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Research Article

OPTIMIZING POWER GRID BY PARTICLE SWARM IN 8 MODELS

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ABSTRACT
In today's power grids, optimization is particularly important in many respects. Power grids are optimized to reduce the rate of loss, improve the voltage profile, enhance the rate of reliability, reduce the costs, etc. One of the major features should be optimally regarded is the position of grid components, including distribution substations (posts), new power supplies and transmission lines. Since the majority of loads are industrial and a good planning considerably impacts cost reduction, this is more important in industrial parks. This research studies the process of modeling and optimizing theses grids. To do this, eight different states were used for the technique of multidimensional particle swarm optimization (MD PSO).

Keywords: *Power Grid, Optimization, Genetic Algorithm, Particle Swarm Optimization*

INTRODUCTION
Introduction
The methods of planning for developing and locating the distribution substations are different regarding the matter of automatically locating the new systems (Lee *et al.*, 1995). They are mostly incapable of automatically locating the new substations and just choose the new ones among the user's options. Furthermore, the geographical situation of supply centers is considered in certain coordinate, regardless of the case in which there is no load (when load is anticipated). They are mostly incapable of automatically locating the new substations and just choose the new ones among the user's options (Lo *et al.*, 1996).
To seek for an optimum model comparing with multidimensional optimization method, this research is aimed at studying an optimum model in Golestan Industrial Park, Yazd. Accordingly, to compare the three techniques of Particle Swarm Optimization (PSO), Modified Particle Swarm Optimization (MPSO) and Genetic Algorithm (GA), eight different states of existing limitations were tested based on consumption, load, geographical place, etc. and established on the results of each phase. The quality and accuracy of this technique was finally tested in this sample.

MATERIALS AND METHODS
Methodology
In this research, location, capacity and the area of optimally servicing the distribution substation in a long-term period were studied using the static, sequential and quasi-dynamic methods. Here, a comprehensive cost function has been presented for optimally locating distribution substations and technical restrictions and economic parameters in the process of modeling have been carefully considered.
Since it is too difficult to thoroughly consider a distribution grid (including feeders, distribution transformers, conductors, as well as super distribution a substation in a fairly big area (cities), downstream grid (distribution) is dealt with as areas with demands at their center of gravities. Demands are determined by load anticipation at mentioned areas.
In this model, the main goal is to keep the cost of proposed model for the new grid to a minimum. The model costs include construction, installation and maintenance costs for new substations, construction and maintenance costs for new transmission lines and the cost of energy losses. The target function is as follow:

$$f = f_1 + f_2 + f_3 + f_4 \qquad (1)$$

where f_1 is the construction cost for a new substation, f_2 is the maintenance cost for the new and existing substations, f_3 is the cost of energy losses, and f_4 is the construction and maintenance cost for lines. Equations 2.2 to 2.5 express the pertinent relationships.
Construction cost for a new substation:

$$f_1 = \sum_{i=1}^{N_{P_{new}}} C_{np} P_{n_i} \qquad (2)$$

where P_{ni} is the supplied load by the new substation i and C_{np} is construction cost for the new substation. Costs are calculated as a fixed coefficient multiplied by exponent. Although construction cost is discrete, namely the number of substations with settled power is limited in the market; the cost of each substation is proportionate to its power. Therefore, this formula is predominantly used. N_{Pnew} indicates the number of new substations and f_2 is the maintenance cost for new and cold substations.

$$f_2 = \sum_{i=1}^{N_P} C_{mp} P_i \qquad (3)$$

where P_i is the supplied load by new and old substation i, C_{mp} is the maintenance cost for substations (new or old) and NP is the total number of new and old substations.
f_3 is the cost of energy losses and it is as follow:

$$f_3 = \sum_{i=1}^{N_P} \sum_{j=1}^{N_c} C_{loss} R_{i,j}\ l(i,j) I_j^2 \qquad (4)$$

L(i,j) is the length of line between i and the consumer j, N_c is the number of consumers, C_{loss} is the cost of losses, $R_{i,j}$ is the line resistance between the substation i and the consumer j, and .I_j^2 is the squared electric load flow j.
f_4 is the construction and maintenance cost for lines as follow:

$$f_4 = \sum_{i=1}^{N_c} (C_{ml} + C_{nl}) \sum_{j=1}^{N_c} l(i,j) \qquad (5)$$

where C_{ml} is the maintenance cost for transmission line (new or old) and C_{nl} is the construction cost for the new transmission line.
In the proposed model, a requirement should be defined for supplying the needed load. Therefore, the delivered load from a substation should not be lower than the total load needed for the connected consumers:

$$\forall i \in [1, N_P] P_i \geq \sum_{j=1}^{Nc} L_{c_j} n(i,j) \qquad (6)$$

where L_{c_j} is the needed load for consumer j. If j is not connected to i, it will be 0 and it will be 1, if it is connected. If the above requirement is not met, a fine coefficient (high) is added to the target function.
Now there is a conditional optimization in which its cost function is equation 1 and its requirement is equation 6. To do this, three methods are employed that we will refer to them in the next section.

RESULTS AND DISCUSSION

Results

To optimize the cost reduction model in chosen industrial park, eight limiting factors are added to the method of multiple-cluster particle swarm in order to compare the results of each phase.

First Limitation

The first goal is optimally locating the super distribution substation with fixed power supply. The major goal is minimizing the cost of proposed model for the new grid in the next period. The costs include construction, installation and maintenance costs for new substations, construction and maintenance costs

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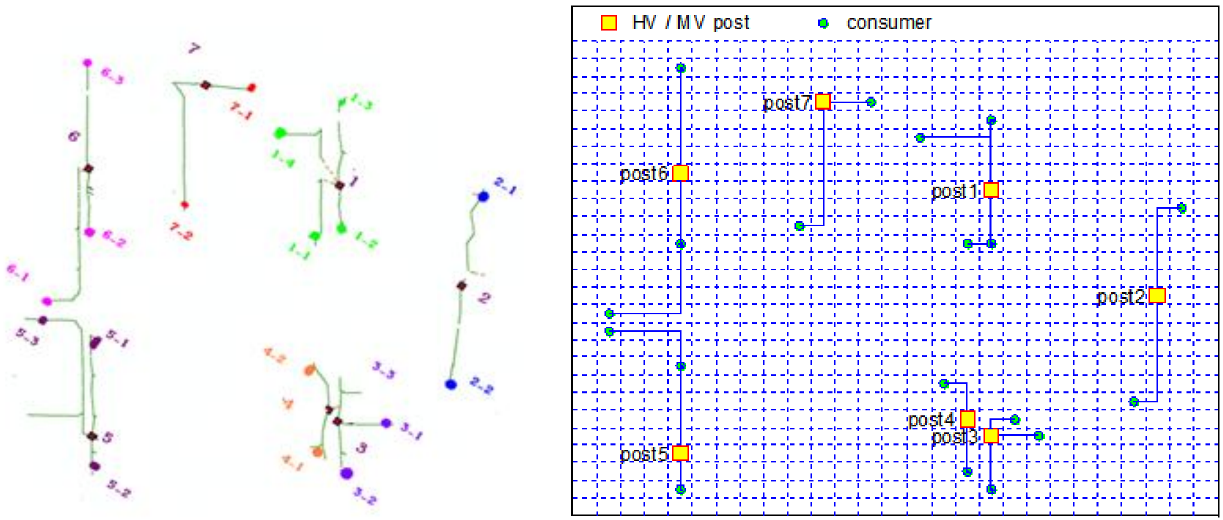
for new transmission lines and the cost of energy losses. About 25 percent of substation power is retained as standby power. Therefore, if the total connected load is higher than 75 percent of substation power, a fine coefficient (lower than the previous state) is added to the target function. Figure 1A illustrates a real image for top view of grid. The grid has seven substations and the connected loads have been separately numbered and divided. For a simpler modeling, distances between points were separated. Finally the grid was depicted in figure 1 to implement the given problem.



