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Research on Dynamic Adaptation of Supply and Demand of Power Emergency Materials based on Cohesive Hierarchical Clustering

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Abstract: Taking the dynamic adaptation of supply and demand of emergency materials as the research object, the condensed analytic hierarchy process was used to analyze the supply and demand risk factors in the supply chain of emergency materials from the supply side and the demand side. A new two-objective optimization model based on cohesive hierarchical clustering and electricity is proposed. Three distribution schemes are developed based on customer demand, shortest transportation time and the combination of both. When the overall satisfaction of the supply chain is the highest, the total revenue is maximized, which is suitable for the optimization of the supply chain of emergency materials under emergencies. Firstly, the power data and behavior data of power users are cross-analyzed to obtain the typical data characteristics of power users. Secondly, the cohesive hierarchical clustering algorithm is used to analyze the power users, and the cohesive hierarchical clustering algorithm is used to improve the calculation operation of score similarity. The adjustment factor is introduced to improve the calculation operation, and the comprehensive weight of each emergency point is determined as the parameter of the objective function by considering the subjective and objective factors that affect the importance of emergency points. Finally, through the simulation analysis of an emergency materials scheduling based on electric power, and compared with the results of random scheduling, the science and effectiveness of the proposed model are verified.

Keywords: Cohesive hierarchical clustering; Emergency supplies; Dynamic adaptation of supply and demand; Regulatory factor; Comprehensive weight of emergency point.

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1. Introduction

Due to the unexpected occurrence of sudden disasters, the complexity of the emergency rescue environment and the vague random uncertainty of the material needs of the victims, and other realistic factors, the distribution of emergency materials has brought certain difficulties to the implementation, and it is easy to lead to the mismatch between the distribution of materials and the actual demand, the shortage or high redundancy of materials, huge cost, low rescue efficiency and other phenomena [1]. According to relevant surveys, among the losses caused by some disasters, the proportion of losses caused by the shortage or untimely supply of emergency relief materials accounts for about 15%-20% of the total disaster losses [2,3], which seriously affects the overall effect of disaster emergency relief.

By analyzing and summarizing the existing classic disaster emergency rescue cases and relevant research in the field of emergency materials distribution [4,5], it is found that there are the following problems in the current research field of emergency materials distribution optimization for sudden disasters: First, the existing research on emergency materials distribution mainly focuses on the single-cycle distribution of emergency materials;

Second, the construction of the existing optimal model of emergency materials distribution often results in the mismatch between the distribution of materials and the actual needs of the disaster sites, and the satisfaction is low; Third, the existing distribution of emergency materials is mostly analyzed from the perspective of complete information, and the complexity of the actual rescue environment and the actual situation that a large number of rescue information is fuzzy, missing or difficult to judge are rarely considered comprehensively. The impact of uncertain factors on the distribution of emergency materials is ignored, so that the proposed distribution plan of emergency materials is often divorced from the actual disaster situation information. Lack of practical applicability.

In view of this, in order to solve the time urgency of logistics resource allocation, based on the analysis of supply and demand adaptation, a dynamic adaptation method of supply and demand for emergency materials based on cohesive hierarchical clustering was proposed to describe the matching degree between supply and demand with the purpose of emergency materials adaptation under the principle of equity. An optimization model aiming at the highest customer satisfaction and the maximum total supply chain revenue was established from two agents respectively, and the weights of their respective adaptive emergency points were obtained by considering subjective and objective factors. Through simulation analysis of a local power system and power emergency material scheduling, the results were compared with those under random scheduling to verify the scientific and effectiveness of the proposed model.

2. Related Work

The basic needs of emergency materials refer to the minimum types and quantities of materials that can be dispatched to meet the needs of relief work at disaster sites [6]. The normal life of the people in the disaster area could not be guaranteed. In the process of emergency rescue, in order to ensure the basic living requirements of the victims, a large number of emergency materials are often needed, and the decision makers must scientifically predict the types and quantities of their needs, so as to carry out more efficient post-disaster emergency rescue. The main demand content of emergency materials is divided into three parts to describe, which are mainly quantity demand of emergency materials, quality demand of emergency materials and structure demand of emergency materials [7,8]. Therefore, the description of the content of emergency material demand will also be carried out from these three aspects. The minimum material demand necessary to ensure the basic needs of people in disaster areas [9]. The characteristics of general material demand can be summarized as suddenness, uncertainty and timeliness [10], which are mostly formed based on the use scenario of emergency materials and the general characteristics of general emergency materials. However, the demand for emergency supplies produced in different environments and conditions often has its special nature. It is proposed that the demand for emergency materials in disasters has six characteristics: timeliness, uncertainty, lag, irreplaceability, relevance and stage [11]. Due to the occurrence and development of emergencies, the focus of rescue work has changed and decided. The demand for emergency materials is dynamic and phased, and the demand model for emergency materials at each stage is different [12]. Based on the analysis of the characteristics of sudden disasters and the dispatch mechanism of relief materials [13]. In the analysis and model construction of single-type emergency materials transportation, two basic objective functions, such as transportation time and transportation cost, were considered [14]. Aiming at the shortest transportation time, minimum emergency cost and highest material satisfaction, the optimization model of emergency relief material scheduling considering multimodal transportation was constructed [15], and the effectiveness of the model was verified through case analysis [16]. The optimization model of relief materials dispatching under the condition of fuzzy disaster information [17] was constructed to explore the clear transformation method of the model when the parameter was triangular fuzzy number.

However, there are many problems in the risk management and control of the supply chain of emergency materials. Based on the quantitative analysis of the relationship between the number of suppliers, supply risk and total cost of procurement, a multi-objective optimization model [18] was established to give the optimal number of suppliers and total cost of procurement under the specified supply risk level [19]. The impact of COVID-19 on the supply chain was analyzed in detail from both macro and micro aspects and corresponding countermeasures were proposed [20]. An enterprise profit maximization model with risk indicators as variables was established [21], and the profit maximization point was found through Excel-Solver software assisted calculation and adjustment of risk indicators. A vaccine supply chain with uncertain output and self-interest-centered consumer demand [22] was studied, and it was found that the equilibrium demand could be greater than the optimal demand of society. Through the decomposition of emergency materials transportation into various stages, a dual-objective resource scheduling model is established with the objectives of the shortest emergency response time and the least number of rescue points in the decomposed stages [23]. With reference to the current situation of multi-commodity distribution, a loss function model aiming to minimize the loss in the disaster-affected area was built based on various disaster factors [24], and the loss function was used to evaluate the distribution of emergency materials. According to blockchain technology, six levels of the emergency logistics supply chain system, including data layer, network layer, consensus layer, contract layer, application layer and user layer [25], are proposed to be reconstructed.

Many scholars have done a lot of research on the service ability of emergency supplies supply and demand adaptation based on electricity. By analyzing different needs of users, personalized power supply services are provided [26]. The power supply service capability is improved through dual incentive power customer control [27]. By improving cosine similarity, power users are analyzed and different services are provided to improve power supply service capability [28]. Different power supply service strategies are formulated by evaluating the power supply quality index of users. It could be seen that the new power supply service methods are diverse and have made certain achievements. However, the above method still adopts a passive way to provide power user services, without setting up an incentive mechanism for power users, and the service mode is single. The vulnerability and criticality of power grid nodes are described through various topological feature parameters of complex network theory [29,30]. In the evaluation of the importance of the area to be restored in the power system, the concept of transmission interface number was proposed [31]. Based on electrical distance, the concept of electrical hazard connectivity of network nodes is proposed, and it is used as an indicator to measure the importance of power system nodes [32]. The power flow and transmission parameters are proposed and applied to the identification of key lines in power system [33]. However, there are few studies on the application of node importance to power emergency dispatch. Subjective factors affecting node importance (load loss, load type, location and economic loss) may cause power emergency dispatch to be less than optimal in some disaster situations.

