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Research on the Performance Management of Carbon Reduction by Local Governments from a Game Perspective—The Case of the Zhejiang Power Restriction Incident

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Abstract: The implementation of low-carbon development and carbon reduction has become an issue of general concern. When local governments adopt carbon reduction measures, they inevitably have a negative impact on the economic development of enterprises and the daily lives of residents. However, the resolution of conflicts of interest between local governments, enterprises, and residents will have a direct impact on the motivation and effectiveness of local governments in implementing carbon reduction measures. This study takes China as an example, conducts a case review of the actual situation of the Zhejiang power restriction incident, and studies and constructs a tripartite evolutionary game model based on the local government, enterprises, and residents. By exploring the factors that influence the behavioral strategies of each stakeholder, this study finds the equilibrium conditions that the tripartite governance target model must satisfy. It is suggested that interactive feedback from enterprises and residents should be incorporated into the performance management of local governments and that performance assessment should be used to establish an effective responsibility and pressure transmission mechanism to help the government's internal control to better implement carbon reduction policies.

Keywords: evolutionary game; energy conservation; emission reduction; government performance management; collaborative governance



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1. Introduction

In recent decades, global warming caused by increased carbon emissions has attracted the attention of countries worldwide. Since 1997, most countries around the world have successively signed the Kyoto Protocol, which shows that they are willing to take the initiative and the responsibility to reduce greenhouse gas emissions [1]. As one of the first economies to sign the Kyoto Protocol, the EU has actively promoted the implementation of regional carbon reduction measures. The EU's policy of sustainability measures mainly includes two types of tools: the use of carbon taxes and other major means to adjust the prices of goods and services and a focus on changing the behavior of producers and consumers. An example includes the carbon boundary adjustment mechanism [2]. In addition, it is assumed that each entity has a carbon emission share and an issuance of carbon emission licenses, and the price is determined through the market's supply and demand. An example includes the emission-trading system [3]. Owing to its flexible and diverse policies and technologies, the EU provides relevant assistance to many countries, including China. However, as China becomes the world's largest energy consumer and demonstrates comprehensive strength in energy and energy-related matters, the EU is increasingly promoting its energy relationship with China to transform from a "donor-recipient" model to a "reciprocal" model and "partnership" [4]. The energy emission

reduction policies of the EU and other developed countries cannot be directly cut and pasted into China's carbon emission reduction implementation. As a developing country, China's carbon emission reduction policy needs to fully consider the country's own national conditions, systems, etc. [5], and it must appropriately draw upon the experience of other countries. Only then can China's carbon emission reduction ideas be provided to other countries and organizations, including developing countries.

Under increasingly stringent environmental protection policies in China, the production and operation activities of enterprises and the lives of residents will inevitably face more severe practical difficulties, and the contradiction between economic development and environmental protection has become increasingly prominent [6]. Against this background, at the end of 2020, the Zhejiang power restriction incident aroused strong public attention [7]. On the basis of sustainable development, proposing reasonable and high-level government solutions and evaluation plans has become a hot issue that remains to be addressed. In regard to the government's performance evaluation, the previous literature mainly studies the relationship between the government and enterprises [8,9], and it studies the government and the public separately [10–15]. The purpose for evaluating the government's performance is to maximize the public value for all the relevant stakeholders on the basis for achieving established policy goals. However, there is a limited body of literature on how to integrate all the stakeholders into government performance management systems to improve government performance levels. By analyzing the case of the local government power restriction in Zhejiang, this paper constructs a three-party evolutionary game model of the local government, enterprises, and residents. It studies the evolutionary path of the game model and the three-party evolutionarily stable strategy (ESS), analyses the factors that affect the evolutionary results, determines the necessary requirements for the three-party governance target model to satisfy the equilibrium conditions, and optimizes the local government's performance evaluation system.

This study makes theoretical and practical contributions. Theoretically, this study discusses the power restriction order in Zhejiang, China, based on a game perspective, introducing residents as a third party to expand the literature on the government's carbon emission reduction behavior. Practically, game theory research strategies will help to promote the realization of equilibrium. The rest of this paper is organized as follows. The Section 2 reviews the relevant literature on the development of the government's performance management in carbon emission reduction policies from the evolutionary game perspective. The Section 3 mainly introduces relevant theories of government performance management. In the Section 4, this paper studies the government's performance in the Zhejiang power restriction incident. The Section 5 introduces the methodology. The Section 6 presents the case-based evolutionary game model analysis. The Section 7.1 is a summary. The Section 7.2 elaborates on the conclusions and offers suggestions.

2. Literature Review

2.1. Research on Carbon Reduction

2.1.1. Influencing Factors of Carbon Emissions

Previous studies have explored the factors affecting carbon emissions based on the aspects of driving factors [16,17], industrial emission characteristics [18,19], and regional emission differences.