A. **B.**

Figure 1: A real grid: A: top view of the real image; B: with discrete distances

In the first step, it is assumed that the connected loads to substation 7 are absent and the goal is to locate and define the power and the way of connecting other loads to substations. Loads are connected to the substations by straight lines.

Tables 1 and 2 present the demanded load for power supply and the delivered load of existing substations (unit of power is kilowatt).

Table 1: Needed load for power supplies

Load Number	1-1	1-2	1-3	1-4	2-1	2-2	3-1	3-2	3-3
Load Power	78.2	84.7	33.2	33.2	42	36.1	45	47.4	41.5
Load Number	4-1	4-2	5-1	5-2	5-3	6-1	6-2	6-3	
Load Power	36.7	54.5	27.8	13.6	31.4	46.2	22.5	43.2	

Table 2: Delivered load for existing substations

Load Number	1	2	3	4	5	6
Load Power	315	250	200	315	200	200

Parameters for cost coefficients are presented in table 3. The unit of final costs is in 10,000 Tomans.

Table 3: Cost coefficients

Cost Coefficient	C_{np}	C_{mp}	C_{ml}	C_{nl}	C_{loss}
Coefficient Value	10	2	5	10	3000

The unit of length is in 25 meters and the unit of line resistance per each unit of length is in 0.01Ω. In optimization problem, x,y coordinate system for a new substation, delivered power and the location of connected substation to each power supply should be found. In this model, it is supposed that each power supply is directly connected to its substation. The transmission line is as a straight line from substation to power supply. In the table 4 parameters of MPSO containing C1, C2 and C3 and their values are shown.

Table 4: Parameters of MPSO

Parameters	**Values**
C1	2
C2	2
C3	0.5
Number of algorithm iterations	650
Number of clusters	3
Number of particles in each cluster	50

Figure 2 presents a diagram showing convergence in minimum cost of sequential iterations of MPSO algorithm. Optimum result was found before iteration 220. Algorithm is then reached convergence. Results have been shown in table 5.

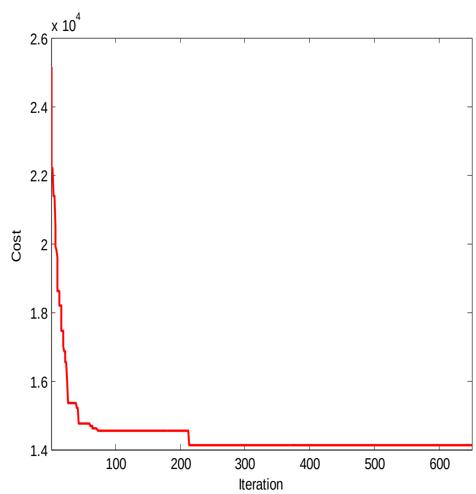


Figure 2: A diagram showing convergence in the minimum cost of sequential iterations for MPSO

Table 5: Results of optimization by MPSO

Xpn	Ypn	Pn	-1 1	-2 1	-3 1	-4 1	-2 2	-1 2	-1 3	-2 3	-3 3	-1 4	-2 4	-1 5	-2 5	-3 5	-1 6	-2 6	-3 6
2	11	104	1	1	1	1	2	2	3	3	3	4	4	5	5	7	7	6	6

The proposed grid by MPSO algorithm based on the results of table 5 is as what has been shown in figure 3. The optimum cost is 14,115 and the running time is 165. In this grid, the new substation is placed in area (2, 11) with delivered power of 104 units and the power supply 5-3 and 6-1 connected to it.

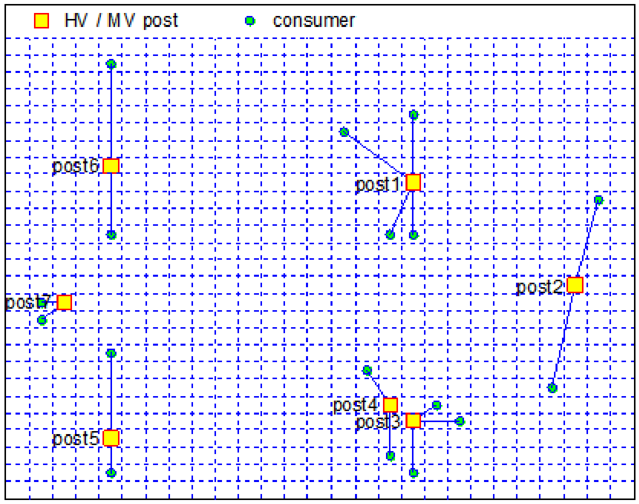


Figure 3: Proposed grid for MPSO algorithm

Second Limitation

In the second model, in addition to locating and arranging the power of new substation (post), it is assumed that several power supplies had been added to the industrial park for the next period. Each power supply announces its needed power. The design is aimed at properly locating the new substation, the new power supplies and the structure of transmission grid in between substations and power supplies. The primary grid is assumed as pervious examples. It is presumed that a substation and two new power supplies are to be constructed in the next period. Cost function would be as cost function of model 1.

Model 2 is optimized with multi population PSO. Location vector is thus defined as in model 1 except that four new elements for x and y coordinates, two new power supplies (the last two elements of location vector) and two new elements for connected substations are added to the new power supplies. Therefore, the location vector of particles has 26 dimensions. Figure 4 indicates convergence diagram for minimum cost in sequential iterations of MPSO for model 2. Optimum response was found before iteration 250. Algorithm then gained its convergence. Results are presented in table 6.