3. Research Framework for Dynamic Adaptation of Supply and Demand of Emergency Materials based on Cohesive Hierarchical Clustering

3.1. Dynamic adaptation framework of supply and demand of emergency materials

Taking material satisfaction and time satisfaction as objective functions, this paper proposes to establish a cohesive hierarchical clustering and dynamic scheduling model of electric power emergency materials. The structural framework is shown in **Figure 1**.

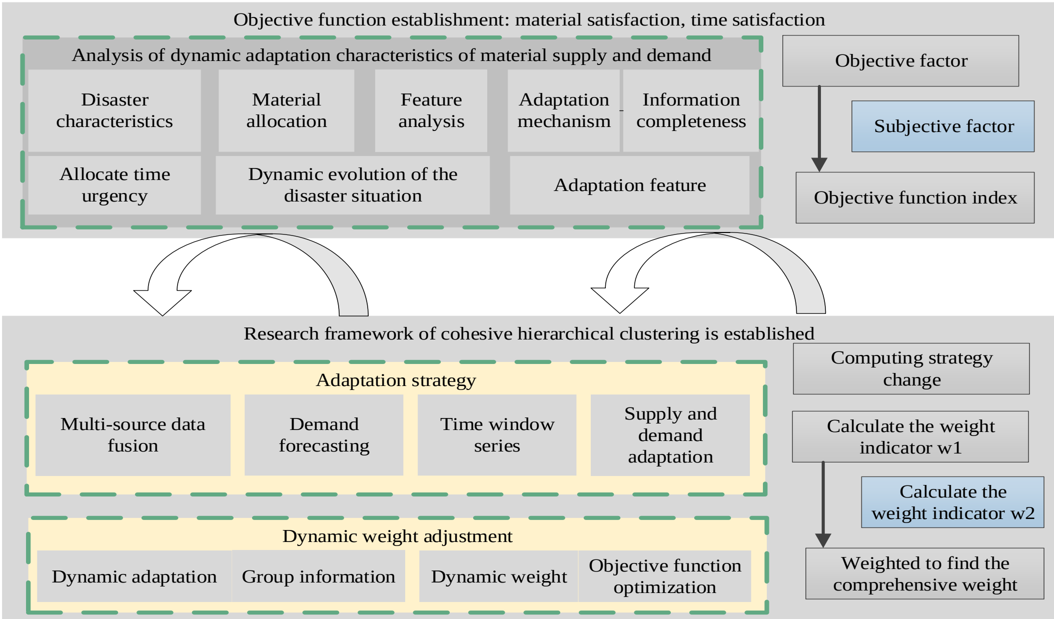

Figure 1. Research frame diagram.

As shown in **Figure 1**.

1) Put forward the objective function of electric emergency material scheduling, including material satisfaction and time satisfaction.

2) To solve the parameters in the objective function (emergency point importance weight), the steps are as follows.

Step 1 Consider the subjective factors affecting the importance of emergency points (load loss, load type, location and economic loss), and use analytic hierarchy process to calculate the subjective factor weights of each emergency point;

Step 2 Consider the objective factors that affect the importance of power system nodes (node electrical hazard connection degree and node voltage change rate, etc.), and calculate the objective factor weights of emergency points.

Step 3 The subjective and objective weights of emergency points are weighted linearly to obtain the importance weights of emergency points.

3) Multi-objective functions are optimized based on the coherent hierarchy algorithm, and examples are analyzed.

3.2. Dynamic adaptation evaluation of supply and demand of emergency materials supply chain

The risk assessment by using the agglomerative hierarchical clustering analysis method involves the weighting between four indicators, so a judgment matrix needs to be set up to judge the influence degree of each indicator in the supply chain and score. The judgment matrix is to judge the importance of two factors according to a specific goal. As shown in **Table 1**.

Table 1. Scoring basis of influence degree.

bij	Definition
2	Bi is just as important as Bj
4	Bi is slightly more important than Bj
6	Bi is more important than Bj
9	Bi is obviously more important than Bj
0	Bi is absolutely more important than Bj
1,3,5,7,8	Bi is between two adjacent degrees of importance than Bj

The weights obtained by the calculation of the judgment matrix illustrate the importance ranking of each factor under a specific target, and the sum-product method is used to further calculate the weights.

$$B=\left\{b_{ij}\right\}=\frac{a_{ij}}{\sum_{k=1}^{n}a_{kj}},(i,j=1,2...n) \tag{1}$$

The normalized judgment matrix is added according to rows:

$$\omega_i=\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n}b_{ij},(i,j=1,2...n) \tag{2}$$

Determine the maximum eigenvalue:

$$\lambda=\frac{1}{n}\sum_{i=1}^{n}\frac{B\omega_i}{\omega_i} \tag{3}$$

The sorting standard of materials at the supply point is the sum of the product of the total amount of all categories of materials from the corresponding transfer point to all demand points and the priority of the demand point. The higher the loading priority of materials, the time from the supply point to the transfer point of emergency materials:

$$TA_{ijst}^{0}=\frac{\sum_{s}\sum_{j}\sum_{k}\lambda_{kt}\sum_{i}m_{jkst}+\sum_{s}p_{ijst}}{\lambda_i} \tag{4}$$

p_{ijst}: The dispatch volume of materials s in stage t from supply point i to transfer point j.

m_{jkst}: The dispatch quantity of material s in stage t from the transition point j to the demand point k.

The time from supply point i to transit point j equals the loading time at the supply point plus the transportation time from the supply point to transit point.

$$TA_{ijst}^{1}=TA_{ijst}^{0}+{d_{ij}}/{v^{1}} \tag{5}$$

d is the distance, v is the speed, and the time when the materials are loaded from the central transfer point j and start to travel to the demand point k:

$$TB_{ijst}^{0}=TA_{ijst}^{1}+\frac{\sum_{s}\sum_{j}\sum_{k}\lambda_{kt}\sum_{i}m_{jkst}+\sum_{s}p_{ijst}}{\lambda_i} \tag{6}$$

The dynamic scheduling model of emergency medical supplies supply and demand constructed by cohesive hierarchical clustering is as follows:

$$\begin{aligned} F1&=\min\sum_{t,s,k}\frac{D_{kst}-\sum_{j}m_{jkst}}{D_{kst}} \\ F2&=\min\sum_{t,s,k}\lambda\times T_{kst} \end{aligned} \tag{7}$$

T_{kst} : The time when the last supplies arrive at point k of demand.

D_{kst}: Actual demand of class k materials at the periodic demand point.

According to the calculation process of the above cohesive hierarchical cluster analysis method, the importance of customer satisfaction with quality (N1), price (N2), quantity (N3) and time (N4) in criterion layer N is compared. The relative importance of each index in the criterion layer N and the scheme layer is scored, and then the average value is taken and summarized into the initial data table to establish the judgment matrix. The normalization results are shown in **Table 2**. All data are reserved to 3 decimal places.

Table 2. Normalization of primary indexes.

	N1	N2	N3	N4
N1	0.081	0.042	0.057	0.164
N2	0.324	0.151	0.134	0.164
N3	0.243	0.313	0.241	0.241
N4	0.243	0.464	0.512	0.472

On the base of the above calculation, the weights of parameter values related to satisfaction factors are calculated. The summarized weight results and importance ranking are shown in **Table 3**.

Table 3. Final weight and importance ranking.

	N1	N2	N3	N4	W	Significance
	0.2	0.3	0.37	0.53		
A1			0.38	0.85	0.418	1
A2	0.43	0.32	0.64		0.232	2
A3	0.77	0.72			0.181	3
A4		0.18	0.21		0.179	4

The weight of criterion-level and decision-level indicators was obtained by using the cohesive hierarchical clustering analysis method. From the above data, it could be seen that among the risk indicators of emergency supplies supply chain, the most critical factor affecting satisfaction is the time response rate, followed by the satisfaction rate, the return rate, and the demand rate. The final weight will be incorporated into the supply and demand risk model with the highest satisfaction as the goal in the form of coefficients.

