In these equations, the X1 Matrix is as '0' and '1'. This matrix shows the place of CHP installation. In this matrix, k shows the numbers of points through which CHP can be installed. The numbers of X2 matrix show CHP capacity. In this matrix, m is equal to '1' of X1 matrix, i.e. the numbers of CHP. Considering that the CHP installation place is a divided variable, todo its determination, we need to calculate a binary MPSO algorithm. PSO and MPSO are inherently continuous and must be modified for the divided index determination

. The difference between these binary and continuous types is their speed that description as probability and cause of one bit's change to zero or one. With the use of one description, the speed would be limited within [0,1] interval. Thus, one equation is used for all of the speeds in [0,1] interval.

The normalized function for speed function is sigmoid, as described in equation (7) .

$$V'_{ij} = sig(V_{ij}(t)) = \frac{1}{1+\exp(V_{ij}(t))} \tag{7}$$

And finally the new place of jth particle and ith population would be obtained as below:

$$x_{ij}(t+1) = \begin{cases} 1, \ r_{ij} < sig(V_{ij}(t+1)) \\ 0, \ otherwise \end{cases} \tag{8}$$

That r_{ij} is a random number in [0,1] interval. In figure 1 the flowchart of proposed algorithm has been shown. In this flowchart, the location of primary particles was selected randomly after determination of MPSO parameters. Then, for i^{th} year the electrical and thermal prices was calculated, considering interest scale and inflation of that year. After that, the interests and costs of CHP installation for that year were calculated. In the next stage, the location and speed of particles would be changed with g-best and p-best updating. This process continues until all the MPSO algorithm conditions are met and the situation that has the highest scale of interests to cost ratio is selected as the best answer of optimization for that year. This work is done for all of the years to horizon years (Nyear).

As described previously, the target function was explained according to the determination place and CHP's cost to interest ration. The CHP costs are considered as investment costs (IC), operation cost (OP), and maintenance cost (MC). The interests of the CHP units are the Reliability Improvement (RI), Power purchase saving (PPS), Heat purchase saving (HPS), and loss Reduction (LR). The target function is formulated as: 9-10-11

