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Design and Application of Global Energy Trade Cross Border E-commerce Optimization Model

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Abstract

INTRODUCTION: With the continuous advancement of global economic integration, cross-border energy trade activities internationally are becoming increasingly frequent.
OBJECTIVES: To improve the efficiency of energy trade, this study is devoted to exploring the optimization model of cross-border e-commerce in global energy trade. Introducing advanced information technology and e-commerce platforms aims to facilitate the digital transformation of energy trade, improve transaction efficiency, reduce costs, and promote sustainable energy development.
METHODS: This study adopts a comprehensive methodology, including a literature review, case analysis, and model construction. First, relevant literature on global energy trade and cross-border e-commerce was thoroughly studied to understand the current development status and existing problems. Second, the successful experiences and challenges of cross-border e-commerce in enhancing the efficiency of energy trade are summarized through the analysis of several international cases. Finally, a set of optimization models that comprehensively consider market demand, technical conditions, and policy environment are constructed to guide the development of cross-border e-commerce in global energy trade. RESULTS: The empirical analysis of the optimization model reveals that cross-border e-commerce has significant potential in international energy trade. The model can effectively improve transaction efficiency, reduce the risk of information asymmetry, and promote the balanced development of the global energy market. It is also observed that digital transformation significantly affects the promotion of sustainable energy, providing a more sustainable path for global energy transition.
CONCLUSION: By establishing a cross-border e-commerce optimization model for international energy trade, this study provides substantial theoretical and empirical support for promoting the digital transformation of energy trade. In the future, governments, enterprises, and international organizations can draw on the conclusions of this study to formulate relevant policies and strategies to promote global energy trade jointly toward a more efficient and sustainable development path.

Keywords: energy trade; cross-border e-commerce; international logistics; network optimization

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1 Introduction

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As the global economy continues to flourish and globalization advances further, energy trade, an indispensable cornerstone of international economic operations, is increasingly becoming a close link between countries[1]. Despite the remarkable development in this vital area, the traditional energy trade model is still mired in a series of problems, such as information asymmetry, inefficient transactions, and high costs, which have seriously constrained the further development of the global energy market and impeded the widespread promotion of sustainable energy[2]. In the current context, cross-border e-commerce, with its innovative trade methods, provides unique opportunities and challenges for optimizing global energy trade[3]. The rapid rise of e-commerce has brought about digital and intelligent changes in various industries, and in the energy sector, this trend offers unprecedented opportunities to break through traditional trade barriers and promote international cooperation and development[4]. Cross-border e-commerce is driven by its ability to improve trade efficiency, reduce transaction costs, and drive the evolution of the energy market toward a more innovative, more efficient, and sustainable direction. With the ongoing increase in cross-border e-commerce transaction volume, logistics efficiency has become a critical factor impacting business profitability[5]. As cross-border e-commerce platforms vary in quality and price of goods, it is necessary to provide good service to gain more customers and improve their competitiveness and brand recognition[6]. Improving the quality and efficacy of cross-border logistics has become crucial for cross-border e-commerce companies looking to boost core competitiveness[7]. However, with the increasing growth of cross-border e-commerce, the traditional method of foreign acquisition no longer meets client expectations.

With the rapid advancement of information technology, e-commerce has quickly spread throughout numerous industries, ushering in a complete revolution in digitization and intelligence in trade activities. Cross-border e-commerce in the energy sector has a bright future, potentially breaking down traditional trade barriers and boosting international collaboration and global energy market development[8]. As a result, the study will thoroughly investigate the cross-border e-commerce optimization model in global energy trade, with the goal of increasing energy trade efficiency and lowering transaction costs through the use of cutting-edge information technology, effectively promoting the global energy market toward more sustainable development[9]. The rapid progress of information technology has laid the foundation for the application of e-commerce in many fields, and its digital and intelligent features are changing the face of business interactions[10]. In the energy sector, the introduction of cross-border e-commerce is regarded as a disruptive innovation, which is expected to break the constraints of the traditional trade model and bring broader international cooperation and development opportunities to the energy market[11]. The study aims to provide a key impetus to the sustainable development of the global energy market through an in-depth analysis of the optimization model of cross-border e-commerce in international energy trade and through the introduction of advanced information technology, which is dedicated to improving the operational efficiency of energy trade and reducing the costs of related transactions[12]. This research will provide theoretical support and practical guidance for building a more flexible, efficient, and sustainable energy trade model.

This paper will specifically sub-situational construct the three aspects of developing a comprehensive discussion of cross-border e-commerce in optimizing the application of global energy trade[13]. The in-depth study of the worldwide energy market is expected to provide valuable theoretical guidance and empirical support for promoting the digital transformation of energy trade and contribute to constructing a more efficient, fair, and sustainable global energy trade system.

2 Related work

China's network coverage rate has surpassed 50%, and 4G network penetration has exceeded 50%, paving the way for the rapid expansion of cross-border e-commerce. It is worth emphasizing that China has achieved exceptional comprehensive national strength and income improvement following reform and opening up[13]. Today, China is the world's second-largest consumer group behind the United States, hastening the expansion of cross-border trade. Since 2008, China's cross-border e-commerce business has grown at an average annual rate of more than 40%; since 2000, China's foreign trade business has increased at an average yearly rate of even higher than 40%, and in 2018 alone, it exceeded \$10 trillion[14]. The rise of globalization and the operation of large-scale platforms provide limitless commercial potential for cross-border e-commerce, so there is an increasing interest in studying it.