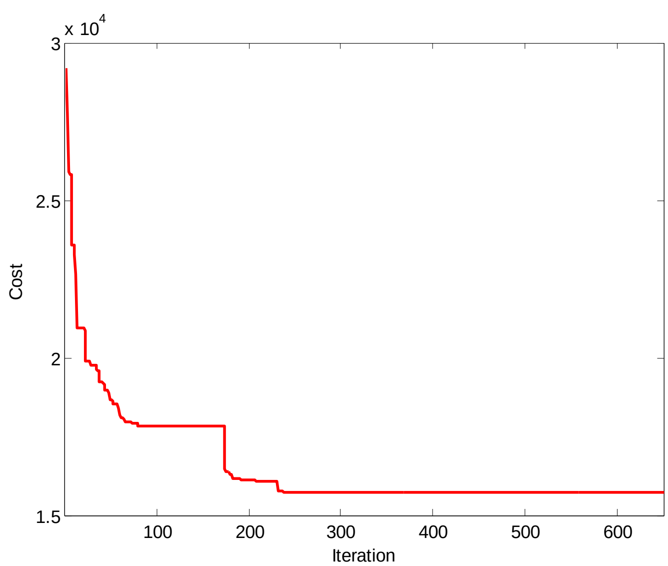


Figure 4: A diagram showing convergence in minimum cost of sequential iterations for MPSO in model 2

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Table 6: The results of optimization by MPSO

Xpn	Ypn	Pn	XI 7-1	XI 7-2	YI 7-1	YI 7-2	1-1	2-1	3-1	4-1	2-2	1-2	1-3	2-3	3-3	1-4	2-4	1-5	2-5	3-5	1-6	2-6	3-6	7-1	7-2
26	17	49	15	18	5	8	1	1	1	6	2	7	3	3	4	3	4	5	5	5	6	6	6	4	1

Proposed grid by MPSO and model 2, based on the results of table 6, is as what has been shown in figure 5. The optimum cost is 15,708 and the running time is 160. In this grid, the new substation is placed in area (26, 17) with delivered power of 49 units and the power supply 2-1 connected to it. The new power supplies are placed in area (15, 5) and (18, 8); one of them connected to the substation 4 and the other one to the substation 1.

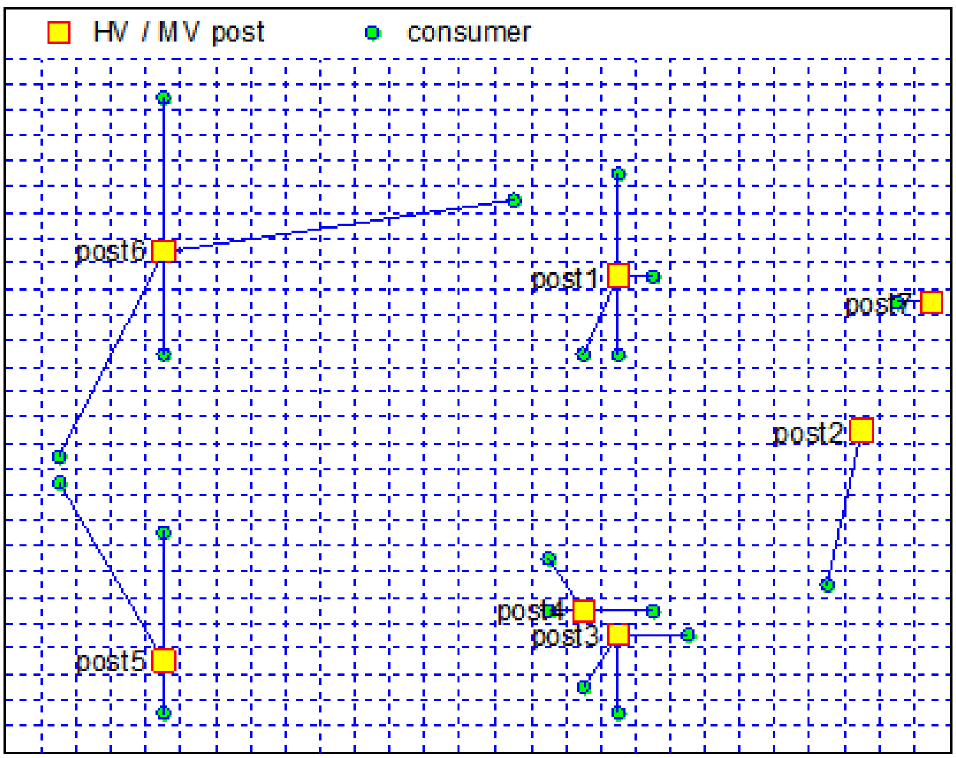

Figure 5: Proposed grid per MPSO and model 2

The result is not optimum because each new power supply can be located nearer to the given substation without any limitation. This freedom is not true in real time and some restrictions should be considered. This would be done in the next models.

Third Limitation

In another model, in addition to location of the new substation (level of power) and new power supplies, geographical information of GIS data should be studied. A summary of this information is clear for each zone in industrial park. Based on geographical differences such as soil, plant, land price, etc., in different regions, different rates of cost should be calculated for construction of substation or power supply. Figure 6 presents geographical cost factors considered for each zone.

Geographical Cost Factors

9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
5	5	5	5	5	5	5	5	5	5	1	5	1	5	5	5	5	5	5	5	5	5	5	5	5	5	5
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	1	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	5	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
9	9	9	5	5	9	9	9	9	9	9	9	9	9	9	9	5	5	9	9	9	9	9	9	5	9	9

Figure 6: Geographical cost factors considered for each zone

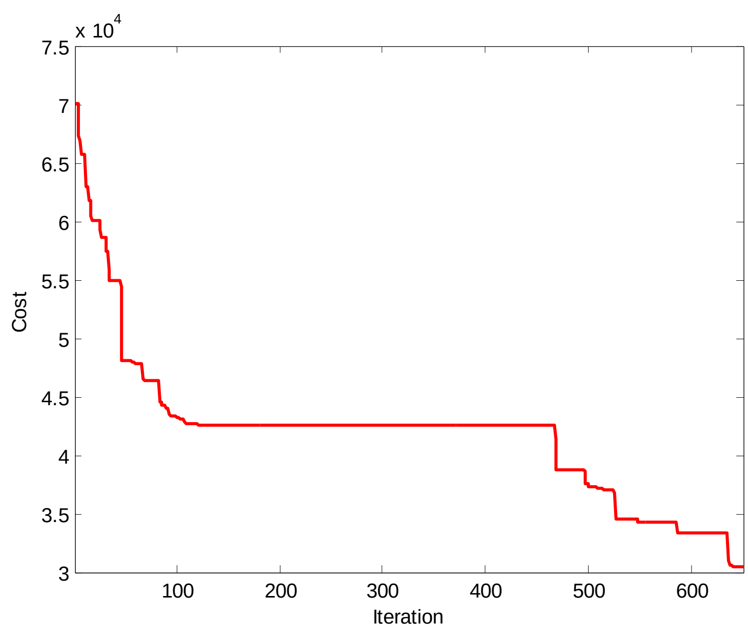

Figure 7: Convergence diagram for minimum cost in sequential iterations for MPSO in model 3

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To prevent installation of new plant in current site, a high cost factor is estimated for current occupied zones and added to geographical factor.