3.3. Dynamic adaptation model of emergency material supply based on cohesive hierarchical clustering

Time response rate. The relative rate between the delivery time required by consumers and the actual delivery time of enterprises.

Order fulfillment rate. That is, the ratio of the demand of customers to the quantity that can be provided by the production enterprise of emergency materials.

Cost-return rate. That is, the relative rate of the difference between the consumer purchase price and the actual price of emergency materials.

Defective rate of emergency materials. That is, the ratio of the number of emergency materials that the enterprise does not meet the standard to the total production. After the above four multi-objective programming models are transformed into single-objective problems by weighted average method, the first model about maximizing customer satisfaction is expressed as:

$$\max f1 = \lambda_1 \frac{t_1}{t_2} + \lambda_2 \frac{Q_1}{Q_2} + \lambda_3 \frac{R-C}{R} + \lambda_4 \frac{P_2 - P_1}{P_2} \quad (8)$$

Where, λ is the weight, t is the delivery time, Q1 is the quantity demanded, Q2 is the quantity supplied, R is the price, C is the production price, P1 is the substandard quantity, and P2 is the total number.

When establishing the function aiming at the maximum total profit of the supply chain, we mainly consider the total revenue, production cost, transportation cost and the proposed penalty cost. The total income considered is only related to the production of emergency supplies (the quantity of the supply) and the selling price. The total income can be described as the product of the production of emergency supplies (the quantity of the supply) and the selling price, namely:

$$R = \sum_{i=1}^{n}\sum_{m=1}^{M}\sum_{k=1}^{K} Q_{imk} \times P_{imk} \tag{9}$$

Production cost can be described as the product of the quantity of emergency supplies produced and the unit cost C, i.e.

$$CT = \sum_{i=1}^{n}\sum_{m=1}^{M}\sum_{k=1}^{K} Q_{imk} \times C_{imk} \tag{10}$$

The penalty cost is divided into two parts: time penalty cost and out of stock penalty cost. The time penalty cost is related to the late delivery time, and the time response rate is used as the time penalty coefficient. The out-of-stock penalty cost is related to the actual shipments of manufacturers and the demand of consumers, and the satisfaction rate is used as the out-of-stock penalty cost coefficient. The penalty cost can be expressed as:

$$\begin{aligned} PC = \lambda_1 \sum_{i=1}^{n}\sum_{m=1}^{M}\sum_{k=1}^{K} C_i \times (t_1 - t_2) + \\ \lambda_2 \sum_{i=1}^{n}\sum_{m=1}^{M}\sum_{k=1}^{K} C_i \times (Q_1 - Q_2) \end{aligned} \tag{11}$$

The decision-making idea of this model is shown in **Figure 2**. (1) At the beginning of the scheduling decision of a certain cycle, the supply and demand information is first updated, where the supply of materials at the supply point is equal to the sum of the external raised amount of this cycle and the remaining amount of materials in the last cycle, and the demand of materials at the demand point is equal to the predicted material demand based on the epidemic data of this cycle plus the shortage of materials in the last cycle; (2) According to the supply and demand of materials in the current period, different model constraints are implemented. When the supply is greater than the demand, the material satisfaction rate at the demand point should be 1; when the supply is less than the demand, the material satisfaction rate at the supply point should be all supplied; meanwhile, the material satisfaction rate at the demand point should be higher than the preset minimum demand satisfaction rate. (3) Output the emergency materials dispatching plan of the current cycle, and judge whether the emergency rescue is over at this moment. If it is over, the calculation will be stopped; if not, the above steps will be repeated.

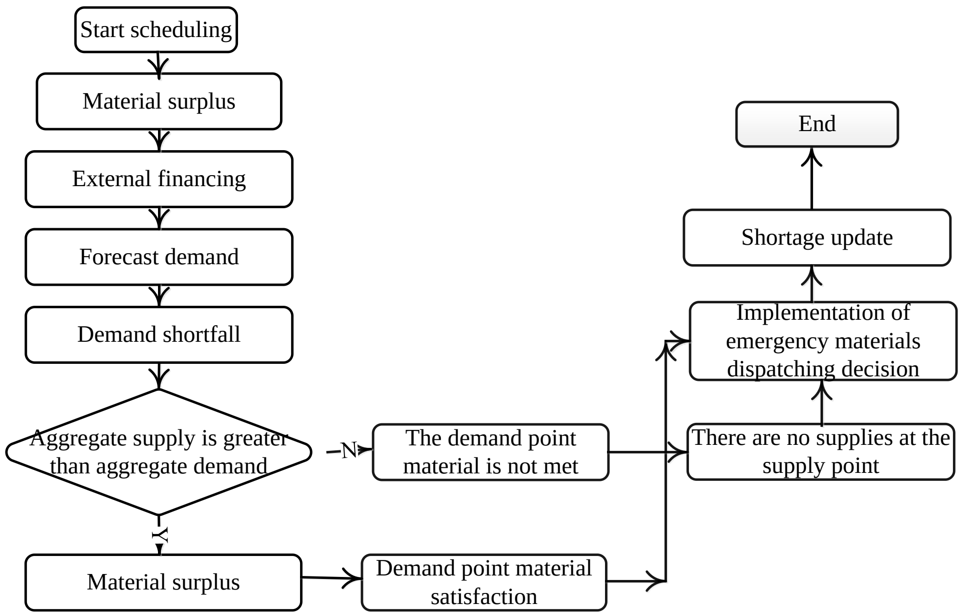

Figure 2. Research ideas of emergency materials scheduling model.

According to the principle of maximum membership, the dynamic adaptation diagram of emergency materials in disaster-stricken areas provides the cohesive 3D clustering result diagram of the average level of disaster, the demand for emergency materials and the supply of emergency materials and the clustering results.

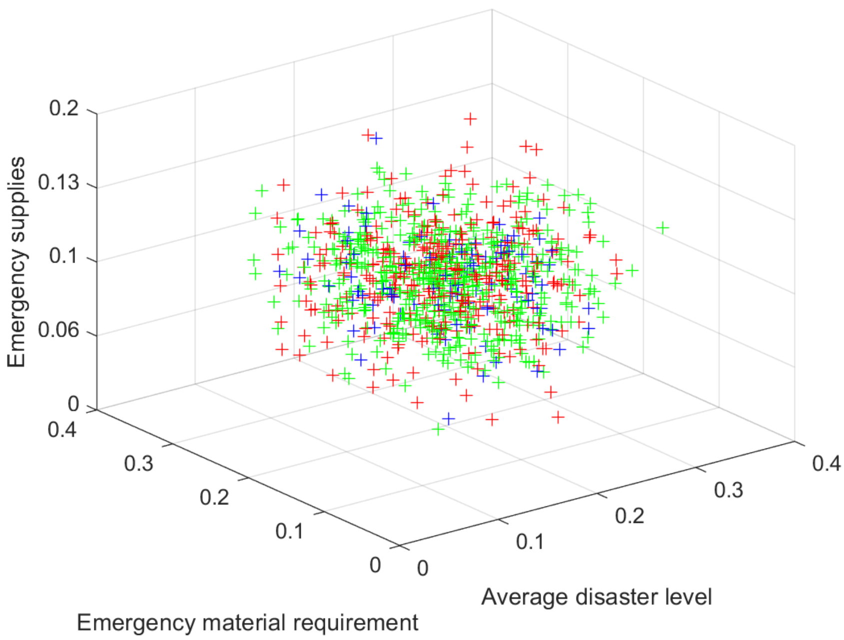

Figure 3. Clustering results of cohesion level in disaster-affected areas.