Considering that the logistics network planning for overseas warehouses involves a multitude of factors, including transportation cost, location of overseas warehouses, upfront investment, merchandise demurrage, returns, timeliness, customer satisfaction, etc., which makes the complexity of this problem increase dramatically, and the difficulty of solving it increases dramatically[15]. Therefore, there is an urgent need to find a multi-objective optimization algorithm to cope with the comprehensive and multi-level nature of this problem.

In recent years, a new evolutionary multi-objective optimization algorithm has been proposed. The traditional EMO method first generates individuals using an evolutionary algorithm and then uses a differential population maintenance strategy to rank the advantages of the individuals to obtain a solution that approximates the Pareto frontier[16]. Being able to generate multiple solutions without falling into local extremes, the population search method has become a research hotspot in several evolutionary algorithms research fields, and some milestones have been achieved. According to the difference in the optimal preservation strategy, the traditional EMO methods can be divided into two main categories: based on the optimal conformal strategy[17]. The first generation of evolutionary multi-objective evolutionary algorithms maintains population diversity by finding the optimal solution and sharing the adaptation values of the optimal solution[18]. Examples include Multi-Objective Genetic Algorithm (MOGA), Ecological Position Based Pareto Dominance (NPGA), and Non-inferior Solution Ordering Based Multi-Objective Genetic Algorithm (NSGA)[19]. The second generation of EMO methods is based on the original genetic algorithms and uses an external population-based approach to maintain elite individuals[20]. For example, genetic algorithms based on Pareto optimal solutions (SPEA, SPEA2), external population-based evolutionary strategies (PAES) and the most classical NSGA-II[21]. For the optimization problem of multi-modal joint transportation networks, a path-based optimization algorithm is proposed and solved by using the decomposition search algorithm, which proves that the proposed method can better solve the 150-node nontrivial problems and is better than some existing approximate solutions.

3 Research Methodology

3.1 Energy cross-border e-commerce

The rapid advancement of information and communication technology, new energy technology, and smart grid technology has had a tremendous impact on the energy, industrial, transportation, and other sectors. Energy cross-border e-commerce is the result of integrating information and communication in the energy industry, an important tool for promoting the transformation of China's energy structure and sustainable growth, and has received international attention in recent years. Domestic and foreign research on energy cross-border e-commerce is now increasing, but a better grasp of this idea is required.

Starting from the Internet, this project aims to research "plug and play" and "two-way flow of energy and information" when accessing intelligent terminals such as new energy and electric vehicles. The project has carried out an in-depth reform of the open peer-to-peer concept and framework of cross-border e-commerce from the core equipment, form, structure, and operation mode to the development concept and other levels. Rivkin provides a new business concept for enterprises, which can decentralize the use, sharing, and energy across boundaries to conduct business. With the continued development of the Internet, this idea will bring new changes and development opportunities to the energy industry. The power router is the core device to realize energy cross-border e-commerce, and its function is equivalent to the router in the information network. And scholars at home and abroad have conducted much research on this. North Carolina State University in the United States has developed an energy router device based on electrical power and information technology, combining energy and information flow. Waseda University in Japan and VPEC jointly developed a power routing protocol for cluster networks, which can regulate power output by stored energy. The University of Tokyo, Japan, has set up a digital grid power router based on "IP addresses." Prof. Kozan of Clemson University in the United States has also developed a line for transmitting energy packets derived from sending telegrams on the Internet. Energy cross-border electricity, according to a team from Tsinghua University's Institute of Information Technology, is a new kind of information-energy convergence vast area network with microgrids, distributed power sources, and other energy sources acting as the local area network and a large power grid serving as the backbone. Additionally, a number of research teams from the National Defense University (NDU) and the Chinese Academy of Electrical Sciences (CAES) have examined energy cross-border e-commerce via the perspective of cross-border e-commerce.

Analyzing the results of existing studies divides them into two types: broad and narrow. From an overall perspective, energy cross-border e-commerce includes a series of networks such as electric power systems, oil and gas pipeline networks, and energy transportation and logistics networks; from a narrow perspective, energy cross-border e-commerce includes smart grids, power generation equipment facilities, and distributed energy supply systems. Despite the differences in scope, they all essentially encompass the fact that with the deep integration of ICT and the energy system, the value creation model of the energy system has undergone a profound change. The rapid development of information and communication networks represented by the Internet has given rise to a new network economy, and the wave of "Internet+" has swept across the world. Network thinking, characterized by "decentralization," "sharing," "transparency," and "openness," reflects the development of a new economy based on information networks. Network thinking, characterized by "decentralization," "sharing," "transparency," and "openness," reflects the changes in the law of new economic development based on the information network. This project is based on the main line of "value," starting from the perspective of energy cross-border e-commerce, from the perspective of "value," from the perspective of "user demand," from the perspective of "energy," "transparency," and "openness." "Energy," "information," and "service" are constructed on three levels. The essential framework and path of value creation at the three levels of "energy," "information," and "service" is constructed from the perspective of "user needs."