At the regional level, regional differences in carbon emissions are significant. Different power generation energy structures [20] and groups of countries [21] will lead to differences in national carbon emission levels. However, owing to the complexity of China's population, geography, and development, it is difficult to fully understand the specific situation of China's carbon reduction at the national level. Therefore, relevant scholars have successively conducted in-depth research on the influencing factors and emission differences in all the provinces in China and the provinces of the Yangtze River Economic Belt and the Yellow River Basin. Improving the quality of urbanization in the Yangtze River

Basin can reduce excessive energy consumption, and technological progress is the main reason for the overall carbon emission efficiency in the Yellow River Basin [22,23].

2.1.2. Carbon Reduction Policy Research

At present, the focus of the Chinese government's administrative emission reduction is how to effectively reduce corporate carbon emissions while also adjusting the implementation of policies, such as quotas, financial subsidies, and reward and punishment mechanisms [24]. The literature examines these issues from the regional and industrial perspectives. The economic development levels of China's provinces vary greatly, giving them different levels of potential and difficulty in meeting carbon emission reduction requirements. A coordinated low-carbon model with the province as the main body is conducive to achieving a balance between economic development and carbon emission control [25]. An example includes quantifying provincial carbon emission reduction shares through production and consumption [26]. In addition, the regional externalities of transportation emissions can be quantified to promote cross-regional emission reductions in provinces with a transportation carbon deficit and in provinces with a transportation carbon surplus [27]. Owing to uneven carbon emissions across provinces, green transfer payment projects can be used to build green projects and achieve energy conservation and emission reduction [28]. From an industrial perspective, formulating differentiated subsidy programs [29], improving reward and punishment mechanisms [30], and establishing governance mechanisms shared by stakeholders [31] can promote the green transformation of various industries and achieve carbon emission reduction policy goals. The literature above shows that the stakeholders in the government's administrative emission reduction are mainly the manufacturing industry, which emits carbon emissions, while ignoring a basic variable in social and economic activities—citizens [32]. From a macro perspective, demographic characteristics, such as the working-age population, family size, and educational level, have an increasingly significant impact on carbon emissions [33]. From a micro perspective, residents can indirectly supervise online public carbon reduction projects through public opinion or directly exert good interactive emission reduction effects by joining environmental organizations or participating in promoting regional green technological innovation [24].

2.2. Evolutionary Games

2.2.1. Evolutionary Game Overview

Game theory is a branch of economics. Neumann and Morgenstern coauthored *Game Theory and Economic Behavior*, marking the initial formation of the modern system of game theory. Commonly used game theory scenarios include price competition, environmental protection, and interpersonal relationships [34].

Classical game theory is based on the basic assumption of complete rationality, but in actual situations, complete rationality is difficult to achieve. Different from game theory, Smith and Price [35] proposed evolutionary game theory under the assumption of bounded rationality. Methodologically, evolutionary game theory is different from game theory, which focuses on static equilibrium and comparative static equilibrium. Evolutionary game theory emphasizes dynamic equilibrium. In essence, evolutionary games are used to discuss how the behavior of game participants develops toward an equilibrium state by studying the dynamic evolutionary model when the game players formulate strategies. This theory is widely used in fields such as supply chains, food safety, social conflicts, and environmental protection.

2.2.2. The Application of Evolutionary Games for Carbon Emission Reduction

The literature pays considerable attention to the game problem of carbon emission reduction and the factors affecting carbon emission reduction strategies. At present, in terms of carbon emission reduction research, from the perspective of all the parties involved

in the game, the participants mainly include the central government, local governments, carbon companies, etc.

First, previous work has studied the game between governments and carbon enforcers, which exists both within international organizations [36] and within countries [37]. At the national level, carbon-trading behavior is affected by the joint action of enterprises and governments [37]. At the industrial level, evolutionary game analysis is mainly conducted on the government and enterprises in important carbon industries. Carbon emissions in the power industry are the focus of the government's carbon reduction work. Local governments should provide relevant support policies and incentives [38]. For example, the operating cost of carbon asset pledge credits has a greater impact on the rigor of the system than the incentive cost, which provides theoretical guidance for the government to promote the innovation and development of low-carbon technology in the power grid [39]. With the strengthening of government supervision, leading companies with a smooth transformation and low-carbon technology have strengthened their market leadership, while companies without low-carbon technology have adapted to the market or exited the market under carbon emission constraints, and the industrial structure has gradually transformed from a decentralized competitive structure to a centralized oligopolistic structure [40]. To better achieve inter-regional carbon emission reduction, the central government and local governments should take cooperative actions [41].