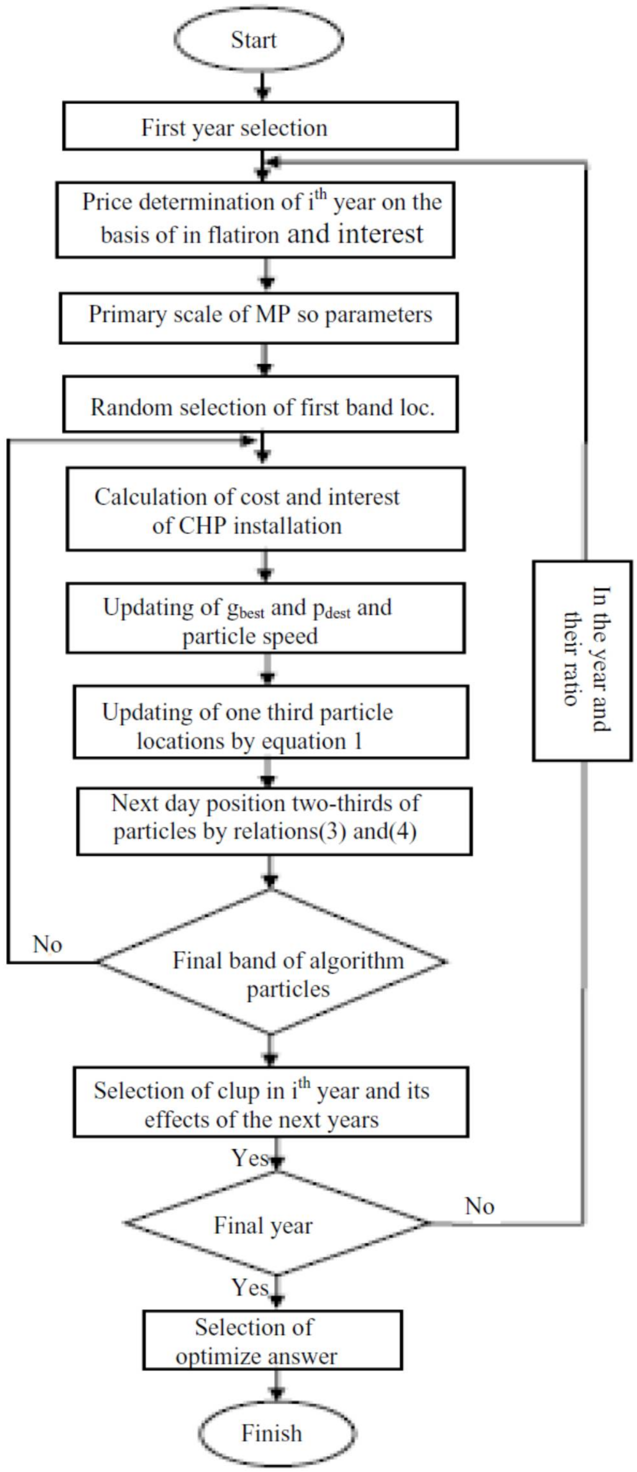

Fig.1. The flowchart of proposed algorithm

$$\text{Obj. func.} = \text{Max}\left\{\frac{\text{Benefit of CHP}}{\text{Cost of CHP}}\right\} \quad (9)$$

Befenit of CHP

$$= \sum_{n=1}^{N_{CHP}} \sum_{i=1}^{N_{year}} \left[\Delta RI_{n,i} + PPS_{n,i} + HPS_{n,i} + LR_{n,i}\right] \quad (10)$$

$$Cost.CHP = \sum_{n=1}^{N_{CHP}} IC_n + \sum_{i=1}^{N_{year}} \left(OC_{n,i} + MC_{n,i}\right) \quad (11)$$

2-1- The interest of CHP units

In this section, we propose the interests of CHP installation. The interests of Reliability Improvement (RI) CHP units can have positive effects on RI of distribution network if installed properly. If network is unavailable for the repair or other reasons, these units cause to provide parts of the network loads and improve the reliability of IR of the system, after CHP installation, described as follows:

$$RI = \sum_{i=1}^{N_{year}} IC_i - IC_i^{CHP} \quad (12)$$

In equation above, IC and IC^{CHP} are the annual costs of subscribers before and after the CHP installation, respectively.

Interest of power purchase saving (PPS):

Actually, PPS is the energy that must be purchased from higher networks, if there are no CHP units. If the price of energy purchase from higher network is equal to PEI in i^{th} year, the interest of PPS is equal to:

$$PPS = \sum\nolimits_{i=1}^{N_{year}} \sum\nolimits_{n=1}^{N_{CHP}} P_{i,n}^{CHP} \times PE_i \quad (13)$$

In this equation, Pi^{CHP} is the production power of CHP unit in i^{th} year with considering that the interest coefficient annually is BO the energy price in i^{th} year is as follow:

$$PE_i = PE_1 \times (1+\beta)^{i-1} \quad (14)$$

In above equation the PE_1 is the energy price in programmed year.

Interest of Heat Purchase saving (HPS):

HPs is the heat purchase saving provided other than CHP installation. If the Heat energy price in i^{th} year is equal to Phi, the following equation is obtained for HPS:

$$HPS = \sum\nolimits_{i=1}^{N_{year}} \sum\nolimits_{n=1}^{N_{CHP}} H_{i,n}^{CHP} \times PH_i \quad (15)$$

In above equation $T_{i,n}$ is the produced heat energy by n^{th} unit in i^{th} year. The yearly interest scale Phi is described as:

$$PH_i = PH_1 \times (1+\beta)^{i-1} \quad (16)$$

Interest of loss Reduction (LR):