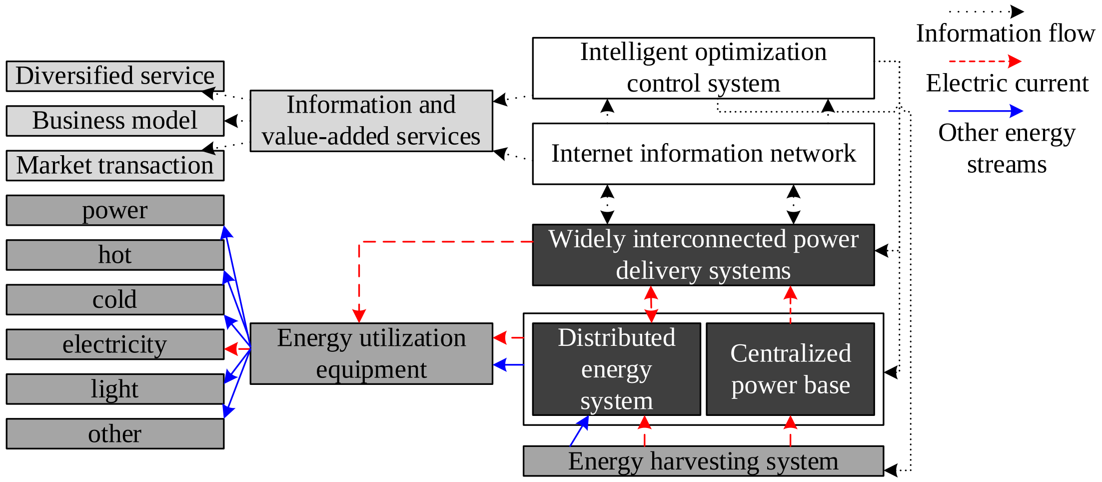

Figure 1. Energy cross-border e-commerce

The energy system is complex and colossal energy production and use of a variety of technical systems collectively, with intelligent energy as a carrier, the integration of various types of power supply and load conversion devices, the formation of centralized and distributed system optimization and local optimization of the interconnection of complementary layered network structure, to achieve the "one source, one load" of the deep interaction, to achieve the multi-energy Complementary optimization, to provide maximum support for the development of clean energy. Based on the above research results, it is necessary to construct an open and functional information network and functional platform to promote the intelligent development of the energy system and create new values. To address this issue, this project proposes to build an "integrated" energy platform from the three levels of "seamless access at the device level," "optimized configuration at the system level," and "two-way energy interaction." The project aims to build an "integrated" energy ecosystem that realizes the demand for energy supply and the identity of multiple users and cultivates a new type of business model.

Traditional energy is a rigid system with a lack of flexibility regarding access, withdrawal, and transmission of electrical energy, resulting in a lack of dynamic flexibility and composability. The vertical multi-layer control approach is slow to respond and cannot build a system with real-time, configurability and reconfigurability; the self-healing nature of the system is all based on entity redundancy; there is a single service object and a one-way transmission of information; there are more information silos in the system, which does not allow for the sharing of information. Although local automation continues to increase, the overall level of energy intelligence is low because of the incompleteness of information and the lack of a real-time, organic, and unified approach based on the network. The development of cross-border e-commerce energy trading can help to improve the efficiency of energy utilization and avoid energy waste, which is in line with the requirements of sustainable development. First, the traditional energy supply, which is represented by coal, oil, and natural gas, is becoming more and more tense. For this reason, cross-border e-commerce energy trading is very important to the energy industry.

Secondly, for renewable energy sources, cross-border e-commerce for energy trading can accelerate the dissemination and popularization of such energy sources. China is replacing coal-fired power generation with new energy sources such as photovoltaic and wind power. However, the intermittent and fluctuating nature of light and wind makes centralized energy scheduling unable to realize the simultaneous integration of the two into the grid, resulting in China's current "abandoned light and wind" problem. In this case, cross-border e-commerce is used to solve the problem of photovoltaic wind power consumption and ensure the rapid development of new energy.

The last is to carry out cross-border e-commerce energy trading, accelerating China's power system reform. Cross-border e-commerce energy can guarantee the reliability of the power system while maintaining a certain level of resource utilization efficiency and reducing the security risks associated with large-scale energy.

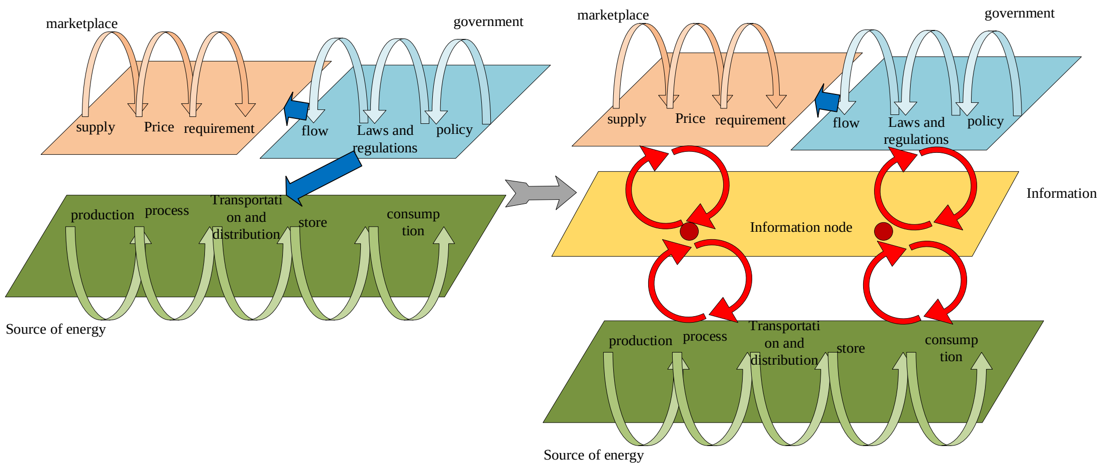

Figure 2. Smart Energy

3.2 Objective model optimization algorithm

Multi-objective optimization algorithms are a class of algorithms used to solve optimization problems with multiple objective functions. In a multi-objective optimization problem, multiple conflicting objectives must be optimally solved under certain constraints. Following are some of the standard multi-objective optimization algorithms:

