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Optimal Scheduling of Park Integrated Energy System Based on Dynamic Game Method

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Abstract: Recently, the energy crisis and deterioration have seriously restricted the improvement of our country. It is urgent to build a safe energy system. The emergence of the integrated energy system is a breakthrough and reform of the traditional energy system. The system is one of the main forms of the system. The purpose of this paper is to analyze the electricity demand and cooling demand of consumer energy based on the dynamic game method of the scheduling of the system, and the motion dynamic game method. The results show that the electrical trading volume and wholesale price of the electricity grid and the natural gas network, that is, the difference in their respective production costs, are the main factors that cause the profit gap between them.

1. Introduction

The system is complex, and the dynamic characteristics of the equipment are diverse. The system can not only increase the flexibility of the social energy supply system, but also reduce the environmental pollution caused by energy consumption, which is of great significance for improving energy utilization [1]. With the data transmission system, the monitoring of the operating status of the system becomes more and more important. As one of the important data processing methods for monitoring the operation state of the integrated energy system, state estimation can not only grasp the actual situation, but also provide reliable data support.

The state estimation of the system is an important basis for the reliable, economical and safe operation of the integrated energy system. Real-time monitoring, analysis and evaluation of the system is an important technical link of the system. It provide important technical support for the improvement of the system. Technical Support.According to Yammani C, the number has increased in recent years for their many environmental benefits. With proper charging and charging of EVs from the vehicle to the grid, the power system can gain controllable storage/generation. A new scheduling mechanism is proposed to determine what batteries are charged/discharged to maximize EV owner profits and respond to power system outages, taking into account the impact of power availability update shocks. This target depends on several criteria, such as the purchase and sale price of energy, battery price situation, availability of renewable DG energy and balancing.A new approach to analysis was improved that eliminates probabilities and choices to reveal the truth [2]. Ghofrane R believes that many of the systems installed today are limited applications because they are designed due to increasing energy demands. Numerous techniques have been proposed to plan operations and reduce energy consumption. In fact, he proposed a new hybrid intervention based on DVS and a combination of neurofeedback planning and an energy-first advance line algorithm [3] to deal with real-time planning of low-energy embedded systems.However, due to the increasing scale and type of energy contained, the traditional state estimation method will no longer be suitable for the state monitoring.

This paper studies the research status of the system, the system, the structure of the typical park-type integrated energy system, the introduction, and the connotation and rise of the dynamic game. In the experiment, the coefficient and value gas were studied, and the electricity demand and cooling demand of consumer energy were analyzed.

2. Research on the Optimal Scheduling of Park Integrated Energy System Based on Dynamic Game Method

2.1. Research Status

Technologies have always been valued by countries around the world. Different countries often formulate their own integrated energy improvement strategies based on their own needs and characteristics. Carrying out research on systems is significant to enhance the country's independent innovation capability. In the construction of the system, the actual domestic situation is not considered, and there is a lack of scientific analysis and applicability [4]. There is a lack of clear conclusions on the planning of the integrated energy system, and it is difficult to set reliable and effective indicators to the construction of services. At present, the improvement scale of the system is expanding, the types of energy included increase, and the cost of building and maintaining the integrated energy system is relatively high. It is necessary to coordinate and optimize energy in terms of multi-energy complementarity to ensure and reduce maintenance and construction costs. At present, there are no mature and reliable results for the actual operation of the integrated energy system, and there is a lack of reality in simulation and experiment [5]. Considering the complementarity between energy sources and the complexity of mutual conversion between energy sources, a unified simulation platform has not been established at home and abroad. The operation characteristic curve of the grid-connected combined heat and power energy system is simulated, and the energy price of the open energy market is predicted and corrected in real time, so as to realize the profit optimization.

2.2. Integrated Energy System

Compared with the traditional microgrid, the system of the supply framework has multi-energy flow, multi-coupling and multi-energy supply mode. Traditional integrated energy systems include combined cooling, heating and power (CCHP), gas boilers, electric refrigeration systems, photovoltaic power generation equipment, wind turbines, batteries, etc., which can exchange electrical energy with external power grids [6]. In this paper, the tank are introduced on the basis of traditional modeling, which helps the system to realize flexible scheduling, improve energy utilization, and realize peak shaving and valley filling of cooling and heating loads.