Model 3 is defined by multi population PSO. So location vector is defined in the same way as in model 2. A requirement, including geographical and occupation factors, is added to the problem. Convergence diagram for minimum cost in sequential iterations of MPSO is shown in figure 7 for model 3. Table 7 shows the results.

Table 7: Results of optimizing model 3 by MPSO

Xpn	Ypn	Pn	XI 7-1	XI 7-2	YI 7-1	YI 7-2	1-1	2-1	3-1	4-1	2-2	1-2	1-3	2-3	3-3	1-4	2-4	1-5	2-5	3-5	1-6	2-6	3-6	7-1	7-2
3	12	171	9	9	16	16	1	1	1	6	2	2	3	4	3	3	4	7	5	7	7	7	6	6	1

Proposed grid by model 3, based on the results of table 2, is as what has been shown in figure 8. The optimum cost is 30476 and the running time is 163. In this grid, the new substation is placed in area (3, 12) with delivered power of 171 units and the power supplies 5-1, 5-3, 6-1 and 6-2 connected to it. The two new power supplies are placed in area (9, 16); one of them connected to the substation 6 and the other one to the substation 1.

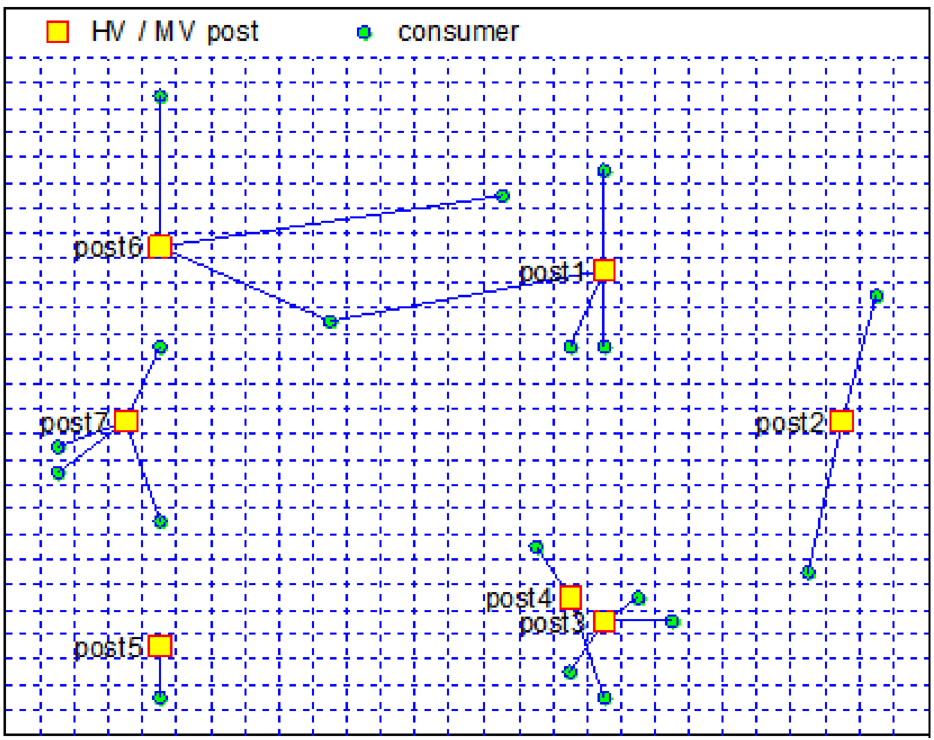

Figure 8: Proposed grid per model 3 and MPSO

Forth Limitation

Looking at fuzzy load, the fourth model was developed. As the required loads for a power supply are not defined for the next period, uncertainty of such quantity is considered based on the concept of fuzzy variables. The requirement for supplying loads is thus expanded. This means that in defining the delivered loads by substation, the uncertainty of connected loads should be examined. A triangular fuzzy load is as

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in figure 9 in which the central number is the anticipated loads for power supply in previous models. The bottom numbers show uncertainty of the defined values. The delivered load should not be lower than the total of maximum uncertainties of connected loads. Being excessively higher than minimums, they include lower risk-taking and higher loss of cost.

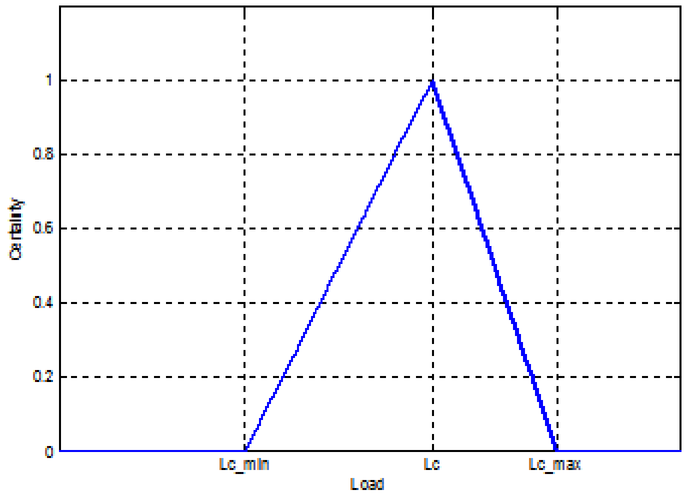

Figure 9: Triangular fuzzy load

Triangular fuzzy load is symmetrically taken and maximum and minimum uncertainties are considered in a distance of one tenth from the central load.
Model 4 is defined by multi population PSO. So location vector is defined in the same way as in model 3. A requirement, including geographical and occupation factors, and a requirement for delivered loads by substations are seen regarding the maximum and minimum fuzzy loads connected to them. Convergence diagram for minimum cost in sequential iterations of MPSO is shown in figure 10 for model 4. Optimum response was found before the iteration 300. Algorithm then gained its convergence. Table 8 shows the results.

