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Construction of Environmental Economic Dispatching Model Based on Electricity Market Environment

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Abstract: Scheduling is one of the important links to ensure the smooth operation of the power system, and it is the guarantee that the load can obtain high-quality power safely and uninterruptedly. This paper aims to construct an environmental economic distribution model based on the energy market environment, summarize the development origin of intelligent optimization methods and the development problems of multi-objective optimization methods, and explain the basic knowledge of multi-objective optimization problems. Systematic investigation of environmental and economic dispatch problems Based on the existing research results, an environmental and economic dispatch mode of centralized charging piles is constructed for the economic dispatch of centralized charging stations of State Grid Corporation of China. The results of network loss sensitivity analysis show that using the network loss sensitivity analysis method, the network loss caused by the uniform distribution of the central load piles is 20.32 MWh, the network loss caused by the uniform distribution of the central load piles is 23.12 MWh, and the total network loss is reduced by 12.11%. Using the network loss sensitivity analysis method can significantly reduce the network loss.

1. Introduction

Scheduling is an important part of the normal operation of the power system, and it is a necessary condition to ensure the safe operation of the system and the reliable, uninterrupted, and high-quality power supply at the end of the load. Since social production and life are widely dependent on electricity, economic mission plays an important role in saving the total production cost of society [1]. Coal-fired power generation accounts for a large proportion of the entire power industry, and a large number of pollutants emitted during the power generation process have caused serious damage to the living environment. Therefore, it is necessary to grasp environmental awareness from the social production source of power economic dispatch, so this paper intends to conduct in-depth research on Environmental Economic Dispatch (EED), aiming to seek better theoretical methods for environmental economic dispatch of power systems [2].

Through searching in CNKI, Chinese scientific journal database, Wanfang Data and other databases, it is found that there are many domestic and foreign researches on environmental economic dispatching model. Ward K R demonstrates a new algorithm that uses simple functional programming to compute profit-maximizing storage schedules, taking into account their price effects. These are technology agnostic and can be considered from short-term battery storage to inter-seasonal chemical storage (eg electricity-to-gas). These models take into account competitive and monopolistic operators and take 1-10 seconds to schedule GW of storage within a year. A case study using the UK power system shows that failure to model price effects can lead to significant errors in margins and utilisation, while in ~50 GW systems over 100 MW of capacity. A new fuzzy multi-objective optimization method is proposed to solve the multi-objective nonlinear programming problem in the power system optimization model [3]. Dey S established a multi-objective power system optimization model in fuzzy environment. Here, the goal is to (i) minimize fuel costs and (ii) simultaneously minimize emission levels while meeting power balance and generation limit constraints. In this model, the design variable is the power output of the generator. The model is solved by an interactive fuzzy optimization technique, which is tested on a 3 generator system with transmission losses. Empirical results demonstrate the effectiveness of the proposed method [4]. Ridzuan MRM proposes a new meta-heuristic evolutionary programming (NMEP) technique to optimize a single ED problem classified as single-objective environmental economic scheduling (SOEELD), which is derived from primitive meta-heuristic evolutionary programming (Meta-EP) and artificial The integrated immune system (AIS) with new arrangements during mutation and cloning has evolved. The best possible outcome was determined by the NMEP method for each specific objective function. Simulations were performed using MATLAB programming that tested standard IEEE 26 and 57 bus systems [5]. Therefore, the study of environmental economic mission becomes more important.

This paper builds an environmental economic dispatch model based on the power market environment research. How to effectively promote energy conservation and emission reduction in the power system has become a research hotspot for many scholars at present. Considering the emission of pollutants in the operation of the system on the basis of the previous economic dispatch is a multi-constraint, nonlinear and even non-convex (if the valve point effect of the unit is considered) multi-objective optimization problems. With the development of computers, many swarm intelligence optimization algorithms have been proposed to solve this problem. To sum up, it is more practical to study economic dispatch considering environmental impact under the current conditions, and it is of certain theoretical significance to seek effective solutions.