The energy of the comprehensive energy system of the park includes: natural gas, wind, light and other clean energy, purchasing electricity from grid companies, etc. Considering that the output of renewable energy equipment is intermittent and fluctuating [7]. In the system, the core energy supply system is the CCHP system, which realizes the energy and improves the conversion efficiency [8]. Cold energy can be produced by steam passing through an absorption chiller. Gas boilers produce heat directly, while thermal storage tanks translate heat loads and store heat. The electric refrigerator can directly produce cold energy, and the cold storage tank can translate the cold load and store the cold energy. Rely on CCHP system, photovoltaic power generation, wind power generation, battery supply and external power purchase to balance the electricity load demand [9].

2.3. Typical Park-Type Integrated Energy System Structure

The core technology in the system is the combined cooling, heating and power technology. The power generation unit is used to generate electricity, and the waste heat generated by the power generation unit is fully utilized for cooling and heating. This energy cascade utilization greatly improves the energy utilization rate. The power generation unit equipment includes gas turbines, micro-gas turbines and gas boilers. Taking gas turbines as an example, in order to use the outlet temperature of the flue gas, it is generally used in conjunction with the waste heat boiler. It is often used in conjunction with absorption chillers and gas boilers [10]. Power generation units, photovoltaics, fans, batteries and grids work together, heat pumps and electric chillers. Its demand is met by the output, the lithium bromide unit and the cold storage device. The lithium bromide unit provides the baseline heat load, and the electric refrigeration unit and the cold storage device are used for peak regulation [11]. The hot water load is met by plate heat exchangers, gas boilers, heat pumps and cooling and heating machines.

2.4. Comprehensive Energy System of the Park

(1) Introduction to the comprehensive energy system of the park

The comprehensive energy system of the park refers to the refined management of the production, conversion, transmission, storage, supply, transaction, consumption and other links in the system. Realize the system, and form a new energy system with multiple subjects, multiple links, sensitivity, high efficiency and integration [12].

(2) The basic characteristics

In the system of the park, it no longer relies on the backbone of a certain energy source, but focuses on the synergistic operation effect brought by various energy sources in the interactive coupling state [13]. The system has the following two characteristics: (1) Improve the stability of the energy system supply. Compared with the single energy network, in the comprehensive energy with complementary electricity-gas-heat multi-energy, the energy conversion coupling device provides an effective guarantee for the failure of each energy network, enhances the self-healing ability of the system, and guarantees The stability of energy supply; (2) Integrate the storage of gas, and heat to provide a backup guarantee for energy supply [14].

2.5. Overview of Dynamic Game Theory

(1) The Connotation of Dynamic Game

The basic feature of dynamic games is that the behaviors of each player are in sequence. In most cases, the player who chooses later can observe the behavior of other players that he chooses before he actually chooses. The person who chooses first may benefit more than the person who chooses later, a situation called "first mover advantage". Because the latter-chosen players have more information to help themselves choose, which can reduce their blindness in decision-making, they are in a more favorable position in terms of information, and they may get more benefits than other players. This situation is called the "backward mover advantage" [15].

(2) The Rise of Dynamic Game Theory

Urban residents are not only affected by personal factors and environmental factors, but also by other travelers when making travel mode choices [16]. In traditional game theory, it is assumed that the players in the game are completely rational people and always pursue the maximization of benefits, but the theoretical results often deviate greatly from the actual situation, so bounded rationality begins to enter the attention of researchers. Game theory, as the fastest-growing and most influential branch of economics in the last century, has become the core content of mainstream economics, and has also become a basic analytical tool for economists [17]. Classical game theory analysis assumes that the game party has the characteristics of a strictly rational person, but the game in reality is often difficult to meet the requirements of complete rationality, and the traditional game theory gradually exposes its own problems in the research. Until the 1980s, related scholars began to seek the Nash equilibrium solution under the dynamic structure under the assumption of "bounded rationality" to break through the limitations of traditional game theory research, aiming at the assumption defects of traditional game theory. The mainstream research theory in the theory [18].

3. Investigation and Research on Optimal Scheduling of Integrated Energy System in Park Based on Dynamic Game Method

3.1. Research Content

Our proposed method is tested on a system with natural gas grid, grid and multiple DENs during the planning phase. In order to understand the electricity demand and cooling demand of consumer energy, through the multi-attribute analysis, multi-evidence reasoning and utility evaluation methods in the dynamic game method, we select the average utility value of the 4 candidates. Compare the retail prices of electric coolers for DNE1, DEN2 and DEN3.