The generalized objective optimization problem is:

$$\min/\max\ f_m(x), \qquad m=1,2,...,M \tag{1}$$

$$\begin{aligned} &\textit{subject to } g_j(x) \geq 0, \quad j=1,2,...,J \\ &h_k(x)=0, \quad k=1,2,...K \\ &\underset{\textit{lower bound}}{x_j^{(L)}} \leq x_i \leq \underset{\textit{upper bound}}{x_i^{(U)}}, i=1,2,...n \end{aligned} \tag{2}$$

The constraints are:

$$f(x)=(f_1(x), f_2(x),..., f_k(x)) \tag{3}$$

$$e(x)=(e_1(x), e_2(x),..., e_m(x)) \leq 0 \tag{4}$$

$$x=(x_1, x_2,..., x_n) \in X, f=(f_1, f_2,..., f_k) \in F \tag{5}$$

Genetic Algorithms: Genetic algorithms are heuristic optimization algorithms based on natural selection and genetic mechanisms.In biology, its design is inspired by the process of evolution. The genetic algorithm looks for the Pareto optimal solution, or set of viable solutions in the search space, by mimicking fundamental biological processes including natural selection, crossover, and mutation. It stands for a non-dominated solution that is incapable of being further enhanced in the face of several competing goals. During the execution of the algorithm, the genes of an individual are expressed as solutions to the problem, and the genetic manipulation of the genes mimics the process of genetic transmission in biological evolution. The concept of natural selection is applied to the fitness evaluation process, which increases the likelihood that people with greater fitness will be passed down to the next generation. Genes from two parents are crossed during crossover operations to create new offspring, simulating the process of hybridization in organisms. In order to simulate the occurrence of gene mutation in an organism, the mutation operation induces random changes in genes. Such a genetic mechanism allows the algorithm to maintain the diversity of the population during the search process, thus making it more likely that multiple Pareto optimal solutions will be found. By borrowing the evolutionary principle from nature, the genetic algorithm explores and maintains multiple potential optimal solutions in the search space in a way that is adaptable and can be applied to multi-objective optimization problems, providing a powerful and flexible optimization tool for solving practical problems.

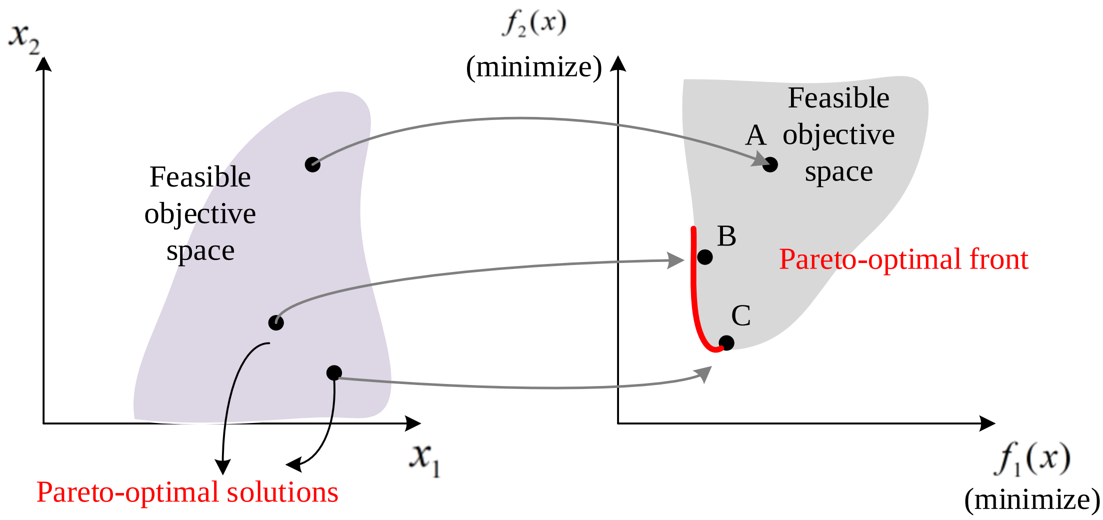

Figure 3. Objective optimization problem

The multi-objective particle swarm optimization algorithm is a kind of particle swarm optimization algorithms designed for optimization problems involving several objective functions. Unlike classical single-objective particle swarm optimization, MOPSO's primary purpose is to find Pareto-optimal solution sets, which are not dominated by any other solution's overall objective functions.MOPSO coordinates the movement and search of numerous particles in order to find and maintain Pareto-optimal solution sets. The key idea of the algorithm is to motivate the particles to search for the global Pareto optimal solutions in the multi-objective space by introducing a multi-objective evaluation criterion so that the position and velocity updates of each particle take into account the optimization needs of multiple objectives.

On the other hand, NSGA-II is a multi-objective optimization algorithm based on a genetic algorithm. It efficiently manages and updates the Pareto optimal set in the population by using the non-dominance ordering and the crowding degree operator. The non-dominated ordering is used to classify individuals into multiple hierarchies to identify dominance relationships. At the same time, the crowding degree operator helps maintain a more homogeneous Pareto optimal set and motivates the algorithm to search better in the solution space. Both algorithms have been significantly influential in multi-objective optimization, representing the superior performance of particle swarm optimization and genetic algorithms. By combining these algorithms, researchers can obtain richer solution sets in solving complex multi-objective optimization problems, providing decision-makers with a more comprehensive choice space.