The research above focuses on the implementation of carbon reduction by the government for supply-side enterprises in the market in an effort to improve the carbon behavior of enterprises through policy rewards and punishments. However, it ignores the demand side, which plays a leading role in the market's mechanism; residents are not only the ultimate emitters of carbon dioxide but also the real beneficiaries of emission reductions. Therefore, the role of residents in reducing carbon emissions cannot be underestimated. However, residents are rarely included in the stakeholder game of carbon emissions. Accounting for the public's participation in environmental management, according to the consideration of consumers' willingness to purchase low-carbon services in the game, consumers are guided to purchase low-carbon services to achieve the goal for promoting carbon reduction at logistics companies [42]. At the same time, the participation of the public, which is a multi-stakeholder, can regulate the behavior of manufacturers through market mechanisms when the cost of government supervision rises sharply, thereby compensating for the lack of government supervision [19].

2.3. Performance Management

2.3.1. Performance Management

In business management, the performance management system can be traced back to Taylor's time research, action research, and the piece-rate wage system in the early twentieth century [43]. In addition, Fayol [44] adopted a broad perspective to extend performance management from industrial and commercial enterprises to various business organizations. Since then, the theory and methods of performance management have been applied to economic, administrative, military, and religious organizations [45]. For example, performance management has been included in the field of public management for research [46,47].

2.3.2. Government Performance Management

In government performance management, the government uses modern management theories and methods to establish an effective evaluation system based on the needs of social development to assess, supervise, and motivate government departments and their staff. Good governance requires long-term and sustained efforts and, more importantly, the entire national mix of the three pillars of the state, namely, government institutions, the private sector, and the people, as well as their commitment and optimism [48]. Among them, citizen participation plays an important role in improving the government's performance. Citizens' opinions can provide government managers with valuable location

information that can help improve the efficiency and effectiveness of public programs. Therefore, the government can enhance the public value of government management through performance management and citizen participation [10,11].

Performance evaluation is a comprehensive analysis of the government's achievement of assessment goals, including economic performance, political performance, environmental performance, and social performance. Government performance related to carbon emission reduction falls under the category of environmental performance. As a governance decision-maker, the government should regularly report on environmental governance, increase the disclosure of the environmental performance, enhance citizens' trust in the government, and promote citizen participation [12]. Government trust has an impact on participation in environmental governance. That is, the higher the trust in the government is, the lower the level of public participation [13]. Therefore, when the government improves people's trust in it, it can expand public participation through education, incentives, publicity, etc. and obtain the latest feedback in a timely manner [14]. For carbon-emitting enterprises that create a harsh environment, the government indirectly affects and enhances the motivation of enterprises to reduce carbon emissions through rewards and punishments [8] and the timely tracking and monitoring of the implementation of corporate performance policies [9].

The previous literature constructed an index system, including low-carbon environmental benefits and low-carbon economic benefits, to objectively evaluate low-carbon effects and efficiency [49]. However, if the government wants to effectively improve the objective level of governance services to improve people's livelihood, it needs to strengthen the investigation of and collection of data on people's subjective feelings [16]. Therefore, the government's environmental performance evaluation indicators should be able to comprehensively reflect public value and have the theoretical feasibility of the performance audit's evaluation process [50].

The government, enterprises, and the public have formed a dynamic multi-game relationship in the performance management of government carbon reduction, with each subject playing a different role. First, as a policymaker, the government carries out the social cost-benefit analysis of the pre-promulgated governance plan, and when the policy is implemented in a region, the government has to play a deterrent and supervisory role. Second, as policy implementers, enterprises need to conduct an economic benefit feasibility analysis of the introduced policies and decide whether to actively cooperate with the policies based on the analysis results. Because the public is not the main opponent in the game with the government, it is often ignored by scholars. However, citizen participation can provide timely feedback on the implementation of enterprises, help the government to correct the process of the plan's implementation, and greatly improve the efficiency of the government's implementation. At this time, citizens play the role of the executive supervisor. It can be seen that the relationship among the three parties is not a simple one-on-one static correspondence; rather, it is a three-party game that is a dynamic strategic evolutionary process. However, few studies have integrated these three parts into an overall system to study a win-win solution. This article starts with a specific case, the Zhejiang power restriction incident, and it combines it with the evolutionary game to analyze in depth the realistic management problems faced by the government during the implementation of the carbon reduction policy. From the cost-benefit perspective, it considers the different roles played by residents in this process, analyses the factors affecting the behavior of stakeholders from the perspective of dynamic deduction, determines the conditions required for the three-party collaborative governance target model, and proposes suggestions for optimizing the government's carbon reduction performance management.

3. Theoretical Basis

3.1. Stakeholder Theory

The economist Freeman argued that stakeholders are "any individual or group that can affect the realization of corporate goals or the entire process of corporate goal realization" [51].

The methods for classifying stakeholders mainly include the multidimensional segmentation method [51], grouping into direct stakeholders and indirect stakeholders [52] as well as contractual stakeholders and public stakeholders [53], and the Mitchell scoring method [54]. The Mitchell scoring method can not only identify different types of corporate stakeholders but also help companies make rational choices when selecting stakeholders so that their behavior conforms to the expectations and requirements of shareholders, employees, creditors, and other stakeholders [54].