3.2. Dynamic Game Method

$N = \{1,2,3,K .n\}$ represents the participant, and the participant refers to the participant in the game, also known as the game party, which refers to the individual or organization in the game that can make independent decisions, act independently, and bear the decision-making results; strategy refers to the participant's action a. In a game, each player has multiple alternative actions, and each action is called a strategy of the player. The set of all strategies of a player is called the player's strategy set or action space A, and $A = \{A_1, A_2, A_3, K\ A_n\}$ indicates that the strategies of all players in a game constitute the strategy set of the game. Profits refer to the rewards that each participant receives after choosing a strategy. The revenue function inputs the participant's joint strategy space $A_1 \times A_2 \times A_3 \times \cdots \times A_n$, and outputs the obtained revenue value R. The income of each participant depends not only on the choice of its own strategy, but also on the strategy choice of other participants. Earnings can be positive or negative. The specific formula is as follows:

$$N = \{1,2,3,\ldots n\} \tag{1}$$

$$A = \{A_1, A_2, A_3, \ldots A_n\} \tag{2}$$

$$r_i : A_1 \times A_2 \times A_3 \times \cdots \times A_n \to R \tag{3}$$

4. Analysis and Research on Optimal Scheduling of Park Integrated Energy System Based on Dynamic Game Method

In terms of wind speed, the change of real-time wind speed is not obvious at different times of the day due to its strong irregularity. On the contrary, the solar radiation intensity varies greatly in different time periods. It's shown in Figure 1 and Table 1:

Table 1. Parameters related to pollution emission

Parameter	Unit	Pollutant		
		Carbon monoxide	Carbon dioxide	Sulfur dioxide
Electric energy	g/kWh	0.1154	715	7.21
Natural gas	g/kWh	0.1841	196.0457	0.000842
Environmental value	$/lkg	0.1567	0.00457	0.964

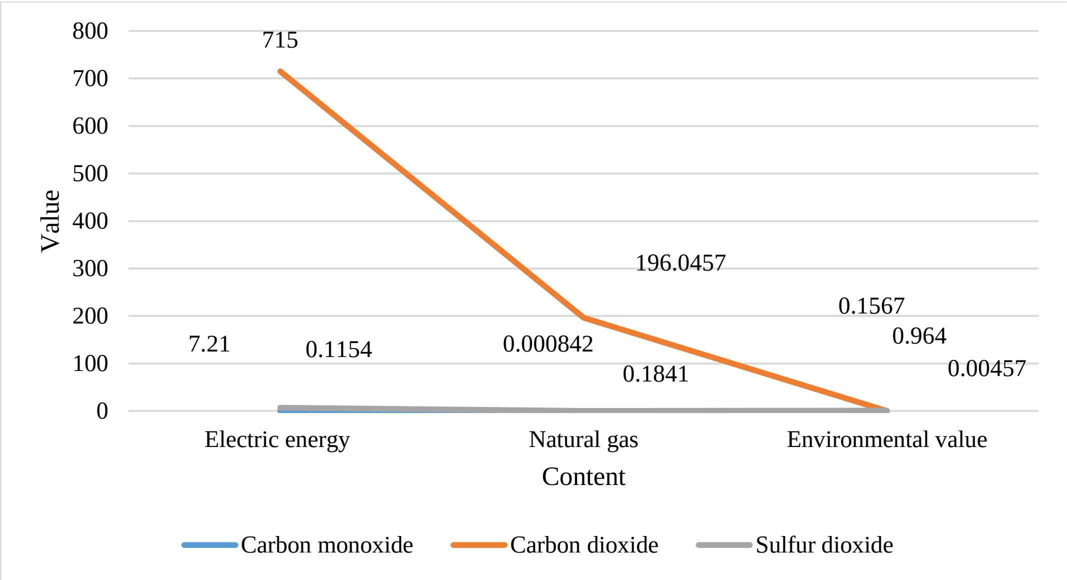

Figure 1. Comparison chart of three energy pollution emissions from environmental value, natural gas and electricity

We will test our proposed method on a system with natural gas grid, grid and multiple DENs, we obtained the average utility value of the four candidate programs, as shown in Table 2 and Figure 2, Table 3 and Figure 3:

Table 2. Consumer energy and electricity demand

Energy users	Electricity demand (MW)		
	DEN 1	DEN 2	DEN 3
1	1.69	1.69	1.69
2	5.12	4.19	4.19
3	6.51	5.14	5.14
4	7.14	4.12	4.12