MOEA/D, or Multi-Objective Evolutionary Algorithm based on the decomposition idea, is an evolutionary algorithm for solving multi-objective optimization problems. Its uniqueness lies in the decomposition idea, which transforms the original complex multi-objective problem into a set of relatively simple single-objective sub-problems to realize the solution of the overall optimization problem.MOEA/D uses the decomposition strategy to decompose the multi-objective problem into independent single-objective sub-problems. Each subproblem is responsible for optimizing a weight vector associated with it, reflecting the objective's relative importance in the overall multi-objective problem. The algorithm starts with a set of randomly generated initial solutions as a starting point for the population. These solutions will be gradually optimized in the subsequent evolutionary process. Each individual is evaluated under the current weight vector and selects others in the neighborhood for information exchange. This process helps to steer the search in a direction that makes it more focused in the direction of the more weighted targets, and evolutionary operations, including operations such as crossover and mutation, are performed independently for each subproblem to improve the quality of the solutions gradually. This step evolves the population by simulating the process of biological evolution through constant eugenics. Neighborhood relationships between individuals are updated based on their relative performance. This helps to promote information sharing in the population to improve the global search performance by reassigning individuals to other subproblems based on their contributions to different subproblems. This helps increase the algorithm's diversity and makes the search more global. The algorithm terminates when a predefined stopping condition is reached, for example, when the number of iterations comes to a predefined value or when a solution satisfies the requirements, at which point the set of Pareto-optimal solutions found by the algorithm is output.

The process of running the multi-objective optimization algorithm obtains the Pareto optimal solution set, i.e., the set of solutions that other solutions under multiple objective functions cannot dominate. Extract the accurate values of each solution on each objective function from the Pareto optimal solution set and use kernel density estimation methods to plot the kernel density for each objective function in the objective space. This can be done using professional data visualization tools or corresponding libraries in programming languages, adding axis labels to represent each objective function. At the same time, if multiple Pareto optimal solution sets exist, different colors or legends can be used to identify them. Adjust the parameters of the kernel density plot, such as the bandwidth, as needed for a more straightforward presentation, and consider adding other information to the plot, such as a scatter plot to indicate the actual location of the Pareto optimal solution set or adding a marginal histogram to the edge of the graph to interpret the graph and emphasize the distribution of the Pareto optimal solution set in the objective space. Distribution characteristics of the Pareto optimal solution set.

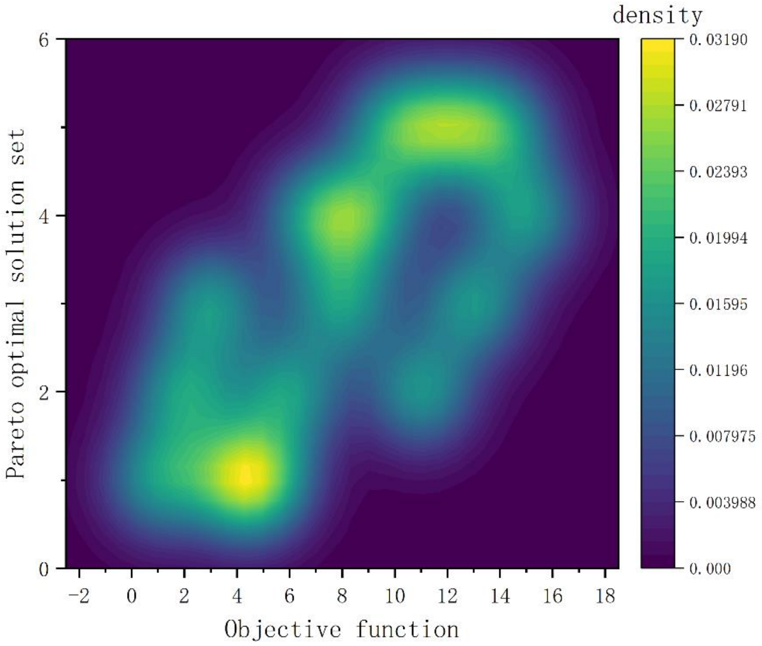

Figure 4. Target kernel density

By plotting the kernel density, the distribution of the Pareto-optimal solutions in the objective space can be more intuitively understood, providing decision-makers with more information about the trade-offs between different objectives.

4 Energy cross-border e-commerce optimization model

4.1 Targeted Empirical Results

The energy cross-border e-commerce model is closely related to weight vectors, direction vectors, and Pareto optimal solutions. When faced with a multi-objective optimization issue, each objective is given a weight that reflects its relative importance. These weights are grouped into a weight vector, the precise value of which is typically chosen by the decision maker or the nature of the situation. Direction vectors are then used to indicate the search direction or optimization direction. In a multi-objective optimization scenario, direction vectors can guide the adjustment of decision variables to find a superior solution.

A Pareto optimal solution is a special set of answers to a multiobjective optimization problem that contain options that can't be improved upon without having an impact on the other objectives. A set of non-inferior solutions to the problem, or one where an equilibrium is formed among the numerous objectives such that no single modification may better one objective without worsening the other objectives, is known as the set of Pareto optimal solutions. When faced with multi-objective choices, decision-makers can refer to the Pareto optimum solutions as a potential collection of optimal solutions to the problem.