A governance model based on stakeholder theory provides a good solution for the government to coordinate the relationship with stakeholders in public affairs management. It is practically important to construct a policy path for citizen participation in the government's performance management process based on stakeholder theory. Doing so can ensure that the wishes and interests of relevant social subjects are fully reflected by the government in the performance evaluation process, thereby realizing the implementation of citizens' right to participate. Only in this way can we take care of the interests of different groups to the greatest extent possible, advocate policies that are acceptable to all the parties, and embody the governing principles of a scientific democracy.

3.2. Cost–Benefit Theory

Smith [55] proposed the labor theory of value and the basic principles of the market economy in his book *The Wealth of Nations*. He argued that economic entities can make behavioral judgments to seek advantages and avoid disadvantages through cost–benefit analysis and then seek behavioral choices that maximize their own interests. Cost–benefit analysis has become an important consideration in the project decision-making process.

As an economic agent, the government is constrained by costs. Therefore, when the government faces the problem for comparing and choosing multiple plans, it is necessary to analyze the costs and benefits brought by each plan separately and then finally select the best plan. The stakeholders involved in carbon reduction policy, that is, each decision-making body, are a typical “economic man”. Regardless of whether they are local governments, enterprises, or residents, the behavioral choices of all the parties will produce a combination of various costs and benefits; when making behavioral decisions, they need to compare and analyze the costs and benefits of their own behaviors and adopt the most beneficial behavioral strategy. On this basis, this paper studies the implementation process of carbon reduction policies by introducing cost–benefit theory to the Zhejiang power restriction incident, and it analyses how various costs and benefits affect the choice of the main behavioral strategy and the impact on the performance management system of the local government.

3.3. Evolutionary Game Theory

With the continuous development and revision of game theory [56], Smith and Price [35] connected game theory with biological evolution and proposed the key concept of the evolutionarily stable strategy (ESS). This concept refers to the tendency in which when most individuals in a population choose the same stable strategy, the individual behavior of a few mutants will not be able to change the overall trend. With the emergence of the ESS concept, research on evolutionary games has developed rapidly. Evolutionary game theory is a theory that studies economic behavior and strategic choices in the business process. In 1978, Taylor and Jonker [57] used the system dynamics model to demonstrate the definition of a traditional ESS for the first time. Replicator dynamics and the ESS are the most basic core concepts in evolutionary game theory. The ESS emphasizes variation, while replicator dynamics equations emphasize selection.

Bounded rationality is a prerequisite for replicator dynamics equations. Under this premise, the research subject can imitate and learn by judging the similarities and differences between the current strategy and the optimal benefit strategy, and it can continuously adjust and change the current strategy throughout the process [58]. Under conditions of limited rationality, the relevant stakeholders involved in carbon decision-making, that

is, each decision-making subject, can calculate the benefit matrix's differential equations through expectations when adjusting the strategy, thus reflecting the behavior of the game participants in the strategy selection process. Through repeated games, an ESS is finally achieved.

3.4. Collaborative Governance Theory

Wood and Gray [59] first proposed the concept of “collaborative governance”, defining it as a management method in which multiple stakeholders make joint decisions on public affairs and reach a consensus. Collaborative governance is generally regarded as a consensually oriented consultative governance mechanism through formal initiation by competent authorities and the participation of governmental and non-governmental stakeholders in the process of policy formulation and implementation or in the management of public projects and affairs [60]. In practice, scholars divide collaborative governance into three models: vertical collaborative governance, horizontal collaborative governance, and cross-departmental collaborative governance [61,62].

To resolve the conflict between economic development and environmental protection in the Zhejiang power restriction incident discussed in this paper, the sought collaborative governance falls under the third model. The main body of cross-departmental collaborative governance is composed of the government, enterprises, citizens, and non-governmental organizations. This type of collaborative governance model is mostly initiated by the government, which seeks collaboration with enterprises, non-governmental organizations, and civil society during the implementation process to address social affairs or public issues that are difficult for them to handle independently. In this collaborative governance model, the government plays a leading role, and the other participants can negotiate with the government on relevant matters [63]. The process of collaborative governance is essentially a game process between relevant stakeholders. During this process, all the stakeholders choose behavioral strategies based on their own goals, interest demands, and power relations, thus forming a multi-party cooperative decision-making system. The effective realization of collaborative governance depends on whether this cooperation system can form a joint force to achieve collaborative governance. Otherwise, in the governance process, it is very likely that there will be deviation from the original goal.

4. Methodology

This study uses evolutionary game theory to analyze the power outage event in Zhejiang. The equilibrium emphasized by evolutionary game theory is the result of learning and adjustment. Participants adjust their game strategies by calculating their expected returns. The goal of the game's participants is to use their own game strategies to obtain the maximum profits. Therefore, when the strategy that they choose leads to low profits, they will continue to learn and imitate and then seek new strategies to correct the current low profits and adjust their strategy choices.