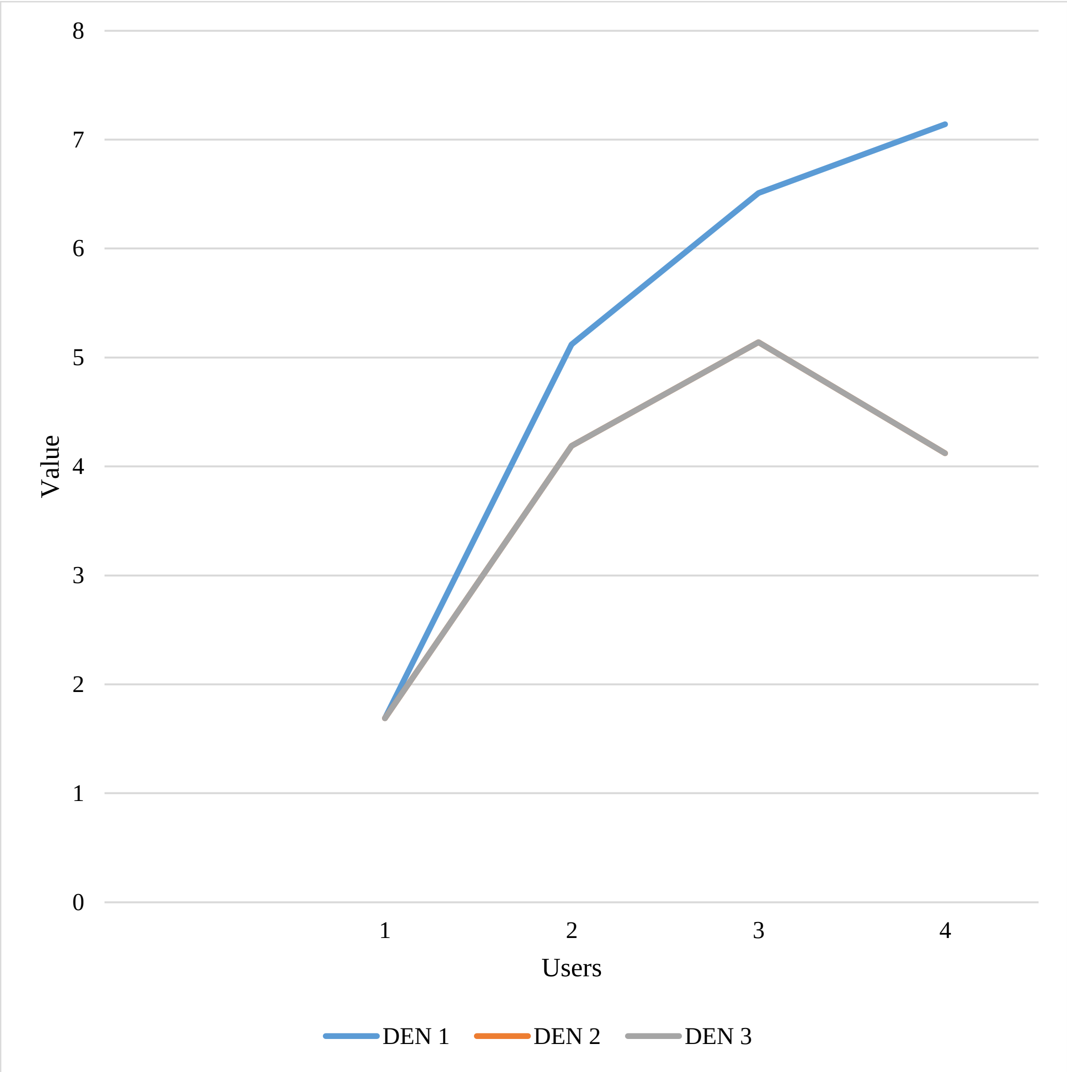

Figure 2. Electricity demand and energy comparison diagram of D E N 1-3

Table 3. Consumer demand for energy cooling

Energy users	Cold demand (MW)		
	DEN 1	DEN 2	DEN 3
1	5.18	4.01	4.01
2	7.59	6.13	6.13
3	8.96	7.67	7.67
4	11.9	10.4	10.4