4. Dynamic Adaptation Model of Power Emergency Materials Supply and Demand based on Cohesive Hierarchical Clustering

4.1 Dynamic adaptation of power emergency materials supply

The dynamic adaptation service method framework of power emergency materials based on cohesive hierarchical clustering mainly includes three parts: typical characteristics analysis of power users, power user portrait and power user marketing service, as shown in **Figure 4**.

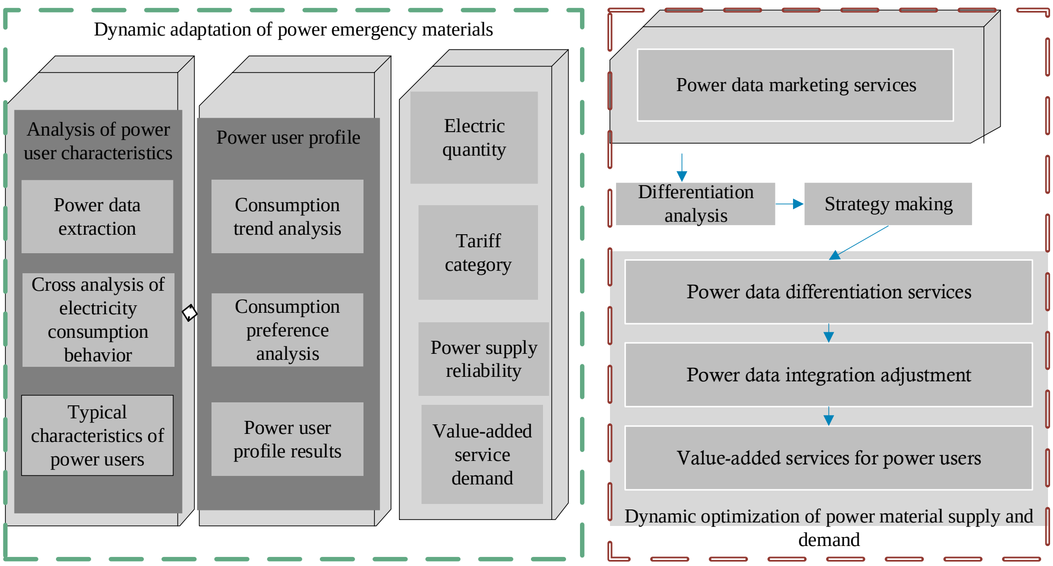

Figure 4. Dynamic adaptation framework of power emergency materials.

The intersection of electricity consumption and behavior of electricity users is:

$$c_i = -e_i \log d_i - (1-e_{i-1}) \log d_{i-1} \tag{12}$$

Where: *e* is the power consumption data of the power user, which selects the power load of the power user; d is the behavior data of power users, which selects the number of interactions between power users and power supply enterprises, in which complaints are deducted points and praise is added points.

The typical characteristics of power users are generated according to the four categories of power consumption, electricity price category, power supply reliability and value-added service demand, as shown in **Table 4**.

Table 4. Typical characteristics of power users.

Category	Index name	Instructions
Electric quantity	Very large power users	Monthly electricity > 100,000 kWh
	Large power user	20,000 kWh. - 100,000 kWh
	Medium power user	20,000 kWh. - 100,000 kWh
	Small power users	Monthly electricity < 2,000 kWh
Tariff category	Large-scale industry	
	General commercial electricity consumption	
	Non-industrial electricity	
	Household electricity consumption	
	Electricity for agricultural production	
Power supply reliability	Primary load	Key units and important political and economic regions
	Secondary load	Important power consumption unit
	Tertiary load	Ordinary user
Value-added service demand	Strong demand	
	Demand ordinary	
	No demand	

Firstly, the cohesive hierarchical clustering method is used to gather users, and different categories are classified according to the clustering results. The clustering results divide users into two categories: resident users and non-resident users, and then these classifications are analyzed, and finally named. According to the date cycle of electricity consumption, it can be divided into migrant workers, idle working days in different places, idle seasonal living by season, and vacant housing. In cohesive hierarchical clustering, Euclidean distance from j and k is:

$$d_{jk} = \frac{\sqrt{\sum_{i=1}^{n} d_i(j,k)^2}}{n} \tag{13}$$

n is the number of Euclidean distance preferred by power users; d is the distance preferred by power users with different measurement methods.

The similarity of objects j and k is:

$$s_{jk} = 1 - d_{jk} \tag{14}$$

In the cohesive hierarchical clustering, through the similarity comparison of power users, if the user with high similarity is combined in pairwise to form a cluster, until all the power user clusters are traversed to form the clustering result.

4.2. Research on emergency material supply scheduling model based on dynamic weights

The dispatch of emergency materials is one of the important tasks of power system restoration. The scientific and reasonable dispatch can ensure the quick load recovery of power system and reduce the loss caused by power system damage.

Material satisfaction is set as the ratio between the number of materials obtained at the emergency point and the number of materials required, and time satisfaction is set as the product of the rate of materials obtained at the emergency point and the satisfaction function. Its structural framework is shown in **Figure 5**.

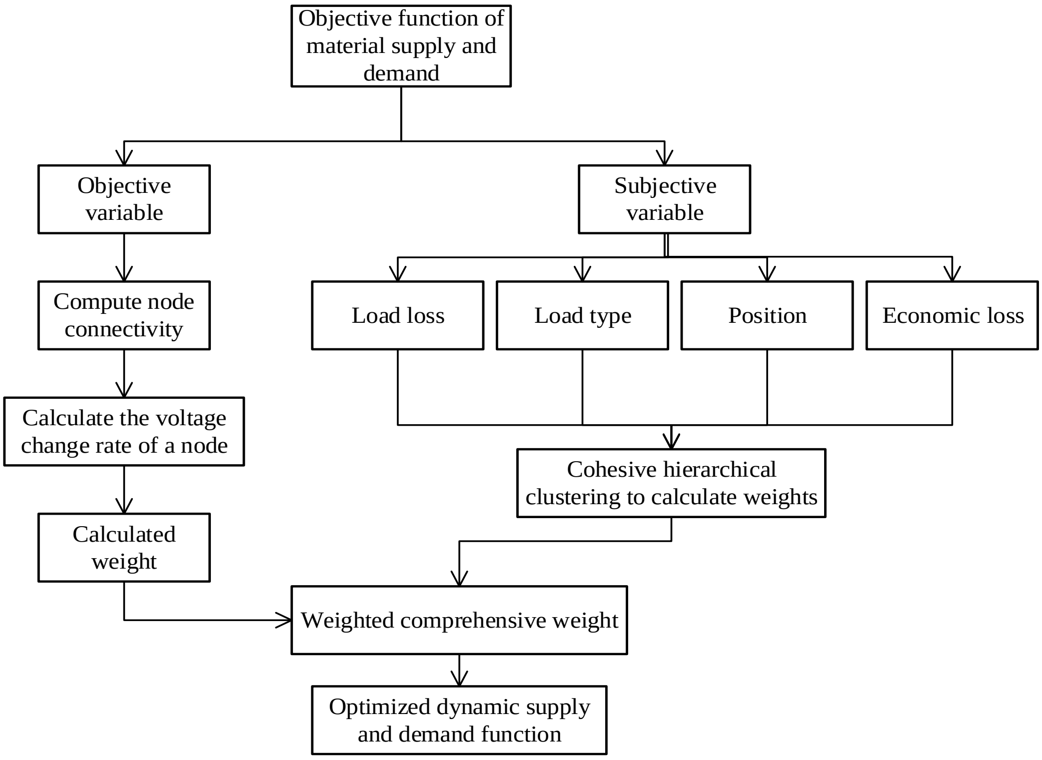

Figure 5. Flow chart of emergency material scheduling model with dynamic weights.