2. Research on Environmental Economic Dispatching Model Based on Electricity Market Environment

2.1. Environmental Economic Dispatch of Power System

Environmental economic dispatch of power system is a planning method based on conventional planning, aiming at the lowest fuel price and optimizing the emission of polluting gas. It is a system that reduces greenhouse gas emissions by adjusting the power generation of each unit according to the power generation cost. The EELD problem is a multi-objective, non-convex, nonlinear and multi-objective optimization problem. How to effectively realize the conflict between constraints and fuel prices and pollution emissions under the condition of satisfying multiple constraints is a problem, and its core is a multi-dimensional optimization problem [6-7].

2.2. Research Status of Environmental Economic Dispatch

(1) The research shows that the BCC algorithm has great potential for optimization, and further research is needed to improve the robustness of the algorithm.

Existing literature studies have improved the bacterial chemotaxis algorithm to make it have the nature of group optimization, which greatly improves the optimization ability; however, there are still many problems in the algorithm: there is still room for improvement in the convergence speed, overcoming the situation of falling into local optimum, The "curse of dimensionality" problem, dealing with multi-objective problems, etc. Therefore, it is necessary to conduct in-depth research on the BCC algorithm to improve the above shortcomings [8-9].

(2) Scheduling modeling and solving in new problems and contexts are challenging

There are few studies on environmental economic dispatching problems under the background of low-carbon technology development, model parameters containing uncertain factors interference, etc. However, these problems are ubiquitous in practice and have a great impact on the model solution, so it is necessary to In-depth research and analysis of the scheduling problems of the above factors are carried out [10-11].

2.3. Economic Dispatch Calculation Method

(1) Particle swarm algorithm

The maximum output of each generator is a particle in the optimal prediction particle swarm, and the economic and emission problems handled by the optimal prediction particle swarm algorithm mainly include: 1 step: the maximum and minimum roughness on the surface of the generator, a particle is randomly released. Step 2: The number of particles is randomly generated [12-13]. Step 3: Measure the activity value of the particles. Particles that violate the demand conditions will be punished, and this value will be adjusted to the particle's pbest. Step 4: Determine the optimal value among all pbest values. Step 5: Re-estimate the latest velocity of the particle [14-15].

(2) Ant Colony Algorithm

First, preparation is based on an insect community optimization problem. Create a search space containing the state and level of the optimization problem, set the number of errors and parameters of the ACO algorithm. Then insects have a system to find their way. According to the law of probabilistic state transition, each insect chooses a state to complete the path. Insects prefer to move to short paths with a large number of pheromone connections [16-17]. Once all insects have completed their routes, the performance of the insects can be evaluated using some appropriate function of the optimization problem. Then update the pheromone between each end [18].

3. Construction of Environmental Economic Dispatching Model Based on Electricity Market Environment

3.1. Data Preparation

In this chapter, the power grid system of three thermal power units is used for simulation verification. The parameter data of each thermal power unit is shown in Table 1.

Table 1. System power plant cost factors and emission factors

Unit	a_i(\$/h)	b_i(\$/(MW ħ))	c_i(\$/(MW^2 ħ))	p_{imax}	p_{imin}
P1	10	100	120	2.0	0.5
P2	15	200	100	2.0	0.5
P3	20	150	80	2.0	0.5

In the table, the values of pimax and pimin related to the active power output of the units are per unit value, and the reference value is 100MW; the three units in the IEEE30-node system are represented by p1, p2, and p3.

3.2. Model Construction

In the power system, the fuel cost function of thermal power units can be expressed as:

$$f_{1k}(P_k^G) = a_{1k}(P_k^G)^2 + b_{1k}P_k^G + c_{1k} \tag{1}$$

where a1k, b1k, and c1k represent the cost coefficient of each thermal power unit.