The role of the weight vector is to guide the selection of the direction vector. In a multi-objective optimization problem, the direction of the weight vector is closely related to the choice of the direction vector because the weight vector reflects the relative priority of the objectives. The direction vector may focus on searching for those solutions in the direction of the objectives with larger weights to achieve a better balance. The formation of Pareto optimal solutions is influenced by the weight vector. Since the weight vector reflects the relative importance of the objectives, the Pareto optimal solutions will be more in line with the decision maker's preferences, which is precisely the guiding role of the weight vector. Selecting direction vectors plays a key role when searching for Pareto optimal solutions. By adjusting the direction vector, the search can be made to proceed in a more favorable direction to reach the Pareto optimal solution.

In this study, WFG1-WFG9 are taken as the research objects, and representative 2D test functions are selected. The original MOEA/D-US algorithm is considered and the improved MOEA/D-US method with uniform distribution is used for algorithm selection. The performance of the algorithms was explicitly compared with the MOEA/D-AW algorithm, which is an improvement of the MOEA/D-US aimed at avoiding the influence of the uniform search direction on the results to make the comparison more fair and accurate. The study used a composite particle filtering algorithm, and a detailed comparison of the effects of MOEA/D-US and MOEA/D-AW was performed. The solution sets' convergence, diversity, and global performance were analyzed in a comprehensive comparison using various methods such as the Intergenerational Distance Index, Spacing Index, Postgenerational Distance Index, and Overcapacity Index.

To ensure the reliability of the results, 20 experiments were conducted independently for each algorithm for each test function. Through this series of experiments and comparisons, the author aim to comprehensively understand the performance differences between the algorithms in solving complex multi-objective problems and provide strong empirical support for further research in multi-objective optimization.

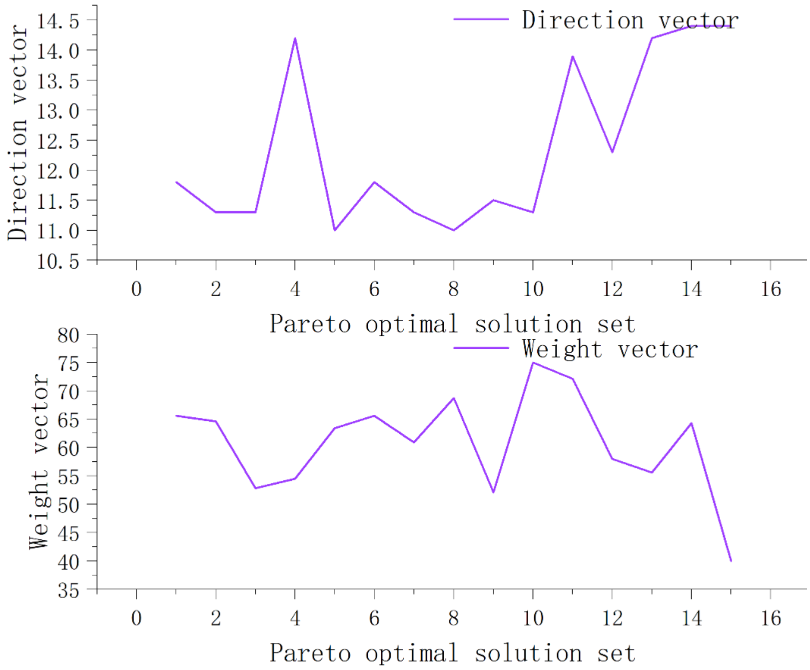

Figure 5. Relationship between weight vector, direction vector, and Pareto optimal solution

By analyzing the relationship between the uniform distribution of weighting vectors, uniformly distributed search direction vectors, and uniformly distributed optimal solution sets, it is suggested that the generation method of balanced distribution be adopted in the multi-objective evolutionary algorithm. Aiming at the characteristics of unknown frontier information of multi-objective testing problems in practical applications, this project proposes to study a new multi-objective optimization-based method and integrate it with the existing MOEA/D method to form a new solution method. Experiments have been conducted on several representative test functions, such as WFG1-WFG9, and the results show that the method has better convergence and more uniform distribution. This project proposes a new efficient solving method and compares it with four methods, MOEA/D-AW, to obtain better solving results.

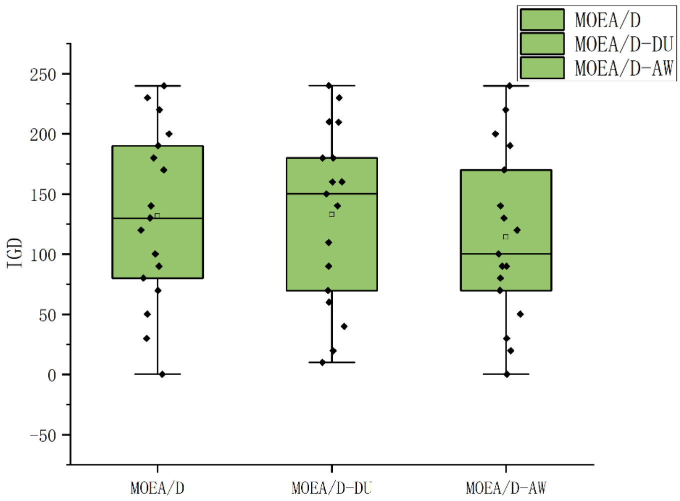

Figure 6. IGD Indicator

This project is planned to adopt the MOEA/D-AW methodology and work on designing an innovative binary mixing and mutation-based cross-border resource allocation strategy for energy trade by establishing a real-valued coding-based decoding criterion for solving the multi-objective optimization problem of energy trade in terms of efficiency and accuracy. Under this framework, the constraints existing in the actual situation are fully considered, and the generation-based new solution correction strategy is thoroughly investigated to enhance the efficiency of population evolution and improve the solution quality simultaneously.