Multiple objective function constraints are as follows.

1) Supply point material quantity balance, that is, the output of each supply point is less than or equal to the storage.

$$\sum_{j=1}^{n} q_{ij} + \sum_{l=1}^{n} q_{il} \le a_i, i = 1, 2..n \tag{15}$$

2) The amount of materials at the transit point is balanced, that is, the amount of materials received at the transit point is greater than or equal to the output.

$$\sum_{j=1}^{n} q_{ij} \ge \sum_{l=1}^{n} q_{il} \tag{16}$$

3) Balance of material quantity at the emergency point, that is, the amount of material output at the emergency point is less than or equal to the amount of material received.

$$\sum_{i=1}^{i+m+k} q_{ij} - \sum_{i=1}^{i+m+k} q_{ji} \ge 0 \tag{17}$$

4) Emergency point material constraints, the received amount is less than or equal to the demand.

$$\sum_{i=1}^{i+m+k} q_{ij} - \sum_{i=1}^{i+m+k} q_{ji} \le N_j \tag{18}$$

5) Disaster weight balance.

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{19}$$

Step 1. Establish a hierarchical structure model. Analyze the problem deeply, determine the target layer, criterion layer and scheme layer.

Step 2. Construct all judgment matrices in each level.

Step 3. Hierarchical single sort and consistency check. For each judgment matrix, the eigenvector corresponding to its maximum eigenvalue can be considered as the relative importance scale after comparison of factors at the same level.

Find the corresponding average random consistency indicator RI, as shown in **Table 5**.

Table 5. Average random consistency indicators.

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.56	0.89	1.14	1.26	1.35	1.45	1.48

Step 4 Total hierarchical sorting and consistency test.

Step 5 Calculate the weight indicators of each scheme. The linear weighting method is adopted to determine the importance weight of the emergency point (comprehensive weight) as follows.

$$\lambda = \alpha\lambda_1 + (1-\alpha)\lambda_2 \tag{20}$$

Where, a is the objective preference coefficient, and 1-a is the subjective preference coefficient, which is given by the emergency scheduling decision-maker according to preference. In this paper, 0.5, that is, subjective preference and objective preference are equally important.

As shown in **Figure 6**, the optimal solution of the dynamic adaptation of power emergency materials for cohesive hierarchical clustering is difficult for two objective functions to reach the optimal at the same time, and the increase of one objective function is at the cost of the loss of the other objective function.

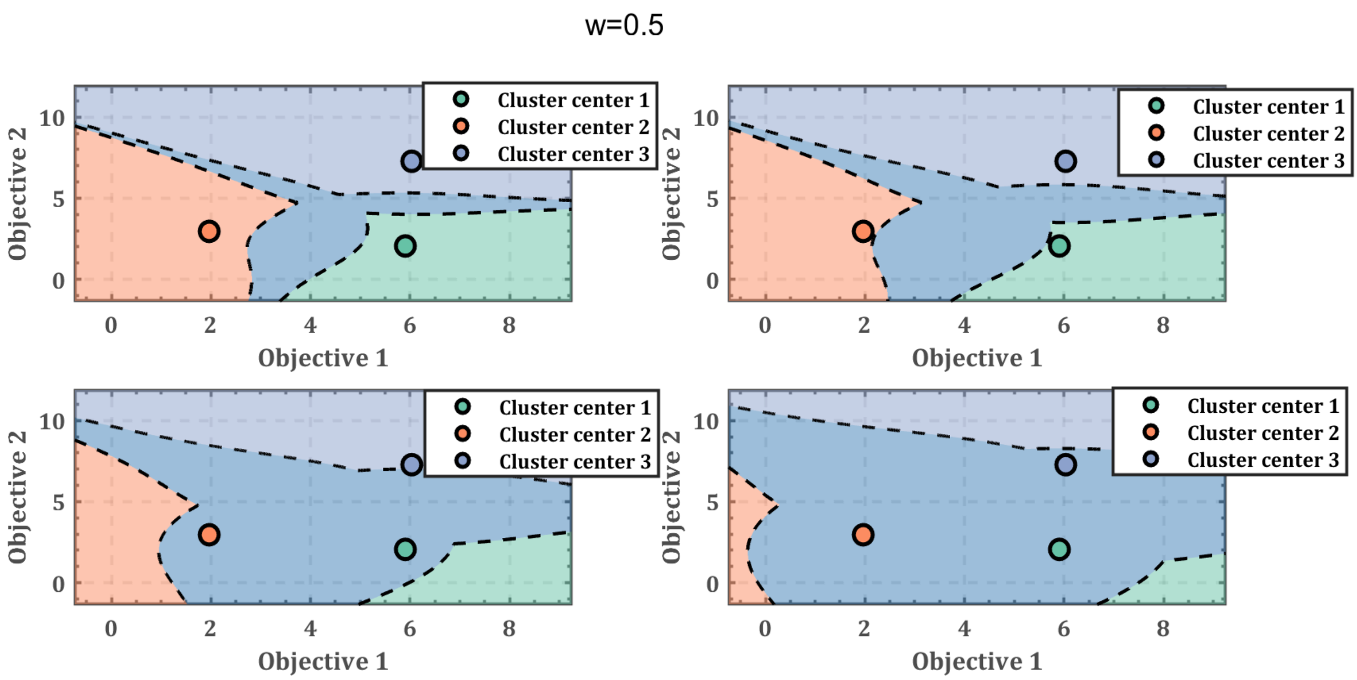

Figure 6. Optimal solution of dynamic adaptation of power emergency materials in cohesive hierarchical clustering.

5. Simulation Verification

This example assumes that the nodes in the power system coincide with the geographical emergency points. Taking a local power system as an example, this paper analyzes the dispatching situation of power emergency materials in the system under Typhoon Du Suri. The topology and parameters of the power system are shown in **Figure 7**.

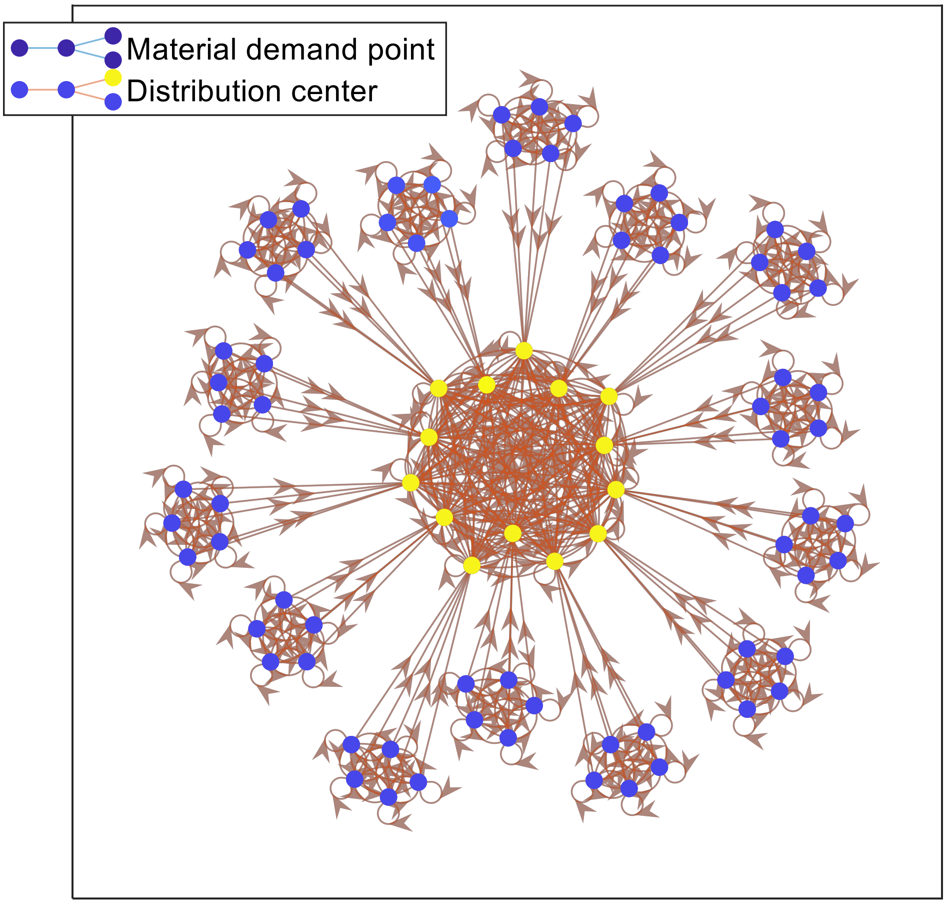

Figure 7. Topology of a local power system.