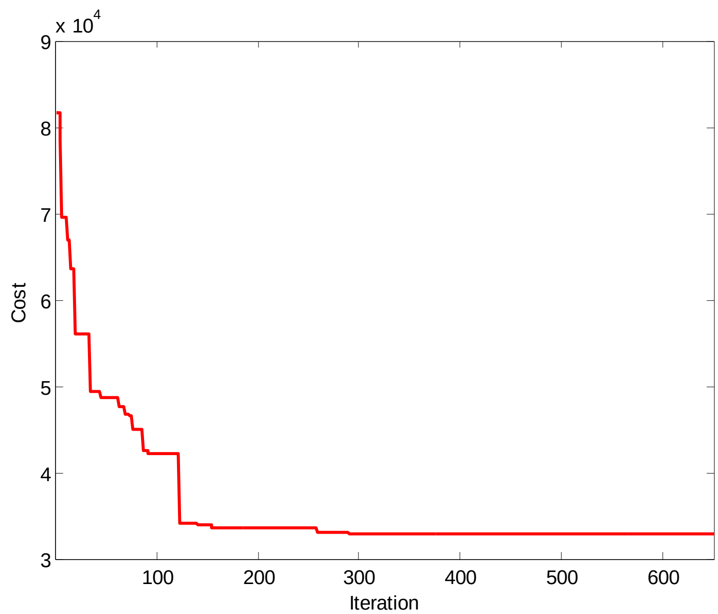

Figure 10: Convergence diagram for minimum cost in sequential iterations for MPSO in model 4

Table 8: Results of optimizing model 4 by MPSO

Xpn	Ypn	Pn	XI 7-1	XI 7-2	YI 7-1	YI 7-2	1-1	2-1	3-1	4-1	2-2	1-2	1-3	2-3	3-3	1-4	2-4	1-5	2-5	3-5	1-6	2-6	3-6	7-1	7-2
12	23	300	10	10	23	23	1	7	1	7	2	2	3	3	1	3	4	5	5	5	6	6	7	7	7

Proposed grid by model 4 and MPSO, based on the results of table 9, is as what has been shown in figure 11. The optimum cost is 32,979 and the running time is 182.
In this grid, the new substation is placed in area (12, 23) with delivered power of 300 units and the power supplies 1-2, 1-4, and 6-3 connected to it. The two new power supplies are placed in area (10, 23).

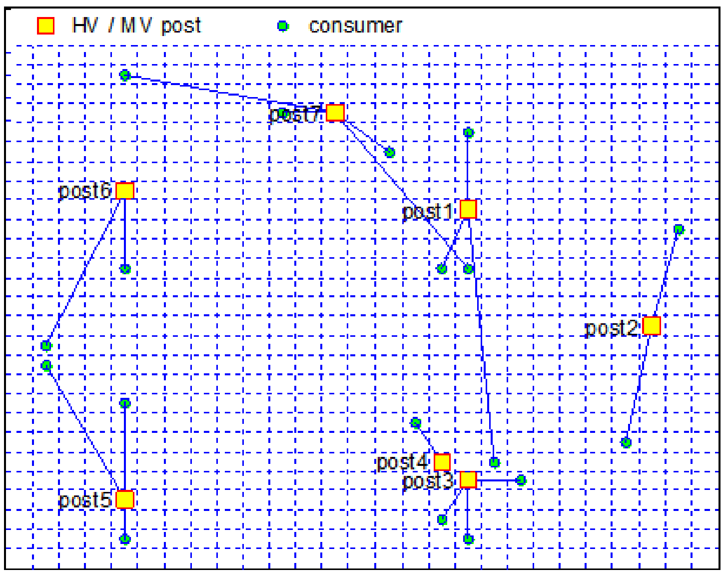

Figure 11: Proposed grid per model 4 and MPSO

Fifth Limitation
Looking at Gaussian fuzzy load, the fifth model was developed.

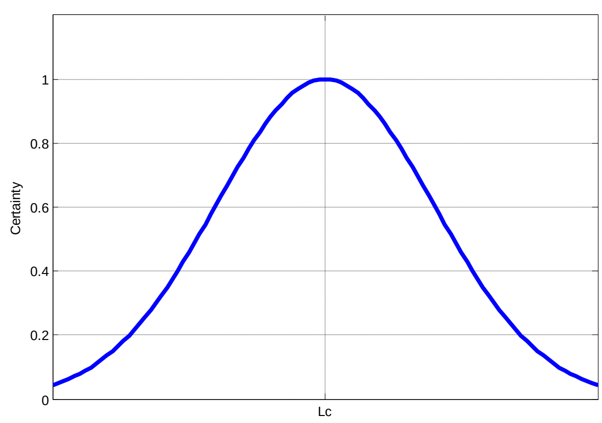

Figure 12: Triangular fuzzy load

A Gaussian fuzzy load is as in figure 12 in which the central number is the anticipated loads for power supply in previous models. Uncertainty is continually seen in two sides of central point in variance of Gaussian function σ. The delivered load should not be lower than the total of maximum uncertainties of connected loads. Being excessively higher than minimums, they include lower risk-taking and higher loss of cost. For Gaussian fuzzy load, supplying the maximum load is dually taken into account: firstly in the distance of σ and secondly in the distance of 2σ but with lower weight for the requirement.
Gaussian fuzzy load is symmetrically taken and variance is considered in a distance of one tenth from the central load.
Model 5 is defined by multi population PSO. So location vector is defined in the same way as in model 4. A requirement, including geographical and occupation factors, and a requirement for delivered loads by substations are seen regarding the maximum and minimum fuzzy loads connected to them. Convergence diagram for minimum cost in sequential iterations of MPSO is shown in figure 13 for model 5. Table 9 shows the results.

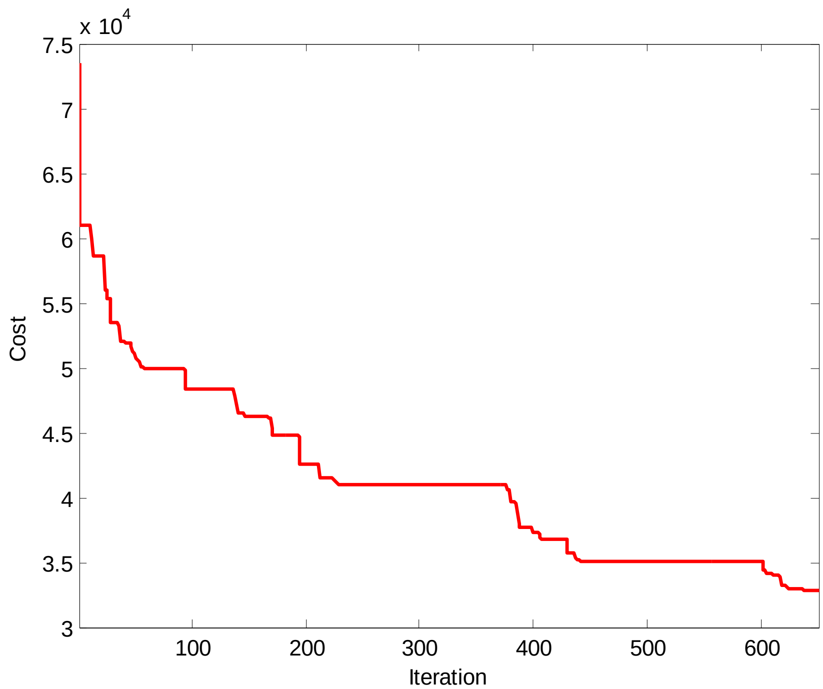

Figure 13: Convergence diagram for minimum cost in sequential iterations for MPSO in model 5

Table 9: Results of optimizing model 5 by MPSO

Xpn	Ypn	Pn	XI 7-1	XI 7-2	YI 7-1	YI 7-2	1-1	2-1	3-1	4-1	2-2	1-2	1-3	2-3	3-3	1-4	2-4	1-5	2-5	3-5	1-6	2-6	3-6	7-1	7-2
16	1	74	12	10	23	23	1	1	2	1	2	2	3	3	3	7	4	5	7	5	6	6	6	1	6

Proposed grid by model 5 and MPSO, based on the results of table 9, is as what has been shown in figure 14. The optimum cost is 32,839 and the running time is 192.
In this grid, the new substation is placed in area (1, 16) with delivered power of 74 units and the power supplies 1-4 and 2-5 connected to it. The two new power supplies are placed in area (10, 23), one connected to the substation 1 and the other to the substation 6.

