A Multi-Objective Optimization Algorithm-Based Approach and Research on Enterprise Level Professional Resource Allocation in the Power Industry

Xushan Yin[1,*], Bo Wang[1], Can Qian[1]

*Corresponding author e-mail: xushanyin34@163.com

[1.]Product Development Department, Jiangsu Electric Power Information Technology Co.,Ltd., Nanjing 210000, China

Abstract: At present, China's power industry is still dominated by coal-based power generation, and the energy system of power companies is facing a huge challenge to reduce costs under the strategic requirement of energy conservation and emission reduction. The power industry is the largest non-sustainable energy source and the pillar industry supporting the development of terminal electrification. Therefore, optimizing the resource allocation of the power industry in the process of achieving low-cost energy conversion can reduce both the production cost and the carbon dioxide emission of the enterprises and reduce environmental pollution. The multi-objective optimization algorithm is then applied to the resource allocation of the electric power industry in an attempt to improve the efficiency of resource allocation in the electric power industry, and finally the algorithm is compared experimentally with other algorithms, and the evidence shows the efficiency of this algorithm relative to the extant algorithms. Among them, the multi-objective optimization algorithm based on the multi-objective optimization algorithm can help companies to save 11.8% of electricity costs, therefore, the multi-objective optimization algorithm based on the power industry professional resource allocation method is very worthy of research technology.

Keywords: multi-objective optimization algorithm; power industry; resource allocation methods and research; enterprise level

1.Introduction

With the transformation of China's power industry from a planned economy to a market-oriented direction, China's power market has undergone great changes, and the influx of a large number of companies has broken the original monopoly pattern, making China's power market increasingly competitive. In this context, companies have to reduce the cost of power generation companies by optimizing the allocation of resources. Along with the marketization process, China's power industry has been renewed, and a large number of private enterprises have entered the power industry, breaking the long-standing monopoly situation, and various power companies have blossomed and intensified competition, thus improving the service quality of the power industry, increasing customer value, and optimizing resource allocation guided by economic benefits is crucial.

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At present, a number of scholars have conducted a lot of discussions on the resource allocation problem of the power industry.Liu Z (2021)studied the carbon emission intensity of gas-fired units in different scenarios of the carbon emission intensity of gas-fired units and proposes a development path for the gas-fired power generation industry in the low-carbon transition period, and in order to optimize the allocation of tender far resources and maximize welfare, the share of natural gas and gas-fired power generation in energy consumption should be increased to exert a synergistic emission reduction effect [2];Zeng M(2016) proposed practical solutions to the problems of large investment, imbalance between supply and demand, low operational efficiency of the power industry, distorted electricity price mechanism, unreasonable grid planning and low utilization of renewable energy in China's power industry [1]; Zhang X (2021)studies the power allocation (PA) problem in code division multiple access (PDMA) networks and proposes a multi-objective version of particle swarm optimization to balance various metrics such as outage probability and system throughput, and this research is used to solve the stochasticity problem of renewable energy generation [3]. However, the pain points related to the professional resource allocation [4] in the power industry remain unresolved in the above study and need to be filled by other techniques.

In this paper, we first analyze and discuss the types of resources of electric power companies, construct the electric power resource allocation model in containing wind power, nuclear power, hydroelectric power, coal power or other for experimental analysis, and use the available data to elaborate the multi-objective optimization algorithm, and apply the method to different power generation systems such as coal, wind power, nuclear power, and hydroelectric power [5-6]. In this paper, the multi-objective optimization algorithm is used for the problem of resource allocation in the power industry is discussed in depth, and the effectiveness of the multi-objective algorithm-based resource allocation in the power industry is thus derived.

2 Multi-Objective Optimization Algorithm Applied To Enterprise-Level Professional Resource Allocation In The Power Industry

2.1Multi-objective optimization algorithm

In the study of business and technology, the selection of human resources, the allocation of scarce resources, and the structural design of investment and financing is a complex problem. It involves the optimal solution of the objective function and decision variables. To solve this problem, the objective function and constraints need to be changed. The multi-objective optimization algorithm [7] has undergone a period of development that can be seen in Figure 1.

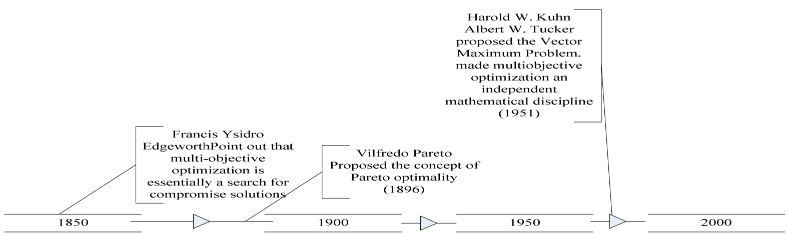

Figure 1. Multi-objective optimization algorithm development

This paper introduces multi-objective optimization evolutionary algorithms, including mathematical concepts, types and algorithmic processes; finally, the main research and related conclusions of multi-objective evolutionary algorithms are summarized in detail.