Thermal power plants will emit a certain amount of nitrogen oxides, sulfur oxides and other polluting gases when they are running. And the emission of these polluting gases will change with the active output power of the unit, and it constitutes a certain functional relationship. In this paper, the following comprehensive model of pollution emissions is used:

$$E = 10^{-2}(\alpha_k + \beta_k P_k^G + \gamma_k (P_k^G)^2) + \varsigma_k \exp(\lambda_k P_k^G) \tag{2}$$

In the formula, E represents the emission of polluting gas.

To sum up, the single-period environmental economic dispatch cost model of the system is expressed as:

$$\min F = \sum_{k=1}^{N_G} f_{1k}(P_k^G) + \sum_{k=1}^{N_G} f_{2k}(P_k^G) \tag{3}$$

3.3. Constraints

Since the simple single-period target model is considered here, the network loss and the unit ramping constraints are not considered when the constraints are added.

The grid power balance constraint is defined as:

$$\sum_{k=1}^{N_G} P_k^G + \sum_{n=1}^{N_W} P_n^W = P^D \tag{4}$$

In the formula, NG represents the total number of thermal power units, and NW represents the total number of wind turbines put into operation in the power grid.

Upper and lower limits of output active power of thermal power units:

$$P_{\min}^G \le P^G \le P_{\max}^G \tag{5}$$

In the formula, P_{max}^G,P_{min}^G respectively represent the upper and lower limits of the active power output by the unit.

4. Analysis and Research of Environmental Economic Dispatching Model Based on Electricity Market Environment

4.1. Overall Comparative Analysis

In order to analyze the impact of centralized charging station access on the total dispatch cost, three different scenarios are set up in this section: Case 1: Considering the charging and discharging of the centralized charging station; Case 2: Only considering the charging of the centralized charging station; Case 3: Excluding the centralized charging stand. The total cost results for the three scenarios are shown in Table 2.

Table 2. Comparison of total costs in different scenarios

Scene	Case 1	Case 2	Case 3
Total cost/dollar	264564.32	286476.56	276543.36
Proportion/%	7.65	0	3.47

As can be seen from Table 2, when only charging at the central charging station is considered, the total cost is $286,476.56; when charging at the central charging station, the total cost is $264,564.32; the total cost is reduced by 7.65%, indicating that charging and charging at the central charging station It's effective. At the same time, the total cost without the central charging station is $276,543.36, which is 4.33% higher than the total cost of charging and charging with the central charging station, which shows the logic of the introduction and use of the central charging station. The total cost ratio is reduced by 3.47% when only considering charging at the central charging station, indicating that considering charging at the central charging station is equivalent to increasing the total system load, thus increasing the total system cost accordingly. As you can see, connecting to a network of central charging stations is an efficient way to save energy.

4.2. Comparative Analysis of Upper-layer Models

When the central charging station is connected to the power grid and is charged and charged from the power grid, the comparison chart of the total output of thermal power units is shown in Figure 1.

It can be seen from Figure 1 that when charging at the central charging station is considered, the output of the module is significantly reduced, indicating that the discharge of the central charging station can reduce the output of the module. Units that consider centralized charging stations are higher than those that do not. The output of the unit increases, that is, the cost condition alone is equal to the increase of the total load of the system and the increase of the total output of the unit. When the central charging station is connected to the power grid, charging and charging are sent from the power grid, which relieves the grid pressure to a certain extent, reduces the total output of the unit, and reduces the total fuel cost in the system, which plays an important role in saving system power consumption.