The data of 40 000 power users in 7 districts and counties of a certain city were selected, in which the power user service method based on agglomerative hierarchical clustering and the Bayesian decision network selected 20 000 power users respectively, and the experimental group and the control group were compared. The comparison results of online penetration of power users are shown in **Figure 8**.

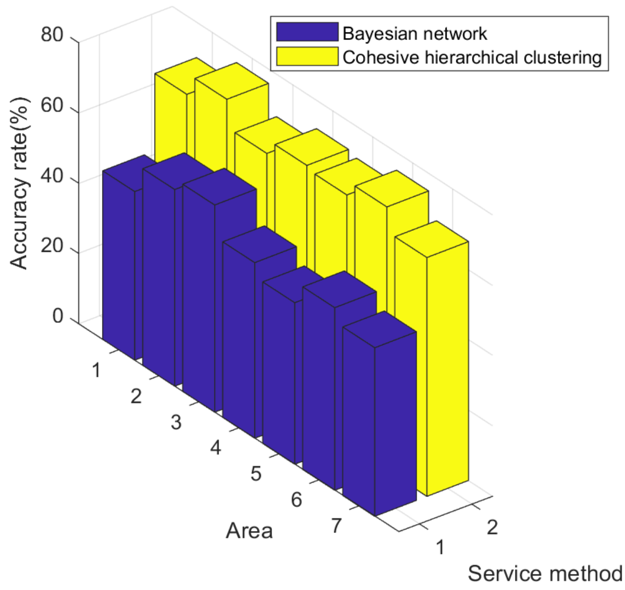

Figure 8. Analysis of online penetration rate of power users.

As can be seen from Figure. 8, the average online penetration rate of the power user service method proposed in the paper based on cohesive hierarchical clustering is 69.5%, which is higher than the average online penetration rate of Bayesian network is 51.4%.

In order to verify the effectiveness of the proposed method, the obtained results were compared with the transport paths between randomly designated nodes, and 20 random paths were selected for simulation calculation. The calculation results are shown in **Table 6**.

Table 6. Optimal objective function values under random path.

No.	Material satisfaction	Time satisfaction
1	1.0916	0.0346
2	0.2464	0.4324
3	0.0959	0.4564
4	0.4126	0.063
5	0.8352	0.0927
6	0.5878	0.1069
7	0.9429	1.4657
8	0	0
9	1.3063	0.1572
10	0.144	0.0063
Average of 20 random paths	0.5669	0.2826
Condensation level clustering mean	1.289	1.9689

As can be seen from **Table 6**, although the optimal value of one objective function may be greater than the optimal value of the corresponding objective function under the proposed method under the random path, the value of the other objective function will inevitably lose a large amount, which is not advisable. In general, the optimal value of the objective function of the proposed method is much larger than the average value of the optimal value of the function in the case of random path. Therefore, the proposed method can satisfy the optimal material satisfaction and the optimal time satisfaction, which verifies the scientificity and effectiveness of the proposed method.

Then, the dynamic adaptation prediction of supply and demand of emergency materials under the two influencing factors of power under the cohesive hierarchical clustering is presented. The simulation results are shown in **Figure 9**. The first is the smoothness test and residual test of the model. It can be seen from **Figure 9** that under the coacervated hierarchical clustering prediction model, the historical data tends to be stable when the second-order difference is taken. Meanwhile, it can be seen from **Figure 9** that the comprehensive weight of the coacervated hierarchical clustering prediction model conforms to the random normal distribution. Therefore, the cohesive hierarchical clustering prediction model can be used.

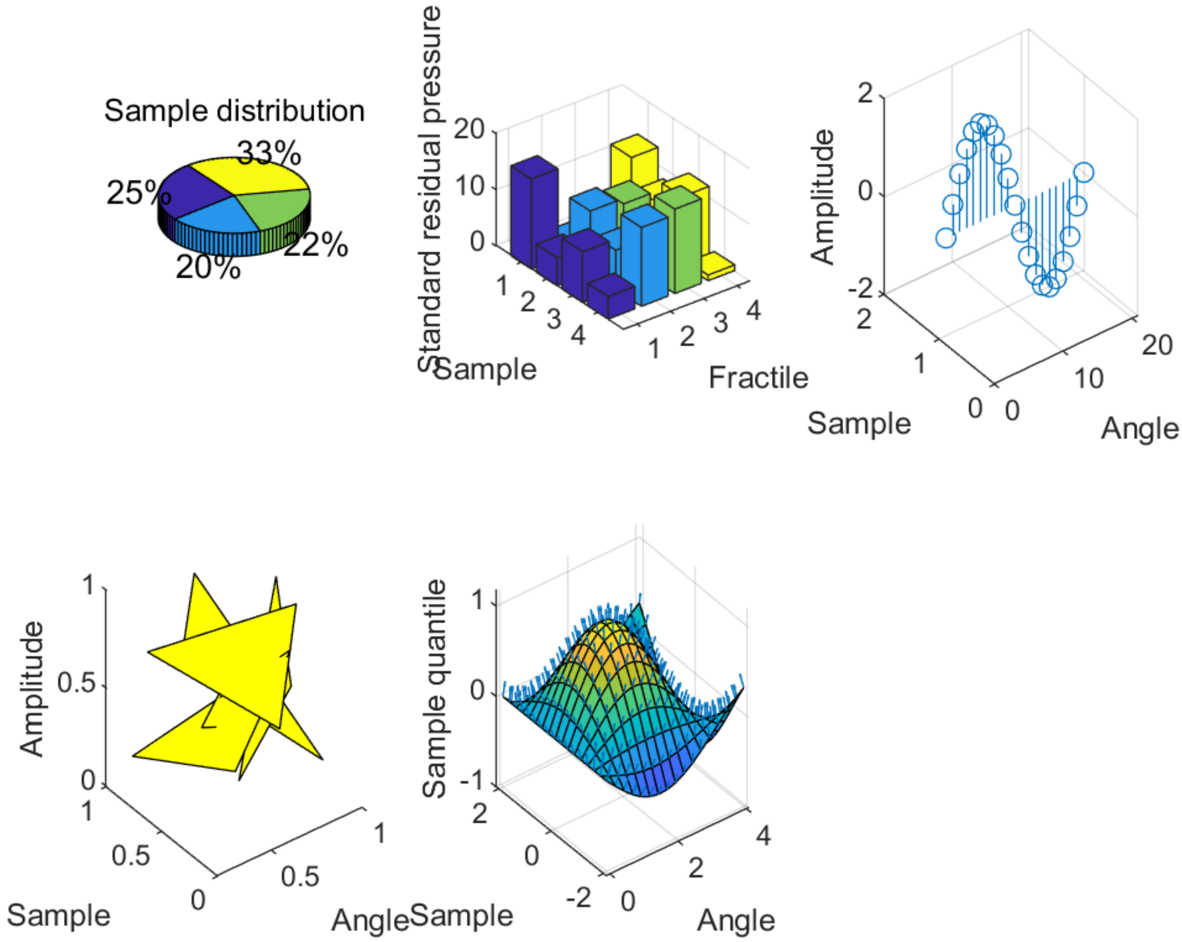

Figure 9. Test of dynamic adaptation model of supply and demand of electric power emergency materials under cohesive hierarchical clustering.