Due to the multiple objective functions, it is not possible to compare the numerical magnitude of an objective function as in the case of single-objective optimization, so as to determine the relationship between the advantages and disadvantages of the multi-objective optimal solution.

Roughly speaking, for example, the objective of minimization, the multi-objective optimization problem can be defined in the following form.

where x=$(x_1, x_2, \ldots\ldots, x_3)$ is the n-dimensional decision variable whose definition domain is Ω , $F = (f_1, f_2, \ldots\ldots, f_m)$ is the objective vector of the m-dimensional minimization problem, $w_i(x) \leq 0 (1 \leq i \leq a)$ is the i-th inequality constraint, and $q_i(x)$ =0 $(1 \leq j \leq b)$ is the constraint of the j-th equation.

Let x be the decision variable and F be the objective function, then the concept of DS is

$$\{D = X \in A | F' < F\} \quad (1)$$

The above problem includes a variation of the multi-objective optimization problem in which the optimal solution is derived based on the constraints of each objective of the formulation. In the process of multi-objective optimization research, many metrics have been proposed to measure the effectiveness of the algorithm solution, and the three more common metrics in the literature are: Inverted General Distance (IGD) metrics and Set Coverage (SC) metrics. Among them ,Inverted General Distance（IGD）The indicator formula is as follows：

IGD Indicators：

$$\mathrm{I(R, A)} = \frac{\sum_{r \epsilon R} d(r, A)}{B} \quad (2)$$

2.2 flow Of Multi-Objective Optimization Algorithm

In the process of solving the optimal solution, it is often necessary to consider the constraints of achieving each objective to find the optimal solution to achieve the objective. The process of this multi-objective optimization algorithm is:

1) Analysis of the actual problem

2) Establishing the optimization mathematical model

3) Optimization algorithm selection, design and improvement

4) Problem solving

5)Verification of the solution

6)Practical application

2.3power Industry Resource Allocation

China's power sources include hydro, coal, wind, bio-intelligence, natural gas, nuclear energy, etc. These factors affect the allocation of power resources, including environmental policies, energy structure, transmission costs, and land resources. Factors affecting power resources include environmental policies, energy structure, transmission costs, and land resources, which are all key factors affecting the configuration of power resources, among which transmission costs depend on transmission distance, and long-distance cross-region transmission has become the focus of power resource optimization. These factors can determine the economic efficiency of electric power resource allocation. It can be seen that all of these factors will become the values that constrain the target value of resource allocation, and this paper incorporates several factors into the experimental analysis. The amount of new energy installed in China in 2016. Among all installed capacity, coal installed capacity accounted for 60.1% and hydropower installed capacity accounted for 51.6% of all installed capacity; this paper analyzes the distribution of coal, wind and wind energy resources in terms of the distribution of coal, wind and wind energy resources, as shown in Table 1.

Table 1 Distribution of electric power resources in China

Type	Cumulative Installed Capacity		New Installed Capacity	
	Capacity	Percentage	Capacity	Percentage
Coal power	75810	69.07%	5166	69.75%
Nuclear power	24891	22.68%	0	0.00%
Wind Power	5083	4.63%	1670	22.55%
Gas power	1346	1.23%	570	7.70%
Other	2627	2.39%	0	0.00%

To reduce costs across the industry, resources must be allocated to the energy industry. Assuming a smooth marginal cost curve, the marginal cost curve MAC is smooth when the system reaches its optimal cost, and the marginal cost line MAC and the average cost curve AC intersect at point G, at the intersection of MAC = AC, see Figure 2.

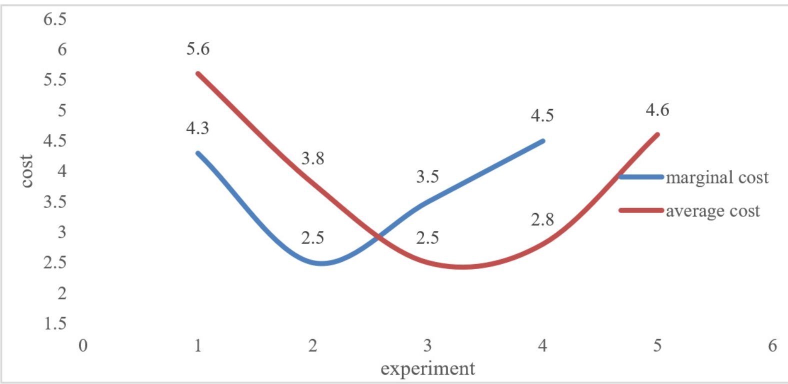

Figure 2. Marginal cost and average cost

3 Power Industry-Level Resource Allocation Based On Multi-Objective Optimization Algorithm

The allocation of power resources is aimed at improving the reliability of power supply, increasing the utilization of clean energy, and optimizing the efficiency of utilization, etc., and is established with the goal of reducing the investment costs of power stations and grid companies in each region [8]. Based on this, a method based on the initial investment, generation variation cost, operation cost and transmission line construction cost of the power grid is proposed, and a cross-regional grid planning optimization model based on the least cost planning scheme is established.