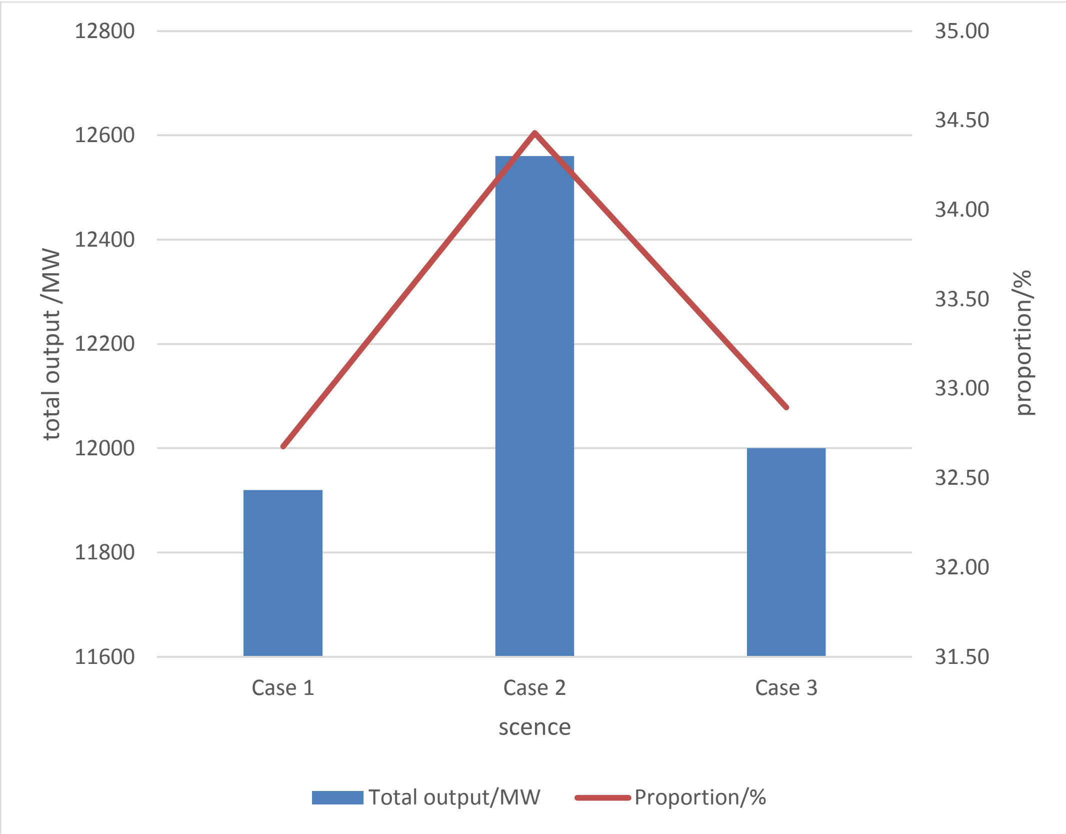

Figure 1. Comparison of unit output results

4.3. Comparative Analysis of Lower Models

In this work, the network loss susceptibility of nodes connected to charging stations at the center of the grid is calculated, as shown in Table 3.

Table 3. Network loss sensitivity of access nodes of centralized charging stations

Node	22	24	28
Network loss sensitivity	0.06	0.34	0.34

As can be seen from Table 3, since the network loss sensitivities of nodes 24 and 28 are equal, the charging and discharging of the two nodes are the same regardless of whether the central charging station is in the charging mode or the charging mode. When the central charging station is in the charging mode, the central charging station is equivalent to a load and is connected to a node that is highly sensitive to network loss, which helps to reduce network loss. It is equivalent to the output of the power supply and connected to the node with low network loss sensitivity. It can play a role in reducing the overall network loss.

In the scheduling model with central charging stations, dispatching central charging stations will cause changes in network loss. The charging station is shown in Figure 2.