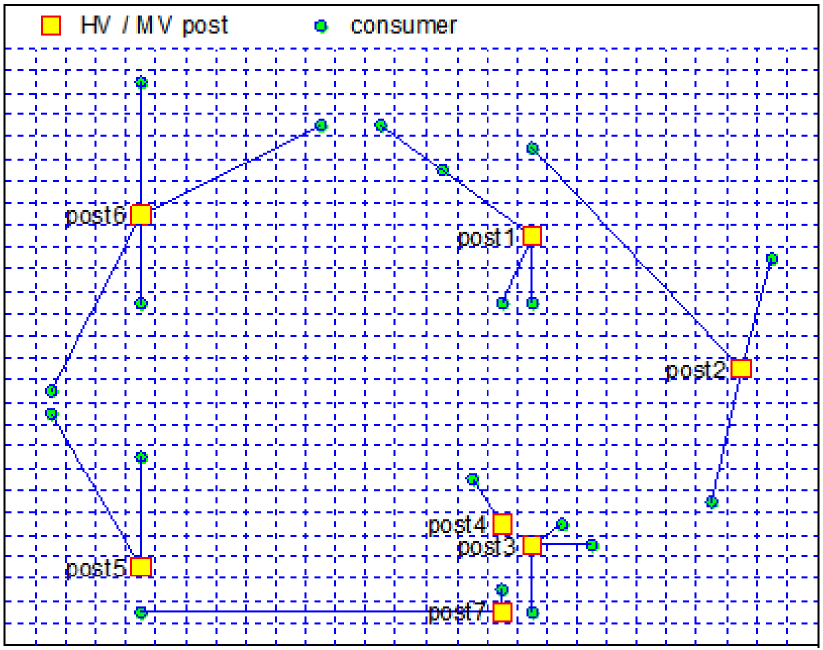

Figure 14: Proposed grid per model 5 and MPSO

Sixth Limitation

Transmission lines in the sixth model are not as straight lines from substations to power supplies but as straight lines along x and y coordinates.

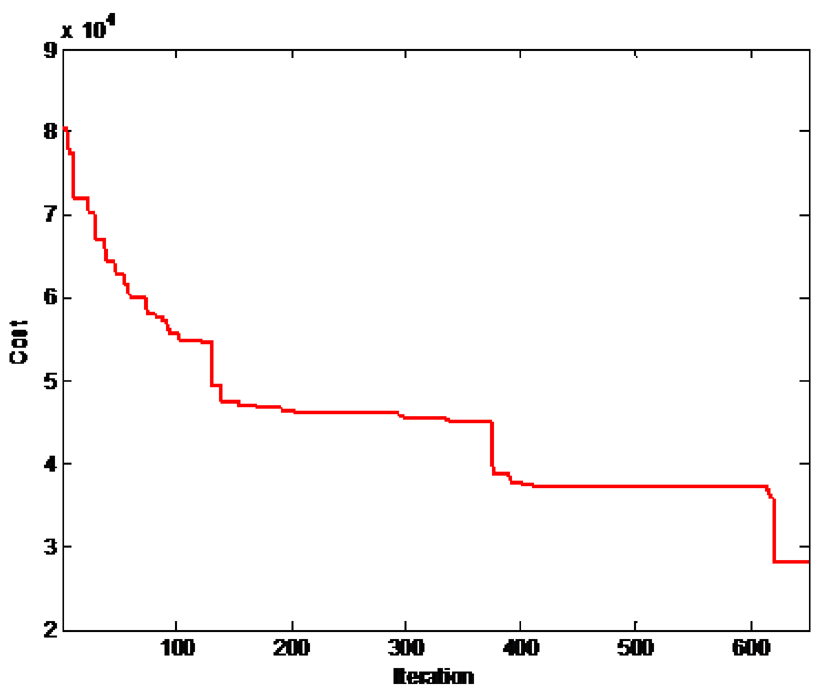

Figure 15: Convergence diagram for minimum cost in sequential iterations for MPSO in model 6

Thus, the length of transmission lines would be more than the previous unreal state. The sixth model is optimized by multi population PSO. The location vector is then defined as in model 5. A requirement,

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including geographical and occupation factors, and a requirement for delivered loads by substations are seen regarding the maximum and minimum fuzzy loads connected to them. Gaussian fuzzy load is symmetrically taken and variance is considered in a distance of one tenth from the central load. Parameters are seen as in table 9. Convergence diagram for minimum cost in sequential iterations of MPSO is shown in figure 15 for model 6. Table 10 shows the results.

Table 10: Results of optimizing model 6 by MPSO

Xpn	Ypn	Pn	XI 7-1	XI 7-2	YI 7-1	YI 7-2	1-1	2-1	3-1	4-1	2-2	1-2	1-3	2-3	3-3	1-4	2-4	1-5	2-5	3-5	1-6	2-6	3-6	7-1	7-2
10	23	110	12	12	23	23	1	1	7	6	2	1	3	3	3	4	4	5	5	5	6	7	6	7	7

Proposed grid by model 6 and MPSO, based on the results of table 10, is as what has been shown in figure 16. The optimum cost is 28,155 and the running time is 212.
In this grid, the new substation is placed in area (10, 23) with delivered power of 110 units and the power supplies 2-3 and 6-1 connected to it. The two new power supplies are connected and placed in area (12, 23).