This paper uses an evolutionary game to explore the improvement in the government's performance management mechanism, and this exploration can be divided into five steps. The first step is to investigate and understand events involving the government's performance management systematically and comprehensively and to identify the stakeholders in such events. The second step uses the principles and methods of evolutionary games to define the stakeholders as all the parties participating in a game. The third step is to analyze the factors that affect stakeholders' behaviors based on the cost-benefit principle. The fourth step is to quantify the factors influencing the behaviors of all the parties in the game and to construct a standard replicator dynamics equation. The fifth step is to use the replicator dynamics equation to find the stable strategy equilibrium solution and to draw policy recommendations based on the equilibrium solution. The main processes and steps above are presented in Figure 1.

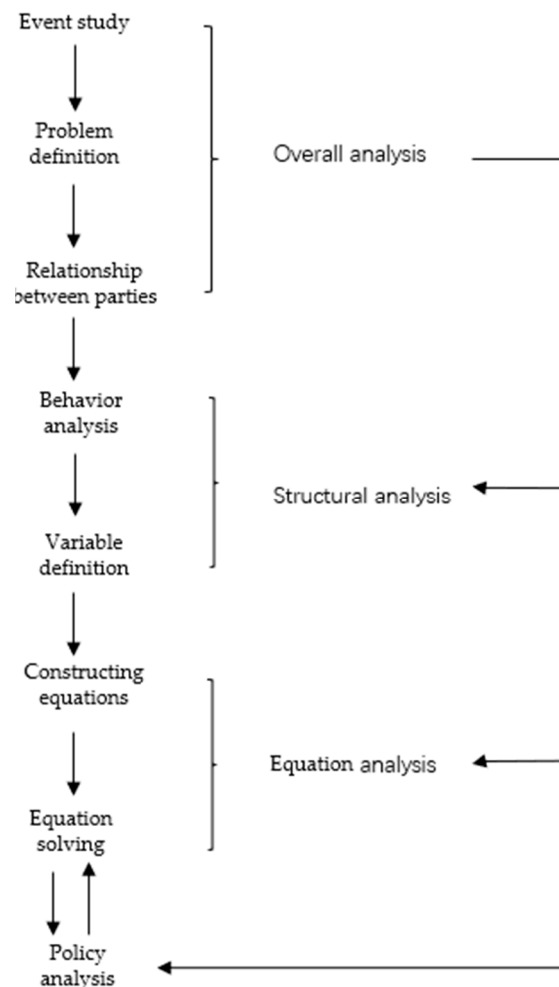


Figure 1. The process and steps of the analysis.

5. Case Analysis of the Zhejiang Power Restriction Order

5.1. Introduction to the Event

The year 2020 was the last in the government's five-year assessment plan for energy conservation and emission reduction. The Zhejiang power restriction incident fully exposed the conflict between environmental protection and economic development in the implementation of energy consumption control and carbon reduction plans, and it failed to reflect a win-win situation between economic development and environmental protection. In recent decades, China's rapid development has been closely related to the use of non-clean energy. For example, the cost of coal power generation accounts for an enormous proportion of China's energy consumption, revealing the importance of coal energy for China's economic growth [64]. The carbon emissions caused by coal are the primary focus of carbon reduction efforts [65,66]. China is at a critical stage of rapid urbanization and industrialization, and the active coordination of economic development and carbon emission targets has become an urgent issue for the country [67]. The transformation of China's urban development model from regional production (GDP) oriented to low-carbon oriented will first have a certain impact on the production and development of carbon-intensive enterprises as well as the lifestyles and consumption habits of residents [68,69]. This article takes the Zhejiang power restriction incident as an example to analyze the reasons behind the power restriction, aiming to provide suggestions for optimizing the government's performance management and promoting carbon emission reduction.

On 11 December 2020, the main leaders of Zhejiang Province hosted a video and telephone conference on the province's energy "dual control" and "coal reduction" and listened to the Zhejiang Development and Reform Commission's report on the energy

“dual control” and “coal reduction” work plan as well as the operational tasks that were deployed and implemented. Immediately afterward, many cities in Jinhua, Wenzhou, Taizhou, Ningbo, and Zhoushan in Zhejiang issued power restriction orders [7]. On 14 December, many factories in Yi Wu received an emergency notice from the local government, requiring all the processing plants to stop production from that moment until December 31. Jinhua required nearly 2000 industrial enterprises to suspend production from December 13 to December 31 to stagger production peaks [70]. After receiving the power restriction order, various companies had to shut down their production lines. In addition to power outages for enterprises, the government issued power restriction measures for citizens, enterprises, and institutions. From 14 December to 31 December, the offices of the relevant units across the province could be open only when the temperature was below 3 °C. The use of air conditioning and other heating equipment was allowed, and the set temperature could not be higher than 16 °C. The relevant provincial departments could turn on heating equipment only when dining in the canteen and had to turn it off promptly after dining, and the set temperature could not be higher than 18 °C. Moreover, the street lights in some areas of Yi Wu and elevators in office buildings were turned off at night.

