Research on the interconnection and rapid deployment of smart energy service platforms under multi-factor game balance

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Abstract. This paper firstly models the relationship between power companies, photovoltaic power generation, wind power generation networks, and users as a three-stage Steinberg game. In this game model, the power company is the dominant player and the leader of the entire game. Secondly, with the game model, a detailed analysis is carried out to obtain the optimal strategy of each game party. Finally, the simplified model was simulated and verified. The simulation result is consistent with the theoretical solution result. The research results of this paper have improved the level of energy services and innovated energy service models.

1 Research background and its significance

At present, a new round of energy revolution is accelerating on a global scale. Smart energy has emerged and developed rapidly, profoundly changing the production and lifestyle of human society. Smart energy, that is, an energy form that has human brain functions such as self-organization, self-inspection, self-balancing, and self-optimization, and meets the requirements of system, safety, cleanliness, and economy. It is not only the ultimate goal of the energy revolution, but also the necessary process of the energy revolution. It is regarded as the basic source of power to set off the third wave of industrial revolution. The smart energy revolution will promote the rapid development of a huge market.

Paras Sitoula has studied the context-aware smart energy recommender [1]; Quanyan Zhu. Researched the game theory model and design mechanism of deception and anti-deception[2]; Xiaotong Wu researched game theory about mobile location privacy[3];Pan Li researched mixed utility functions for unexpected suggestions[4]; Xiaozhong Zhang researched interactive view recommendation[5]; Changhui Yang studied the economic benefit evaluation of distributed photovoltaic energy storage hybrid system based on dynamic load;Eren Yildiz studied the defragmentation of energy storage in battery-less sensor devices; Jiasheng Zhang studied the use of independent system operators to invest and manage stored energy as public assets; Vikas Hassija studied the energy transaction framework between

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solar base stations and the grid based on blockchain; But none of them use game theory to improve energy service levels and innovate energy service models.

2 Energy research of smart energy service platform based on game theory

This paper fully considers the relationship and interaction between power companies, thermal power generation, solar power generation, wind power generation, and users. The smart grid system composed of the three is modeled as a Steinberg game model. The users are determined by a dominant power The company and multiple photovoltaic power generation and wind power generation networks provide power to users at the same time, and users have a higher preference for the electricity sold by photovoltaic power generation and wind power generation networks based on renewable energy power generation. The total number of power companies is recorded as I, the total number of photovoltaic and wind power generation networks is recorded as M, and the total number of users is recorded as C. Among them, the leader of the power company game, photovoltaic power generation, wind power generation network and users are the followers of the game.[6]

This paper adopts a method based on multi-objective optimization. The utility functions of power companies, photovoltaic power generation and wind power generation networks are all modeled as electricity sales minus power generation costs and pollution emission costs, and the user's utility function modeling is user satisfaction minus purchases. Electricity expenses.

The utility function of the power company is:[7]

$$
\begin{aligned}
&U_g\left(L_g, p_g\right) \\
&= R_g\left(L_g, p_g\right) - C_g\left(L_g\right) - I_g\left(L_g\right) \\
&= L_g p_g - a_g\left(L_g\right)^2 - b_g L_g - c_g - \alpha_g\left(L_g\right)^2 - \beta_g L_g
\end{aligned}
$$

$$(1)$$

In the above announcement, the meaning of each function is:

$R_g\left(L_g, p_g\right)$ --Electricity company sales income;

$C_g\left(L_g\right)$ --Electricity company generation cost;

$I_g\left(L_g\right)$ --The cost of polluting emissions from power companies;

p_g --Electricity price;

$L_g = \sum\limits_{c=1}^{c} L_{c,g}$ The amount of electricity purchased by all users from the power company.

The three-stage Steinberg game process is as follows:[8]

The first stage: the dominant power company, as the leader of the game, first release the electricity price p_g [9].

The second stage: the m-th photovoltaic power generation and wind power generation network, as a follower of the game, decides its own electricity price as p_m according to the electricity price p_g issued by the power company:

The third stage: the c user, as a follower of the game, determines the power purchase $L_{c,g}$ from the power company based on the electricity price p_g issued by the power company in the first stage and the electricity price p_m issued by the photovoltaic power generation and wind power generation network in the second stage , The electricity purchased from mth photovoltaic power generation and wind power generation network $L_{c,m}$.

3 Simulation analysis

According to the mathematical model using matlab to simulate, the simulation results are as follows:
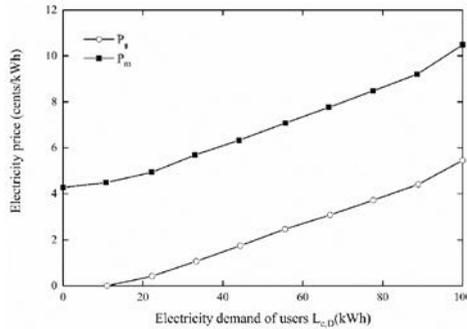

Fig. 1. The trend of electricity sales prices of power companies and photovoltaic power generation and wind power generation networks with changes in user power demand.
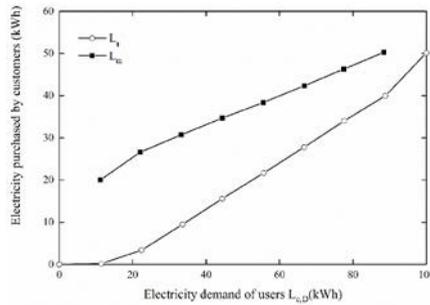

Fig. 2. The trend of power purchases from power companies, photovoltaic power generation and wind power generation networks by users along with changes in user power demand.
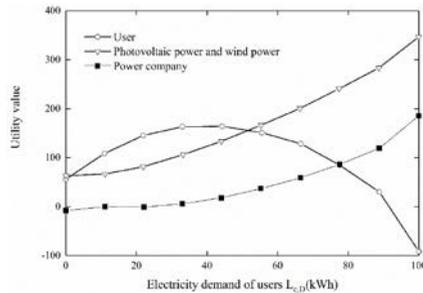

Fig. 3. The utility value of power companies, photovoltaic power generation networks, and users' utility value changes with users' electricity demand.

4 Conclusion

This paper proposes an energy management strategy for photovoltaic power generation and wind power generation networks based on the three-stage Steinberg game. In the first stage, a dominant power company in the system announces its own electricity selling price; in the second stage, multiple photovoltaic and wind power generation networks in the system decide to sell electricity according to the decision of the power company in the first stage Price: In the third stage, users adjust their own electricity demand and announce the amount of electricity demand based on the price of electricity sold by the power company and multiple photovoltaic and wind power generation networks.

The research results of this paper have improved the level of energy services and innovated energy service models. The research results of this paper expand the service business areas and revenues of integrated energy companies, expand the integrated energy service market, and improve the revenue capabilities of integrated energy companies. The research results of this paper have improved the energy service quality and satisfaction of residents. By providing differentiated intelligent energy-using precision services for residents, it can improve the participation and satisfaction of residents' comprehensive energy services and demand response, and solve the problem of high residential customers. The demand for quality services enhances the stickiness of residents. The research results of this article can guarantee economic and social development and improve people's quality of life. Through the analysis and evaluation of household electricity and energy consumption, it provides users with scientific and reasonable energy use suggestions, promotes the scientific and orderly use of electricity by residents, improves energy utilization efficiency, and guarantees sustainable economic and social development; at the same time, clean, A low-carbon, reliable and safe energy supply system will help improve the quality of people's lives.

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