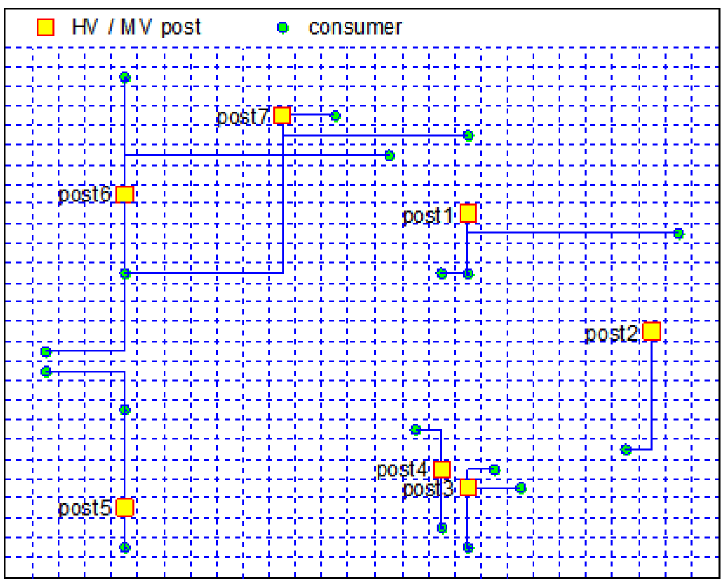

Figure 16: Proposed grid per model 6 and MPSO

Seventh Limitation
The seventh model is based on preventing voltage drop in power supplies. On account of transmission lines resistance, the voltage from the power supply will drop in proportion to the reference value. Regarding the necessity of preventing voltage drop, the distance between lines and the delivered power is designed in a manner that the voltage drops no more than a specific limit. Model 7 is created based on all parameters and methods in model 6 as well as voltage drop condition. Voltage is calculated according to the delivered power, length of line, and reference voltage (here is 1pu). If the voltage is lower than a specific limit, a large amount of it is considered as the cost of that design.
The seventh model is optimized by multi population PSO. The location vector is then defined as in model 6. A requirement, including geographical and occupation factors, and a requirement for delivered loads by substations are seen regarding the maximum and minimum fuzzy loads connected to them. Gaussian

fuzzy load is symmetrically taken and variance is considered in a distance of one tenth from the central load. Convergence diagram for minimum cost in sequential iterations of MPSO is shown in figure 17 for model 7. Optimum response was found before the iteration 300. Algorithm then gained its convergence. Table 11 shows the results.

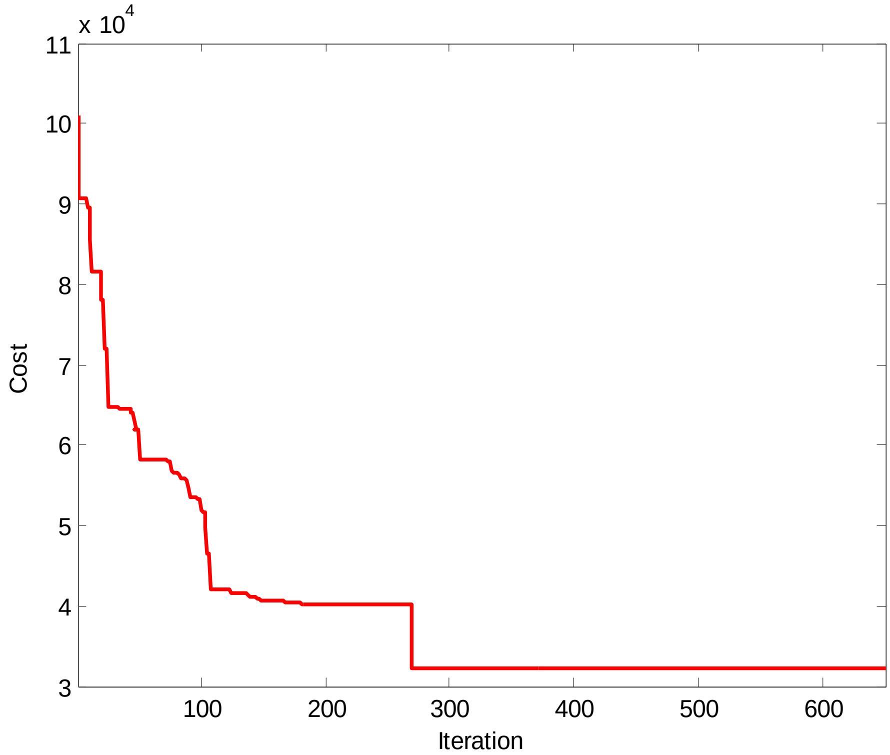

Figure 17: Convergence diagram for minimum cost in sequential iterations for MPSO in model 7

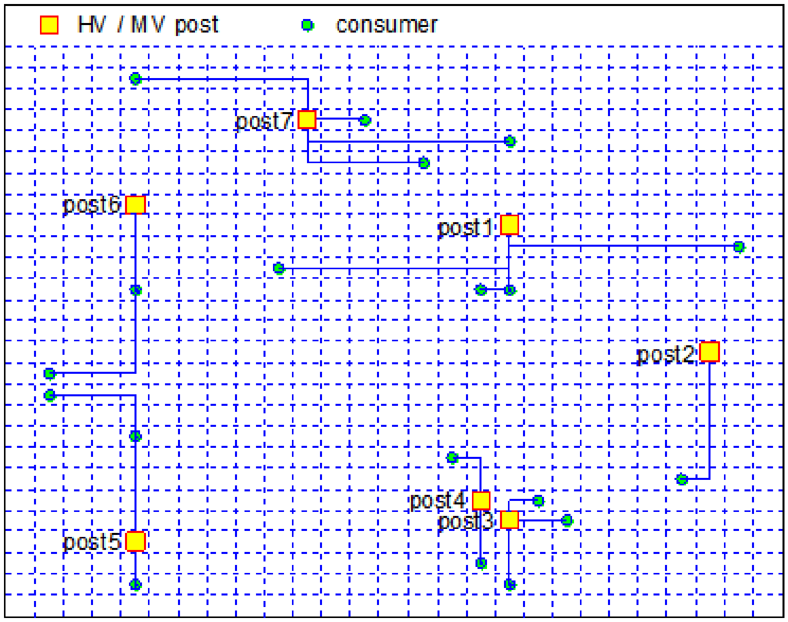

Figure 18: Proposed grid per model 7 and MPSO

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Table 11: Results of optimizing model 6 by MPSO

7-2	7-1	-36	2-6	1-6	3-5	2-5	1-5	2-4	1-4	3-3	2-3	1-3	1-2	2-2	4-1	3-1	2-1	1-1	Yl 7-2	Yl 7-1	Xl 7-2	Xl 7-1	Pn	Ypn
7	1	7	6	6	5	5	5	4	4	3	3	3	1	2	7	7	1	1	23	16	12	9	174	23

Proposed grid by model 7 and MPSO, based on the results of table 11, is as what has been shown in figure 18. The optimum cost is 32,167 and the running time is 210.

In this grid, the new substation is placed in area (10, 23) with delivered power of 174 units and the power supplies 1-3, 1-4, 3-6 and 7-2 connected to it. The two new power supplies are placed in areas (9, 16) and (12, 23); one connected to substation 1 and the other to substation 7.