To cope with complex constraints more comprehensively, the focus is on developing a new solution correction strategy that can effectively deal with new solutions in multi-objective problems to ensure that the algorithms can evolve robustly in the face of practical constraints. Ultimately, multiple optimal allocations of energy resources for cross-border e-commerce will be proposed by combining them with the decision maker's preferences, and empirical tests will verify their effectiveness.

To improve the search efficiency of the algorithm, its performance and accuracy are continuously optimized to find the best solution more quickly. Through this series of research and optimization, this project aims to provide innovative and efficient solutions to the energy multi-objective optimization problem and practical decision support for the resource allocation problem in cross-border e-commerce.

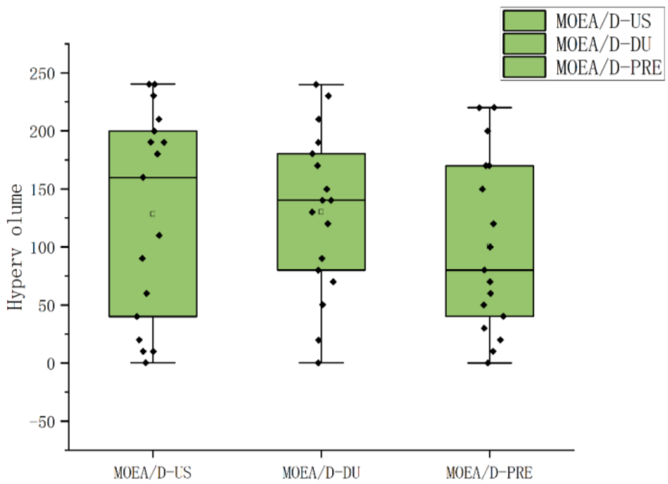

Figure 7. Comparison of indicators

4.2 Optimization Performance Analysis

To improve the performance of the global energy trade e-commerce model, a series of strategies and optimization measures are taken to consider adopting a distributed architecture, splitting the system into multiple services or modules to improve parallel processing capabilities and system scalability, and using appropriate caching mechanisms to reduce frequent access to databases or other resources. This can significantly improve response time. Optimize database queries using indexes, suitable data types, and sound database design to improve query performance. Consider database sharding to handle large amounts of data, use load balancers to distribute requests to multiple servers to ensure that the system can balance the load and improve overall performance and availability, and use asynchronous task processing to improve system responsiveness, especially when dealing with large amounts of data or complex computations. Asynchronous processing is a method of improving the response time of a system by pushing tasks to the background for processing without blocking the execution of the main program, which enhances system responsiveness. When processing large amounts of data or complex computations, asynchronous task processing can optimize system performance by using task queues to manage asynchronous tasks. Tasks that require asynchronous processing are added to the queue, and then the background process handles these tasks individually. This ensures that tasks are executed sequentially and avoids resource contention. For distributed systems, message queues are a common asynchronous processing mechanism. Asynchronous messages are sent between system components through message queues, thus decoupling and improving system scalability, introducing background workers or task schedulers responsible for executing asynchronous tasks. This helps people to manage better and monitor the execution of background tasks. Asynchronous task processing improves the concurrency performance of the system as it allows the system to process multiple tasks simultaneously without waiting for each task to complete. Implement appropriate error-handling mechanisms to handle errors that may occur with asynchronous tasks. This includes logging.

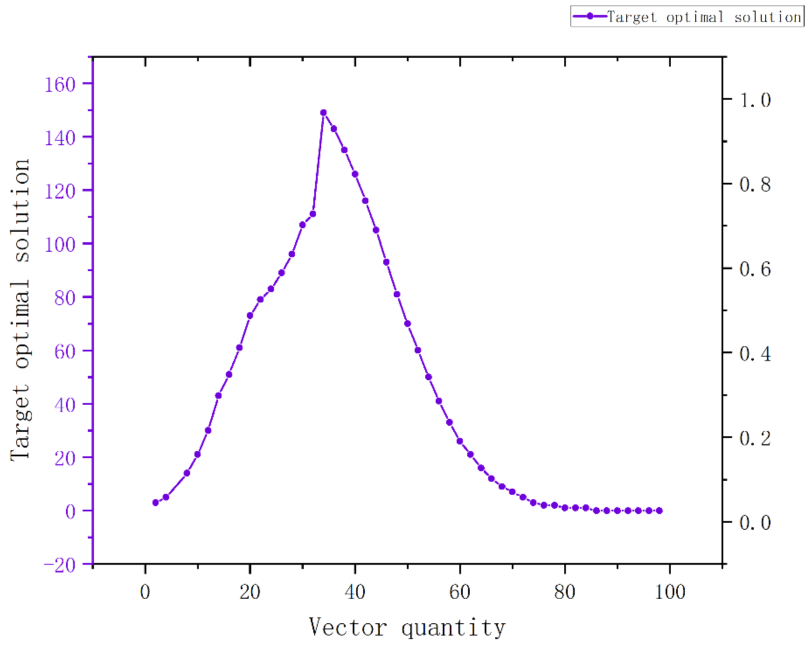

Figure 8. High-dimensional objective optimization

Optimize network communication to reduce request response time. Consider using a content distribution network (CDN) to accelerate the loading of static resources while using compression algorithms to reduce the amount of data transferred, enable appropriate client-side and server-side caching to reduce data transfer time, implement effective concurrency control strategies to prevent data conflicts and ensure data consistency, and ensure that system security is maintained while optimizing performance. Use appropriate encryption and authentication mechanisms to prevent potential security threats, establish a regular performance testing process to monitor system performance and identify and resolve potential issues promptly, and conduct capacity planning following business expectations and development plans to ensure that the system will still be able to deliver high performance under future loads. Continuously monitor the latest technology trends and consider upgrading system components when appropriate to capitalize on the performance enhancements of new technologies.