The secretary-general of the National Development and Reform Commission responded at a press conference of the State Council Information Office that Zhejiang Province had abundant energy reserves and a stable power supply that could guarantee the province’s power demand. To promote energy conservation and emission reduction, some areas in Zhejiang Province independently adopted power restriction measures. Therefore, Zhejiang’s power restrictions were mainly due to policy reasons: To achieve the requirements set by the binding indicators of the “dual energy consumption control” assessment of the “Thirteenth Five-Year Plan” by the end of the year, the local government chose to implement an emergency power restriction, which led to the power contradiction between energy conservation and emission reduction and the failure to ensure people’s livelihood at this stage.

In 2017, the Zhejiang provincial government promulgated the “Zhejiang Provincial Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 13th Five-Year Plan” [71]. In 2018, the Zhejiang provincial government issued the “Implementation Plan for Further Strengthening Energy ‘Dual Control’ to Promote High-Quality Development in Zhejiang Province (2018–2020)” [72], which clarified the province’s and cities’ energy “carbon reduction”, “reduction in energy” assessment objectives, as well as corresponding assessment rewards and punishments. The specific assessment methods are shown in Table 1.

Table 1 reports the environmental protection performance assessment plan of Zhejiang Province. The “dual control” target indicators of the total energy consumption and intensity of the indicators in Table 1 are all the veto indicators. Full points are awarded for completing the annual goals, and no points are given for unfulfilled goals. The target indicators of the energy-saving measures are all the assigned indicators. For example, the supervision, inspection, and evaluation standards involve carrying out energy-saving law enforcement supervision and inspection. The specific scoring standard includes three parts. The first part consists of verifying relevant documents, spot-checking relevant enterprises and units for verification, carrying out law enforcement supervision and inspection, and investigating and punishing illegal energy use behaviors. Either 1 or 0 points are scored. The second part consists of strengthening the construction of energy-saving supervision capabilities and improving the energy-saving supervision system. One point is scored. In the third part, if the energy conservation supervision agency includes the implementation of energy consumption limit standards in the supervision plan and completes the supervision tasks, it will receive 1 point. The specific scoring details for other indicators can be viewed through Zhejiang Development and Reform Energy Notice No. 819 (2017) (https://fzggw.zj.gov.cn/art/2018/1/5/art_1599544_30220003.html) (accessed on 14 November 2023).

Table 1. Zhejiang Province’s energy “carbon control” assessment plan.

Categories of Indicators	Indicator Content	Score
Total energy consumption and intensity of “dual control” target indicators (40 points)	Annual energy consumption intensity reduction indicator	10
	“Thirteenth Five-Year Plan” energy consumption intensity reduction progress indicator	15
	Annual total energy consumption control index	5
	“Thirteenth Five-Year Plan” total energy consumption control progress indicators	10
Energy-saving measure implementation indicators (60 points)	Target responsibility	9
	Structural adjustment	7
	Energy savings in key areas	21
	Key projects	2
	Technology promotion	2
	Support policy	6
	Market mechanism	4
	Supervised check	3
	Energy-saving management and service	6

Source: Zhejiang Development and Reform Energy Notice No. 819 (2017) (https://fzggw.zj.gov.cn/art/2018/1/5/art_1599544_30220003.html, accessed on 15 November 2023).

Table 1 shows that paper documents and on-site inspections by superior governments can determine 60% of the regional government’s assessment results. The assessment results are highly subjective and operable, making it difficult to give full play to performance management in promoting regional governments’ carbon emission reduction work. However, the results provide regional government leaders with operational opportunities to improve their personal performance. In this case, government officials will mainly focus on carbon reduction law rather than economic development or even people’s livelihoods. This phenomenon led to the power restriction case in Zhejiang [73].

Figure 2 shows a review of the completion of the energy “dual control” target and the evaluation results of the implementation of energy-saving measures by local governments in Zhejiang Province [74–77]. The results show that from 2017 to 2019, there were cities that failed to complete the assessment requirements every year. Especially in 2018 and 2019, the basic number of cities that failed to reach the target level (completed and uncompleted) exceeded 50% of the overall number. For example, in 2019, Ningbo was one of the cities that did not complete the plan. The possible reason is that the average annual growth in energy consumption exceeded 1.7%. For other urban energy consumption indicators, refer to the “Notice of the People’s Government of Zhejiang Province on Issuing the Comprehensive Work Plan for Energy Conservation and Emission Reduction in Zhejiang Province during the 13th Five-Year Plan” (Zhejiang Zhengfa (2017) No. 19) (https://www.zj.gov.cn/art/2022/6/30/art_1229019364_2409806.html) (accessed on 14 November 2023).