Considering the proper CHP units installation, the electricity energy is used in place. So it reduces the power transmission from lines and this leads to the loss reduction. The interest of LR could be proposed from the following equation:

$$LR = \sum_{i=1}^{N_{year}} \left(P_{loss,i} - P_{loss,i}^{CHP}\right) \times PE_i \quad (17)$$

2-2- Problem conditions

In this study, the active reactive and recovery limitations of CHP units and load distribution are considered as problem conditions. These conditions are formulated as follow:

$$\mathrm{P_{min}} \leq \mathrm{P_n^{CHP}} \leq \mathrm{P_{max}} \quad (18)$$

$$\mathrm{q_{min}} \leq q_{\mathrm{n}}^{\mathrm{CHP}} \leq q_{\mathrm{max}} \quad (19)$$

$$\frac{P_n^{CHP}}{\sqrt{P_{CHPn}^2 + q_{CHPn}^2}} \geq PF^{min} \quad (20)$$

$$\mathrm{V_{min}} \leq \mathrm{V_i} \leq \mathrm{V_{max}} \quad (21)$$

$$\mathrm{P_G^{CHP}} + \mathrm{P_G^{UG}} = \mathrm{P_D} + \mathrm{P_{loss}} \quad (22)$$

$$\mathrm{Q_n^{CHP}} \leq k_{heat} P_n^{CHP} \quad (23)$$

In above equations, Q_n^{CHP} and k_{neat} are heat recovery coefficients in nth unit and the produced heat from that unit, respectively. P_G^{CHP}, P_C^{UG}, P_D and P_{loss} are the total produced electricity power by CHP units, total power purchased from higher networks, the total usage power of consumers and the total loss power, respectively. Vi, $V_{\min}, V_{\max}$ are allowed. $P_{\min}$ and $P_{\max}$ are the minimum and maximum active power produced from CHP, $g_{\max}$ and $g_{\min}$ are the maximum and minimum reactive power produced from CHP unit. And $PF^{\min}$ is the allowable power coefficient from nth unit.

3- Numerical Study

The proposed method was done in one of the industrial cities of Azerbaijan, named Besath industrial city. This city has above 10800 acres area and its first phase is constructing above 588 hectares area. Considering Azerbaijan local electricity as ministration's documents, this city demands to provide 100 MW in first phase. According the process results, this power will be provided in first phase from diverse resources.

The results are shown in table 1. The precast load determined with use of three methods of engineering, time series, and known load methods and the usage scale obtained from proposed algorithm. Also, according to studies, the share of this city from studied years was illustrated in table 2. By using precast average load first column and the industry share (table z), the precast load for every industry was obtained. In table 3 the total load of city is shown, i.e. total loads of total industry for the research year. In table 4, the precast results of heat loads from diverse industries of Besath Industrial city are shown.

In this study, 3 numbers on CHP units in the first phase of city were taken into consideration. Also CHPs from the Gas turbine were considered with maximum 4MW capacity. In the calculation of IR, It was considered that 4 loads were exiting.

According to simulation results, one CHP gas unit with TOMW capacity was proposed in 1396 for metal and steel industry.

Table.1. The results of load precast for first Phase of Besath industrial city

average	Known load	Time series	Technological and engineering	The name of industry
43/5	37/7	59/8	33/1	Metal and steel
28/6	25/2	31/6	29/0	Food industry
8/8	4/1	11/0	11/3	Loom industry
1/8	1/3	1/4	2/6	Wood and cellulose
31/7	34/4	33/9	26/7	Chemical industry
22/8	2/9	30/9	34/7	Non-metal inorganic
5/6	14/2	1/2	1/4	Electricity and electronic
1/3	0/0	1/9	1/9	Building Industry
0/8	2/4	0/0	0/0	Services
144/8	122/2	171/6	140/7	Total Industries