$$\mathrm{MinC_i} = \sum_{i=1}^{l} r(FC+VC+OC+LC) \tag{3}$$

In the objective function, r is the depreciation rate; FC is the fixed cost; VC is the variable cost; OC is the power supply operation and maintenance cost; and LC is the depreciation cost of transmission line construction (in million)

In this problem, since the total resources of each power producer are fixed, it is important to decide how much to invest in the different production resources depending on the generation mode. In accepting the optimum of the resource allocation [9], the algorithm requires that a part of the available resources or all of the power resources are arranged according to the actual situation. And if the purpose is to achieve energy conservation, reduce environmental pollution, etc., first, it is possible to allocate high efficiency and high cost power, which does not require much energy but is costly; second, it is possible to allocate low efficiency and low cost energy, but may require more resources, which may not be costly; and if it is necessary to reduce costs, set low output production resources. Thus, the relationship between production cost, resource quantity, and sustainable use is complex, and the pros and cons have to be weighed in a realistic manner. In this context, in this paper, a hybrid resource allocation planning model is developed to explore the resource allocation [10] and scheduling problems of electric utilities by combining the cost, cost, and sustainable energy use of electric resources.

In this paper, with the lowest generation cost as the optimization objective and load demand, carbon trading price, fuel price and investment cost as the constraints, interval algorithm and control values are used to ensure the safe and economic dispatch of the wind power system, and the predicted output confidence of the wind farm and the limit penetration power of the wind farm are used as the metrics. Based on this, a method based on an improved ant colony algorithm combined with a multi-objective optimization algorithm is proposed. In Tables 2 and 3, the decisions are compared by the utility values of the two algorithms.The so-called utilization rate of electrical equipment refers to the ratio of the comprehensive maximum load actually undertaken by the electrical equipment to its rated capacity.

Table 2. Resource utilization of the optimal solution based on the multi-objective optimization algorithm resource allocation

Utilization rate	Coal power	Nuclear power	Wind Power	Gas power	Other
1	0.60	0.5	0.87	0.89	0.85

2	0.75	0.6	0.56	0.56	0.83
3	0.8	0.9	0.99	0.70	0.70

Table 3. Resource utilization rate based on the optimal solution of resource allocation based on improved ant colony algorithm intelligent algorithm

Utilization rate	Coal power	Nuclear power	Wind Power	Gas power	Other
1	0.57	0.42	0.82	0.87	0.81
2	0.66	0.55	0.53	0.50	0.73
3	0.76	0.85	0.95	0.67	0.64

Algorithm performance analysis

In the case of quantitative analysis of Pareto optimal solutions based on different algorithms, two performance evaluation methods are used in this paper: coverage index and inverse generation interval, as shown below.

a.Coverage index

$$C(B,D) = \frac{\{b \in B | \exists d \in D\ b > c\}}{v} \quad (4)$$

where B and D are the sets of two non-identical Pareto optimal solutions, v denotes the number of optimal solutions in the solution set B, and C(B,D) expresses the percentage of solutions where D is dominated by more than one solution in B to the number of solutions in B.

b. Reverse generation distance

$$IGD(B,P)=\frac{\sum XPmind(x,a)}{P} \quad (5)$$

where P stands for the Pareto optimal solution set, and the best solution is obtained by performing multiple operations on all algorithms to obtain the solution set and then ranking the non-dominated solutions. b is an optimal solution method, where d (x, a) is the Eulerian distance between two solutions x and a. Each solution has 2 components, because reducing different components produces different effects, so in the calculation of the Eulerian distance normalization is used [11-12].IGD (B, P) represents the average distance between each of the actual Pareto optimal solution set P and the set B of non-dominated solutions obtained by some algorithm, and the lower the IGD value, the better performance the corresponding algorithm exhibits [13].

The results proved that the utility values and resource utilization of solving optimal solutions based on multi-objective optimization algorithms in coal, nuclear, wind, gas and others are generally higher than those of improved ant colony algorithm intelligent algorithms, so multi-objective optimization algorithms based on multi-objective optimization algorithms are quite effective tools in resource allocation, and applying multi-objective optimization algorithms to resource allocation in the power industry is recommended [14].

4.Conclusion

Electricity is an indispensable public product, but due to the special nature of coal resources, coal is an important energy source in China, and coal resources are non-renewable. Many places are facing the problem of energy shortage. If the energy cannot be allocated scientifically and efficiently, it will cause great constraints to the social and economic development of the region, thus affecting the living standard of the people. The power resource system is a multi-factor integrated system that requires the synergy of multiple disciplines and subjects to be applied efficiently. Regarding the decision problem of power resource allocation, many scholars at home and abroad have adopted different methods. According to the experiment compared to the traditional algorithm, the multi-objective optimization algorithm based on multi-objective optimization algorithm to deal with the allocation of electric power resources has certain promotion and application value, which is an unparalleled technical method.

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