Public concerns about the local government’s environmental performance management have begun to emerge, calling for a more flexible approach, such as appropriately adjusting the ambiguity of assessment targets to prevent lower-level officials from taking chances [78], as shown in the Zhejiang Province Energy “Dual Control” Assessment Results and Issuance of Power Limitation Order. Figure 2 shows that some cities in the region exceeded their goals, while other cities did not reach their goals. However, it can be seen from the consequences of the power restriction incident in Zhejiang Province that a more effective and reasonable formulation of power restriction orders requires a more comprehensive consideration of the factors of the relevant stakeholders, rather than mandatory power restriction, to achieve the desired evaluation results.

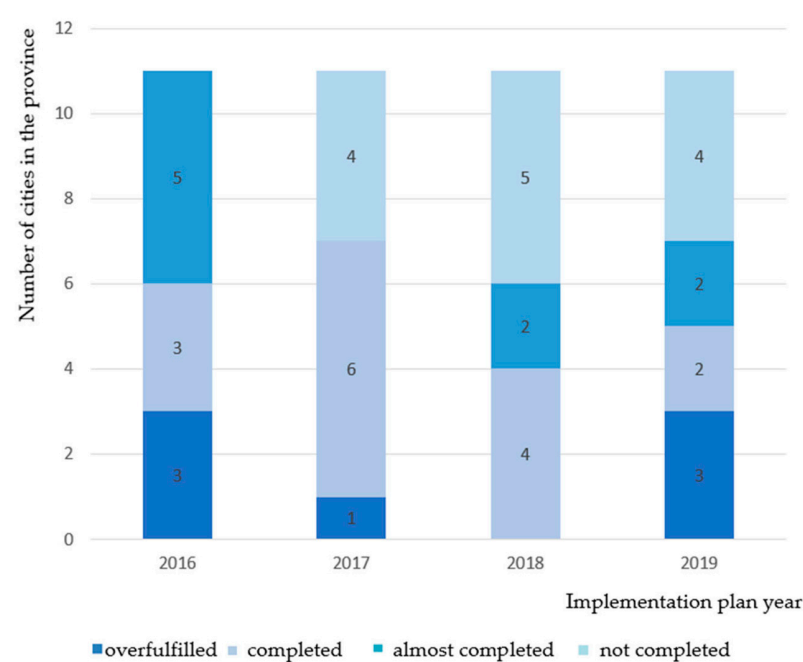


Figure 2. Distribution of the target assessment results in Zhejiang Province from 2016 to 2019. Source: Zhejiang Provincial Development and Reform Commission, Announcement on the Evaluation Results of the Energy “Dual Control” Target Responsibility Evaluation of Districts and Cities in 2016–2019 and 2017–2020.

5.2. Analysis of the Stakeholders in the Zhejiang Power Restriction Incident

5.2.1. Definition of Stakeholders

When determining the relevant interests of all the parties (see Table 2) involved in the implementation of the Zhejiang provincial government’s carbon policy, the following four main principles need to be followed:

Table 2. The core stakeholders of the Zhejiang power restriction incident.

Principal	Role Classifications
Local government	Decision makers, motivators, and regulators
Enterprises	Producers and emitters
Residents	Consumers, emitters, and supervisors

First, the Zhejiang provincial government controls the developmental direction and management tools of its implementation of carbon reduction policies. Second, its interests are significantly affected by the direction and strategy of its implementation of carbon reduction policies. Third, it can affect the formation and management level of its carbon reduction policy implementation system. Fourth, the Zhejiang provincial government can provide relevant information and suggestions on its problems and strategies in carbon reduction implementation and performance management.

China’s environmental management implements the principle of territorial management. Therefore, the government groups among the stakeholders in this research, especially local governments, as one of the key subjects of power restriction, play the most important role in effecting the energy conservation and emission reduction. In addition, the enterprises studied in this paper refer to those entities that produce products and supply them to the market. They are not only producers but also the main source of greenhouse gas emissions. The resident group mainly refers to social residents in the implementation of energy conservation and emission reduction. On the one hand, residents act as consumers

in the market, consuming various commodities produced by enterprises, and residents' daily lives also produce certain carbon emissions. Therefore, to a certain extent, residents are also one of the contributors to carbon emissions. In addition, the carbon emissions of enterprises and individuals will cause the residents themselves to become victims of carbon emission pollution. In contrast, if we strengthen the control of carbon emissions, constructively promote energy conservation and emission reduction, and simultaneously restrict the production and operational activities of enterprises through perfect government policies and systems, reduce the carbon emissions in the production process, and then reduce the overall carbon level of the whole society, residents will become the main beneficiaries of the environmental improvement. On the other hand, social citizens, as the masters of the country, are also the supervisors of the social order and the ecological environment. They implement the relevant supervision and norms for the implementation of corporate behavior and government policies and provide timely feedback to the government.

5.2.2. Stakeholders' Behavioral Strategies

Local governments are the executors, leaders, and defenders of power cuts. As rational, regional economic entities, local governments must not only execute the environmental protection policies of their superiors but also consider the local economic development. Therefore, local governments will often make tradeoffs at the two levels of environmental protection and economic development to maximize their interests and those of officials [79]. Looking at the entire "power restriction" process, the strategic choices of local governments can be classified into the following two categories (see Table 3):

Table 3. Local governments' behavioral strategies.