In combination with the relevant data of the above power, the cohesive hierarchical clustering algorithm was used to solve the distribution scheme of emergency materials. After a certain number of iterations, a satisfactory solution was obtained. The minimum value and the iterative objective function value of the successive iterations were shown in **Figure 10**. The scheme of two power grid emergency supplies supply warehouses participating in the distribution of emergency supplies at fault demand points is output.

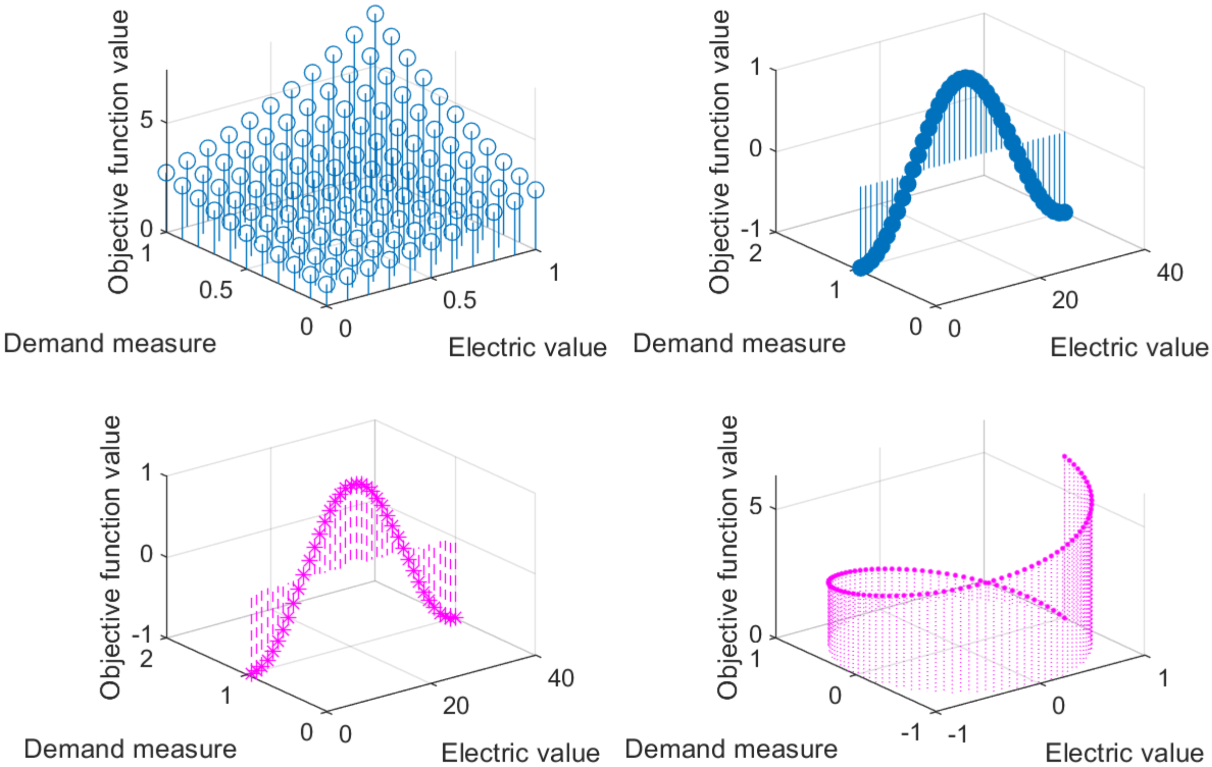

Figure 10. Previous objective function values obtained by algorithm iteration.

Finally, the emergency materials dispatching plan was obtained, as shown in **Table 7**.

Table 7. Emergency materials dispatching scheme.

Demand point	Risk level	Dispatch volume (PCS)	Material satisfaction rate /%	Distribution route	Delivery time /h
Y1		64 625		G1-49-34-20-17-6-5-Y1	0.65
Y2	I level	75 569	68.93	G2-50-35-21-20-17-6-5-Y1	0.85
Y3		59 272		G3-26-9-1-Y1	0.35
Y4	I level	110	68.94	G3-26-24-40-59-58-Y2	1.56
Y5		50 181		G4-59-58-Y2	0.88
Y6	II level	28 761	53.24	G3-41-42-68-67-Y3	1.03
Y7	II level	17 431	53.24	G5-76-Y4	0.48
Y8	II level	15 681	53.24	G1-49-91-64-71-72-79-Y5	3.43
Y9	II level	6 848	53.24	G3-41-42-68-67-66-69-Y6	2.97
Y10	II level	7 570	53.24	G5-76-75-69-Y6	2.4
Y11	II level	12 435	53.24	G5-76-77-78-81-89-Y7	4.68
Y12	II level	10 635	53.24	G5-76-77-78-Y8	2.85
Y13	II level	10 597	52.78	G4-59-56-92-Y9	1.15
Y14	III level	9 491	52.87	G5-76-84-85-Y12	1.45
Y15	III level	9 272	52.89	G1-49-91-64-Y13	0.87

As can be seen from **Table 7**, the satisfaction degree of emergency materials demand at disaster points at all levels is as follows: I >II >III, which reflects the priority and emphasis of emergency materials distribution on serious disaster points and meets the needs of actual emergency rescue work. In addition, by comparing the satisfaction rate of emergency materials at disaster points at all levels, it can be found that the satisfaction rate of emergency materials at disaster points with the same risk level is basically consistent, which reflects the strong fairness of emergency materials distribution in this paper.

6. Conclusion

In this paper, a dynamic adaptation model of power emergency materials based on cohesive hierarchical clustering is proposed. It is concluded that when customers have the highest satisfaction with the overall distribution of emergency materials, the order of customer delivery will generate the largest total supply chain revenue. The power emergency material scheduling problem is transformed into a multi-objective optimization problem and a function aiming at material satisfaction and time satisfaction is established. Secondly, in the determination of objective function parameters (emergency point importance weight), the subjective and objective factors are comprehensively considered to determine the emergency point weight, which not only ensures the objectivity of the results, but also does not ignore the subjective experience judgment of emergency scheduling decision-makers. Finally, through the simulation analysis of a local power system and power emergency material scheduling, and compared with the results under random scheduling, the proposed optimal value of the objective function is larger than that under random path, which verifies the scientificity and effectiveness of the proposed model. The results show that the method is effective and the online penetration rate and satisfaction rate of power users are improved.