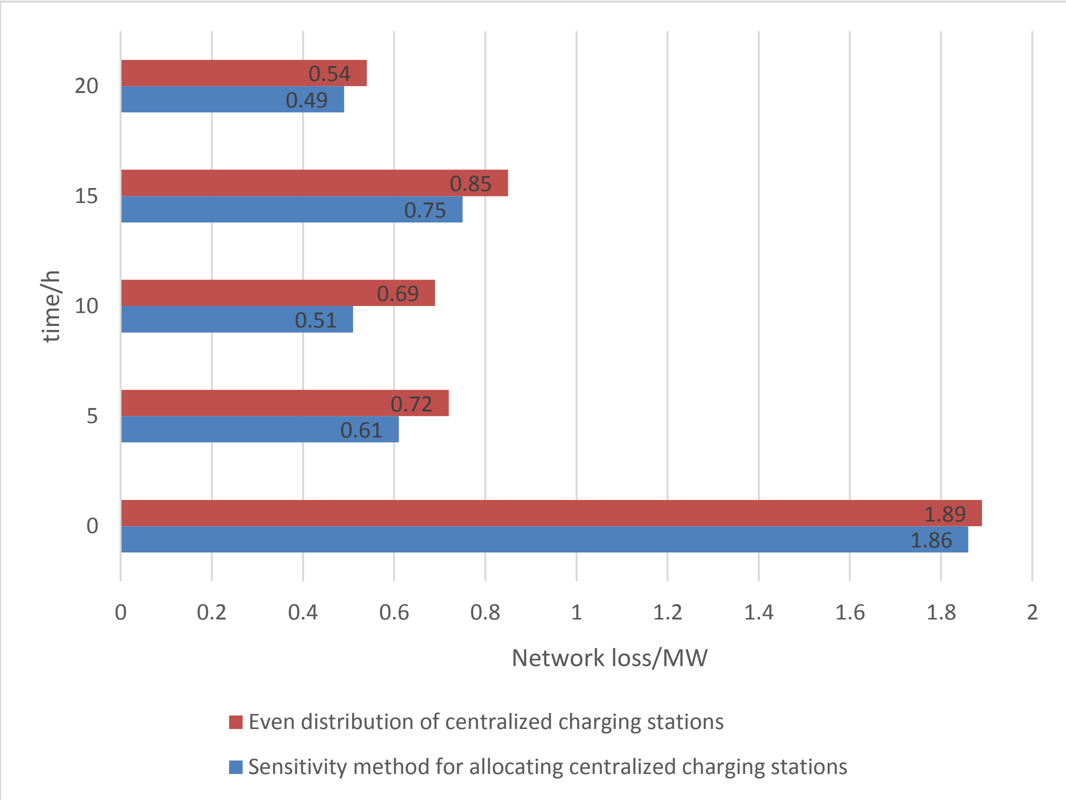

Figure 2. Comparison of network loss results at different times

It can be seen from Figure 2 that no matter whether the central charging station is in the charging mode or the charging mode, the network loss caused by sharing the central charging station using the network loss sensitivity analysis method is smaller than the network loss. Due to the distribution network, the network loss caused by the central charging station is 20.32MWh, while the network loss caused by the uniform distribution of the central charging station is 23.12MWh, and the network loss is reduced by 12.11%, indicating that the loss sensitivity analysis of the network method can be significantly reduced. network loss.

5. Conclusion

This paper builds an environmental economic dispatch model based on the study of the power market environment, and summarizes the environmental and economic issues of power system configuration. A multi-objective optimization method based on nonlinear fractional programming, the specific optimization process of the two optimization methods is given, and they are respectively applied in the static environmental economic dispatch and dynamic environmental economic dispatch of the power system. The analysis results show that the two proposed in this paper are The multi-objective optimization method can well adapt to the multi-constraint and nonlinear actual situation of the power system. Compared with other optimization algorithms, it has obvious advantages. It provides a new idea and method for the field of multi-objective optimization of the power system. However, there are still areas that need to be improved and perfected. For example, in order to better study and verify the optimization performance of these algorithms, these algorithms can be extended to more complex multi-objective environmental economic scheduling problems or multi-objective optimization problems in other fields. applied research.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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