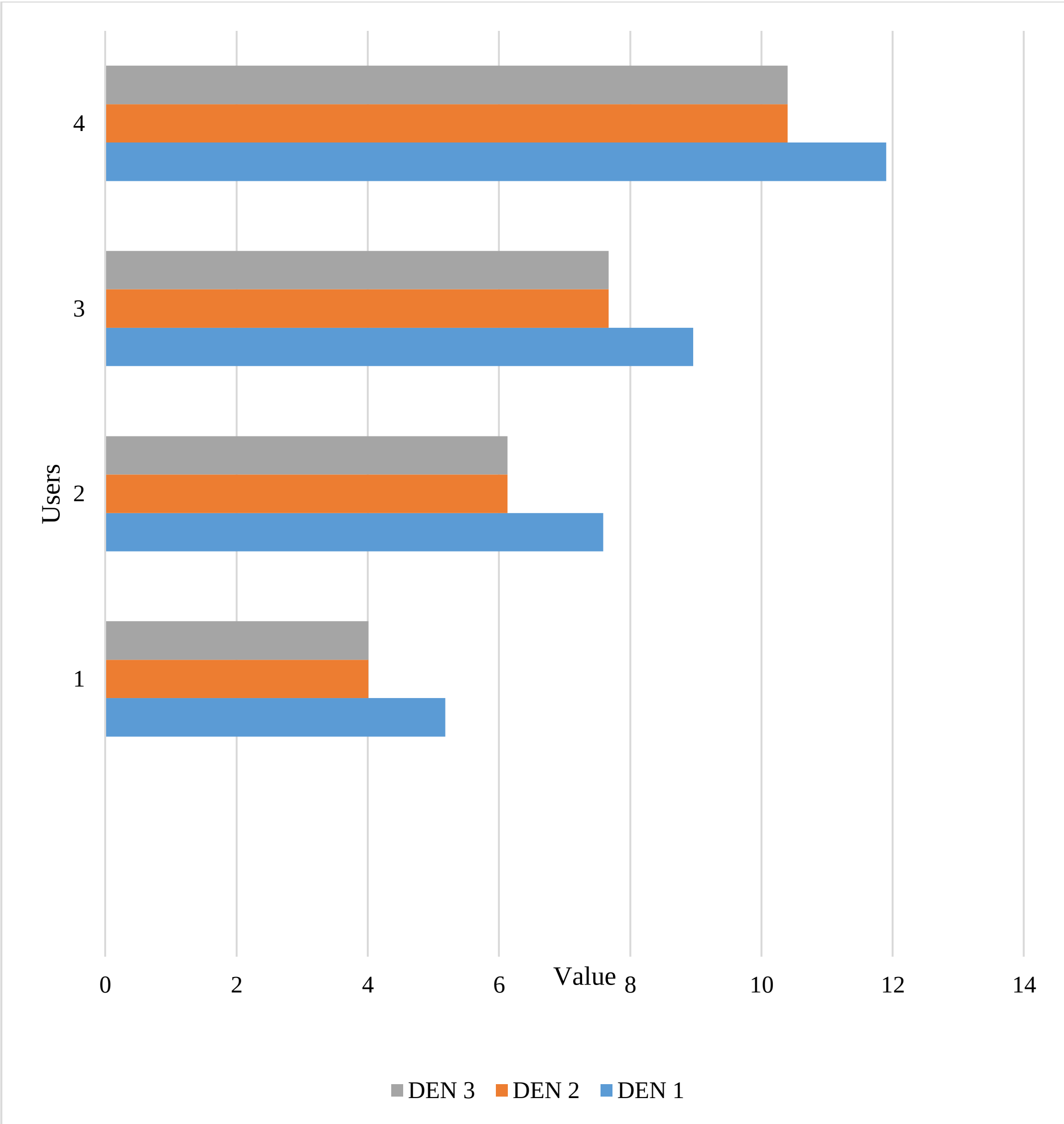

Figure 3. Cold demand energy comparison diagram of D E N 1-3

The results show that even if the retail electricity price and user energy demand in DEN1 are significantly higher than those in the other two regions, it fails to make the DESs in DEN1 obtain higher profits than those in other regions in the local market competition environment. The main reason for this phenomenon is that in DEN1, the number of DESs involved in energy trading is more than that in DEN2 and DEN3, which makes the competition in DEN1 more intense, thereby reducing the profits that DESs in DEN1 can obtain.

In addition, comparing the results of DESs in DEN2 and DEN3, we can find that all DESs in DEN3 are less profitable than DEN2. The retail prices of electric coolers for DEN2 and DEN3 are very similar, respectively, and make the unit energy sales revenue of DESs in the two regions very similar. Therefore, the difference in the electrical transaction volume and wholesale price of each DES in DEN2 and DEN3 with the grid and gas grid, that is, their respective production costs, are the main factors that cause the profit difference between them.

5.Conclusion

The park-type integrated energy system is the improvement trend of future energy. Renewable energy such as wind, light and biomass energy is used as the energy supply side to combine with the integrated energy system and the demand side response of the park. consumption, reducing the pollution of primary energy to the environment. In practical engineering applications, the optimization of the park-type integrated energy system is a complex problem involved, and more research work can be carried out in future theoretical 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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