In the figure 19 voltage per units for each load is shown, if the voltage numbers are multiplied by 380 then the exact numbers are calculated.

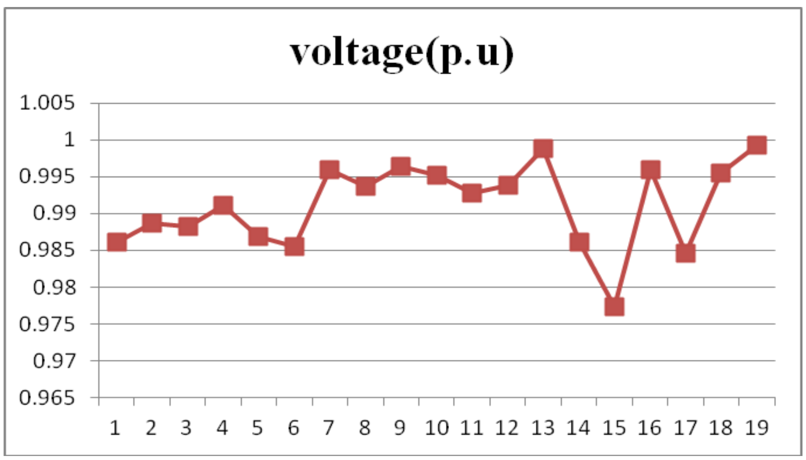

Figure 19: Voltage values for network loads

Eighth Limitation

In eighth limitation, another type of line is used to connect the loads to substations.

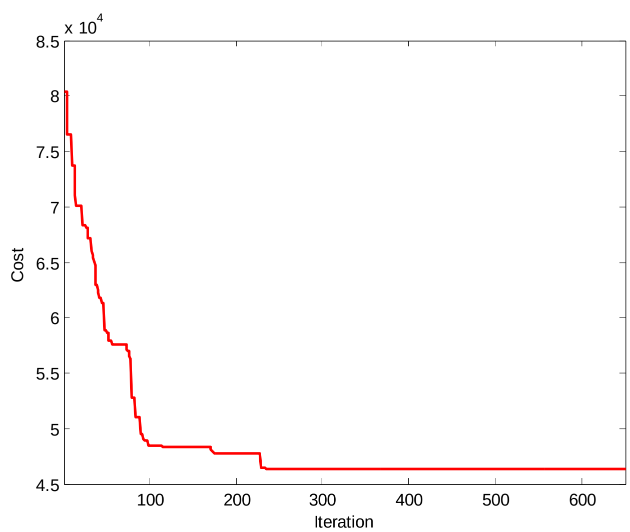

Figure 20: Convergence diagram for minimum cost in sequential iterations for MPSO in model 8

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Table 12: Results of optimizing model 8 by MPSO

Xpn	Ypn	Pn	XI 7-1	XI 7-2	YI 7-1	YI 7-2	1-1	2-1	3-1	4-1	2-2	1-2	1-3	2-3	3-3	1-4	2-4	1-5	2-5	3-5	1-6	2-6	3-6	7-1	7-2
17	2	199	16	12	1	23	1	1	1	6	2	2	3	7	7	7	4	5	5	5	5	6	6	1	7

Proposed grid by model 8 and MPSO, based on the results of table 12, is as what has been shown in figure 20. The optimum cost is 46,319 and the running time is 235. In this grid, the new substation is placed in area (17, 2) with delivered power of 199 units and the power supplies 2-3, 3-3 and 7-1 connected to it. The new power supplies are placed in area (12, 23); one connected to substation 7 and the other one to the substation 1. Values in table 12 show that despite of lower cost of construction and maintenance, high resistance in this line yields weaker results. In the figure 21the proposed grid for model 8calculated by MPSO is shown as there are 7 posts 19 loads which are shown based on model 8.

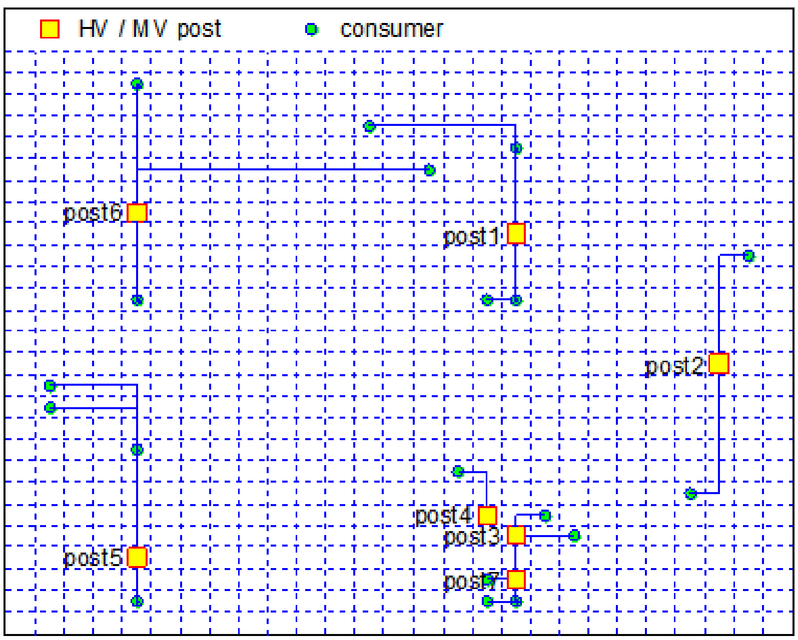

Figure 21: Proposed grid per model 8 and MPSO

Conclusion

In MPSO, all particles are divided into several subpopulations. This leads algorithm to reach the desired result with fewer particles and in less calculation time. On the other hand, algorithm division prevents particles from falling into local traps, because each population may perform the delivering process in a different section from the searching space. In case of convergence of a population around a local minimum, other population may continue searching in other points (Wei *et al.*, 2006).

This research was aimed at studying the problem of designing and reconstructing power grids in industrial areas such as industrial parks. The main model was proposed and expanded regarding eight version of it in more details. Comparing to the previous researches, in proposed model, the problem of locating new power supplies was also considered. According to the discussed models, various aspects of designing were examined, including uncertainties in load demands, difference in geographical factors, voltage drop, and different feeder lines (private or public). In the table 13 the results of the all models can be seen.

Table 13: Results of all 8 models

Type	Optimized Cost	Running time
Model 2	15,708	160
Model 3	30,476	168
Model 4	32,979	182
Model 5	32,839	192
Model 6	28,155	212
Model 7	32,167	210
Model 8	46,319	235

As table shows:
A. In model 5, Gaussian load delivered better result than fuzzy load in model 4.
B. Model 8, comparing to the model 7 in which the type of line just changed (with higher resistance) indicates that despite of lower cost of construction and maintenance, high resistance in this line yields weaker results.

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