Table.2. The maximum share of usage load of industries in Besath Industrial city

Building	Power	Mineral	Chemical	Cellulose	Textile	food	Steel & Metal	year
%1/1	%0/7	%18/0	%19/8	%0/8	%6/4	%18/4	%34/8	1393
%1/0	%0/6	%16/2	%19/7	%0/7	%5/8	%17/2	%38/8	1394
%0/9	%0/6	%14/4	%16/9	%0/6	%5/2	%16/0	%42/9	1395
%0/8	%0/5	%12/7	%19/3	%0/6	%4/6	%14/6	%46/9	1396
%0/7	%0/4	%11/2	%19/0	%0/5	%4/0	%13/3	%50/9	1397
%0/6	%0/4	%9/7	%18/6	%0/4	%3/5	%11/9	%54/9	1398
%0/5	%0/3	%8/4	%18/1	%0/4	%3/0	%10/6	%58/7	1399
%0/4	%0/3	%7/2	%17/5	%0/3	%2/6	%9/3	%62/3	1400
%0/4	%0/3	%6/2	%16/8	%0/3	%2/2	%8/2	%65/7	1401

Table.3. The total electricity load prediction for different years

1401	1400	1399	1398	1397	1396	1395	1394	1393	year
210	200	185	160	145	55	45	30	15	Load

Table.4. The obtained results from heat load prediction for different industries in first phase of Besath

Building	Power	Mineral	Chemical	Cellulose	Textile	food	Steel & Metal	Industry
60	140	100	120	30	30	45	100	Thermal load

One unit of 40MW in 1397 for chemical industry and one unit were suggested in 1399 for food industry. After these unit installations, the total load of this city would be 210MW in 1901 and total loss decrease would be equal to 20/5%. In figure 3, the diagram of losses in studied years after and before CHP units' installation was shown. In figure 4 the produced energy by CHP units and provided energy from higher networks for different years were shown. From this figure, it was concluded that with load increase, the load provided by CHP is cheaper than that purchased from higher networks.

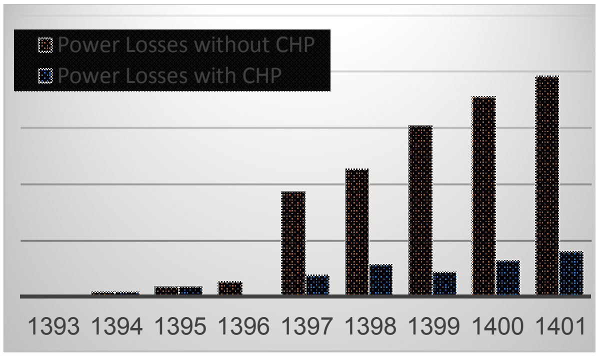

Fig.3. Relatire loss in research years after and before CHP units' installation

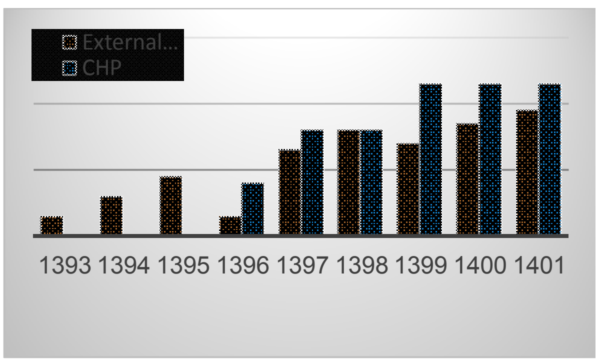

Fig.4. The total provided power from higher network and CHP units in the research years.

4- Conclusion

In this study, it was determined how to optimize Size (capacity) and place of CHP units dynamically in one of the industrial cities. For resolving the optimization problem, MPSO algorithm was used as one of the strong intelligent algorithms. The target function was considered as the interest to cost ratio of CHP. The interest of CHP includes the Reliability interest, power purchase saving and Heat power purchase saving and Heat Power purchase saving and loss reduction. The costs of CHP include the investment, operation, maintained cost. The simulation results showed the improvement of network situation after CHP installation.

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