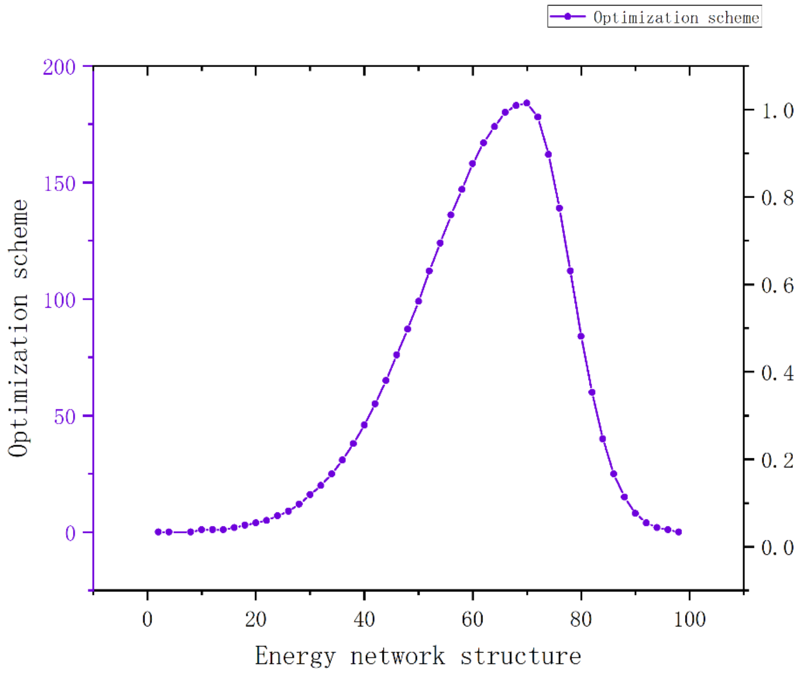

Figure 9. Optimization model

Using a multi-objective evolutionary method based on partial order and congestion distance sampling, this study attempts to explore the multi-objective optimization problem of cross-border e-commerce for energy trading. Given the inadequacy of existing algorithms in dealing with discretization problems, this project plans to establish a series of hybrid and variational strategies using real-valued coding and decoding criteria. Through the design of these strategies, the multi-objective optimization problem in energy trade cross-border e-commerce energy will be effectively solved and transformed into an easy-to-operate adaptive function. In addition, to overcome the constraints in real issues, the project will propose new solution correction strategies to facilitate population evolution and improve the solution quality. The project's final results are expected to provide effective and tractable solutions in cross-border e-commerce for energy trade.

Based on the optimization solution derived from the algorithm, combined with the decision maker's preference, various eligible energy trade cross-border e-commerce energy resource optimization allocation schemes are provided. This research will use the dominance dimension as an entry point to deeply explore the role of high-dimensional evolutionary algorithms in energy trade and cross-border energy resource optimization allocation and provide a new thinking path for future research on multi-objective optimization problems. The research results of this project will provide innovative insights and methods for solving cross-border challenges in the field of energy, and by using different multi-objective algorithms, provide more decadent references for solving the optimization of cross-border e-commerce problems in energy trade and promote the research and practice in this field. This diversified approach contributes to a more comprehensive understanding of the problem's complexity, provides more flexible options for decision-makers, and offers broader insights for future related research.

5 Conclusion

This work investigates an optimization model for the comprehensive analysis of international energy trade cross-border e-commerce. The possible effects of e-commerce on global energy trade are thoroughly examined throughout the research, and a novel optimization model is suggested to raise the sustainability and efficiency of energy trade. An in-depth analysis of the global energy market not only reveals the great potential of e-commerce in facilitating cross-border trade, enhancing market transparency, and reducing transaction costs but also highlights that the adoption of an advanced e-commerce platform is expected to accelerate the supply chain process and simplify the cumbersome steps to improve the overall efficiency in the current global energy trade environment. In the design of the optimization model, advanced algorithms and techniques are employed to ensure that the model is accurate and practical. The study results show that introducing the proposed e-commerce optimization model will enable global energy trade to achieve a more efficient, secure, and economical transaction process. This will positively boost the development and cooperation of energy markets in various countries. An in-depth global energy market analysis reveals that e-commerce can facilitate cross-border trade, enhance market transparency, and reduce transaction costs. The study further emphasizes that adopting advanced e-commerce platforms can help accelerate the entire supply chain process, reduce unnecessary steps, and improve overall efficiency in the current global energy trade context. In terms of model optimization, advanced algorithms and techniques are employed to ensure the accuracy and practicality of the model. The study results show that introducing advanced model optimization for e-commerce makes it possible to achieve a faster, safer, and more economical transaction process in the global energy trade. This has a positive impact on the development and cooperation of the energy markets of various countries but also provides strong support for future innovation and efficiency improvement of the industry. The study offers an innovative and feasible optimization model in the field of global energy trade, which is a powerful reference for governments, enterprises, and relevant stakeholders. By adopting the proposed model, international energy trade can be promoted to achieve more efficient, sustainable, and intelligent development.

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