References

1. Chen, X., Jiang, H., Zhou, Z. Research on Dynamic Fault Recovery Strategy of Distribution Network Based on Multi-objective Optimization Considering Fault Hazard Degree. IEEE, 2021, 4, 6910-6923. https://doi.org/10.1109/ACPEE51499.2021.9436910
2. Liu, J., Tian, Y., Zheng, H. Research on Dynamic Evolution Simulation and Sustainability Evaluation Model of China's Power Supply and Demand System. Energies, 2019, 12(10), 2009-2022. https://doi.org/10.3390/en12102009
3. Lei, H., Baowei, Y., Ting, Y, U. Research on Characteristics of Water Supply and Demand in Shiyan City Based on System Dynamics. Pearl River, 2019, 9(4), 76-89.
4. Niu, G., Ji, Y., Zhang, Z. Clustering analysis of typical scenarios of island power supply system by using cohesive hierarchical clustering based K-Means clustering method. Energy Reports, 2021, 7(6), 10-23. https://doi.org/10.1016/j.egyr.2021.08.049
5. Vaughn, V, M., Saint, S., Krein, S, L. Characteristics of healthcare organisations struggling to improve quality: results from a systematic review of qualitative studies. BMJ Quality And Safety, 2019, (1), 154-167. https://doi.org/10.1136/bmjqs-2017-007573
6. Yao, X., Mao, S. Electric supply and demand forecasting using seasonal grey model based on PSO-SVR. Grey systems: theory and application, 2023, 25(1),159-165. https://doi.org/10.1108/GS-10-2021-0159
7. Yu, K., Guo, W., Chen, X. Research on dynamic control of low-voltage distribution network with high penetration of electric heat pumps based on PMU measurements and data-driven approach. IET Generation, Transmission and Distribution, 2020, 14(19), 864-876. https://doi.org/10.1049/iet-gtd.2020.0864
8. Sun, M., Jiang, H., Lu, Y. A prediction method of residential load transformer demand factor based on time series. Journal of Physics: Conference Series, 2020, 1633(1), 12161-12175. https://doi.org/10.1088/1742-6596/1633/1/012161
9. Jia, J., Yan, X. Research on Characteristics of Wireless Power Transfer System Based on U-Type Coupling Mechanism. Journal of Electrical and Computer Engineering, 2021, (2), 61-69. https://doi.org/10.1155/2021/6683800
10. Li, Y., Chen, Y., Shi, Y., et al. Research on short-term load forecasting under demand response of multi-type power grid connection based on dynamic electricity price. IEEE, 2021, (10), 4096-4106. https://doi.org/10.1109/ICPICS52425.2021.9524096
11. Chai, Q., Cong, W., Chen, C. Research on Demand Forecast of Power Grid Emergency Materials Based on CBR Method Improved by Information Update. Presented at 2019 IEEE 8th International Conference on Advanced Power System Automation and Protection (APAP). IEEE, 336-339. https://doi.org/10.1109/APAP47170.2019.9225094
12. Li, X., Pang, Y., Li, P., et al. Emergency material reserves model based on dynamic programming for icing disaster of power distribution network. Industrial Instrumentation & Automation, 2019, 6, 356-368.
13. Ji, J., Jin, Y., Hua, A. Multiscale Theories and Applications: From Microstructure Design to Macroscopic Assessment for Carbon Nanotubes Networks. Chinese Journal of Mechanical Engineering, 2023, 36(1):1-18. https://doi.org/10.1186/s10033-022-00826-w
14. Pant, K., Thakur, M., Chopra, H, K. Characterization and discrimination of indian propolis based on physico-chemical, techno-functional, thermal and textural properties: A multivariate approach. Journal of King Saud University - Science, 2021, (6), 101405-101417. https://doi.org/10.1016/j.jksus.2021.101405

15. Perry, S, J., Johnson, L, U., Witt, L, A. Equipping soldiers to benefit from goal-focused leadership: The moderating effects of non-discriminatory leader behaviors and workgroup cohesion. Military Psychology, 2021, 33(5), 341-355. https://doi.org/10.1080/08995605.2021.1962182
16. Ashkouti, F., Kham, K., Shei, A. DHkmeans-diversity: distributed hierarchical K-means for satisfaction of the -diversity privacy model using Apache Spark. The Journal of Supercomputing, 2021, 1-35. https://doi.org/10.1007/s11227-021-03958-3
17. Greenhill, L., Stojanovic, T, A., Tett, P. (2020). Does marine planning enable progress towards adaptive governance in marine systems? Lessons from Scotland's regional marine planning process. Maritime Studies, 2020, 19(3),171-176. https://doi.org/10.1007/s40152-020-00171-5
18. Jindal, S, G., Kaur, A. (2020). Automatic Keyword and Sentence based Text Summarization for Software Bug Reports. IEEE Access, 2020, 7(2), 5222-5235.
19. Wang, M., Wu, C., Zhang, P. Multiscale Dynamic Correlation Analysis of Wind-PV Power Station Output Based on TDIC.IEEE Access, 2020, 8, 5533-5546. https://doi.org/10.1109/ACCESS.2020.3035533
20. Wang, H., Zhang, L., Ren, Y. Day-Ahead Scheduling Model Based on Supply-Demand Interaction Mode Considering Production Process of Short-Process Steel Enterprise. Present at Student Conference on Electrical Machines and Systems. IEEE, 2020, 934-941. https://doi.org/10.1109/SCEMS48876.2020.9352312
21. Yan, S., Qian, J., Jin, J, M. An Advanced EM-Plasma Simulator Based on the DGTD Algorithm with Dynamic Adaptation and Multirate Time Integration Techniques. IEEE Journal on Multiscale and Multiphysics Computational Techniques, 2019, 76-87. https://doi.org/10.1109/JMMCT.2019.2901533
22. Liu, Y., Wang, L., Li, M. A distributed dynamic load identification method based on the hierarchical-clustering-oriented radial basis function framework using acceleration signals under convex-fuzzy hybrid uncertainties. Mechanical Systems & Signal Processing, 2022, (172), 172-187. https://doi.org/10.1016/j.ymssp.2022.108935
23. Yuan, L., Ying, C., Yongfu, S. (2021). Research on Short-term Load Forecasting under Demand Response of Multi-type Power Grid Connection Based on Dynamic Electricity Price. IEEE, 2021, 9(2), 96-115. https://doi.org/10.1109/ICPICS52425.2021.9524096
24. Shao, Y., Min, Z., Xia, D. Research about Dynamic Evolution of Supply Chain Based on Agent. Journal of Physics: Conference Series, 1995, (1), 12067-12075. https://doi.org/10.1088/1742-6596/1995/1/012067
25. Zhang, W., Rao, B., Ding, Y. Conceptual Design of the Power Supply for Magnetic Island Divertor Configuration on J-TEXT. IEEE Transactions on Plasma Science, 2020, 4(9), 497-503.
26. Lin, X., Wu, H., Ye, B. (2019). Dynamic Equivalent Modeling of Motors Based on Improved Hierarchical Clustering Algorithm. Journal of Electrical Engineering and Technology, 2019, 14(4), 154-159. https://doi.org/10.1007/s42835-019-00154-5
27. Feng, J., Bin, Z., Yuzhou, Z. Design Research of Distributed Controller of Emergency Power Supply Based on Microgrid. Electric Engineering, 2019, 12(3), 167-179.
28. Han, C, S., Thorup, K, R. Integrated equilibrium planning for emergency logistics warehouse allocation based on internet plus mode. International Journal of Information Technology and Management, 2021, (3), 20-32. https://doi.org/10.1504/IJITM.2021.116054
29. Zhu, C., Fang, G., Wang, Q. Optimization on Emergency Resources Transportation Network Based on Bayes Risk Function: A Case Study. Mathematical Problems in Engineering, 2019, 7(1), 71-79.
30. Shen, Y., Ren, G., Ran B. Cascading failure analysis and robustness optimization of metro networks based on coupled map lattices: a case study of Nanjing, China. Transportation, 2021, 4(6), 66-78. https://doi.org/10.1007/s11116-019-10066-y
31. Xu, L., Wang, C., Dong, W. A method for optimal allocation of regional rail transit emergency resources based on resource sharing. Journal of Physics Conference Series, 2020, 1624, 42037-42045. https://doi.org/10.1088/1742-6596/1624/4/042037
32. Eker, R., Aydin, A., Akay, A, E. Optimization of timber transportation with network approach: A case study from Aladag Forest Enterprise. International Journal on Information, 2020, 16(5), 3145-3154.
33. Vaezi, A., Dalal, J., Verma, M. Designing emergency response network for rail hazmat shipments under uncertainties: Optimization model and case study. Safety Science, 2021, 141(5),105332-105347. https://doi.org/10.1016/j.ssci.2021.105332

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