Strategy Type	Specific Measure	Strategic Impact
"Active power restriction" strategy	Actively introduce energy conservation and emission reduction policies	Strengthen the supervision of enterprise production behavior and support the development of environmentally friendly technologies, such as energy conservation and emission reduction; residents will feel the improvement in the air quality and get a better living experience
"Passive power restriction" strategy	Take no action	No impact on businesses and residents

1. Corporate Behavioral Strategies

In the event of a power restriction, according to the related factors of the impact, enterprises are faced with two different behavioral strategy choices as follows (see Table 4):

Table 4. Corporate Behavioral Strategies.

Strategy Type	Specific Measure
"Active green transformation" strategy	Enterprises increase resources and invest in green technology, actively promote energy-saving transformation and upgrading, and continue to adopt environmentally friendly green production methods.
The "status quo" strategy	Enterprises will passively respond to the government's call, maintain the status quo, and continue to use the traditional production model.

2. Residents' Behavioral Strategies

In the three-party game, residents are consumers of both corporate products and the government's public services. At the same time, residents are supervisors of the corporate

pollution discharge behavior and supervisors of the government's policy implementation. They often pursue their own comprehensive interests in the game process. The strategic choices of the largest number of new residents in a "power restriction" event can be classified into the following two categories (see Table 5):

Table 5. Residents' Behavioral Strategies.

Strategy Type	Specific Performance
Engagement strategy	Residents actively respond to and support energy-saving policies, conduct the real-time supervision of corporate production behaviors, consciously consume environmentally friendly green products, and reduce carbon emissions from the source.
Do not engage strategy	Residents do not participate in the supervision and feedback mechanisms of the corporate behavior and policy implementation and choose traditional products with relatively low prices for consumption.

5.2.3. Analysis of the Factors Affecting Stakeholders' Behaviors

The economist Becker argued that cost–benefit theory can be used to measure and explain human behavior and to predict the developmental direction of human behavior [80]. In the "Zhejiang power restriction" incident, local governments, related enterprises, and all the residents met the basic assumption of the "rational economic man" proposed in economic theory, and they made their own choices based on the principle for comparing costs and benefits.

1. Analysis of the Factors Affecting the Local Government's Behaviors

Local governments play multiple roles in the implementation of power restriction policies, including decision-makers, motivators, and regulators of policy implementation. The actions of local governments will affect their relevant stakeholders. They can use some administrative regulations or financial support to provide more room for enterprises and residents to play a role institutionally and to guide enterprises and residents to participate in energy conservation and emission reduction, thereby effectively promoting the achievement of the dual-carbon goal. Table 6, "Analysis of the factors affecting the local government's behaviors", is as follows:

Table 6. Analysis of the factors affecting the local government's behaviors.

Subject Behavior	Costs and Benefits	Specific Costs and Benefits	Explanation
Local governments actively curtail electricity	Costs	Implementation costs	Refer to the costs paid by local governments to formulate, implement, and revise relevant carbon reduction policies and systems and to maintain the better operation of the regulatory system
		Loss of economic benefits	The impact on the local economy due to an active power restriction, such as the decline in added industrial value and the decrease in tax revenue due to the economic slowdown
		Loss of social benefits	Social instability caused by the migration of the permanent population and the reduction in public safety due to an unstable power supply
		Government support for enterprises	Government incentives for enterprises to actively reduce carbon emissions, such as green technology subsidies and preferential tax policies
	Benefits	Environmental benefits	Environmental benefits for actively limiting power to alleviate the pressure of the dual control assessment of energy consumption
		Government punishment for enterprises	Enterprises maintain the status quo and reduce carbon emissions. If detected by the local government, companies will be fined, and these fines will become a part of the government's revenue.

Table 6. Cont.

Subject Behavior	Costs and Benefits	Specific Costs and Benefits	Explanation
Local governments eliminate power limits	Costs	Environmental loss	Refers to the adverse impact on the environment caused by the emission of greenhouse gases; to mitigate this adverse impact, a part of the economic cost must be consumed.
		Performance loss	The failure of the dual control index of the energy consumption leads to a negative performance appraisal.
	Income	Economic benefits	Refer to the direct implementation costs paid by local governments relative to the active implementation of the power restriction policy; cost savings can be achieved when the policy is passively implemented.

2. Analysis of the Factors Affecting Enterprises' Behaviors

As an “economic man” with bounded rationality and with profit as its primary goal, an enterprise will respond to local government policies in the process for seeking to maximize its own interests and use them as a basis to make choices based on multiple considerations of profit-maximizing behavioral strategies. When enterprises choose the behavioral strategy of the “positive green transformation”, they need to invest in the transformational cost of the technological transformation, such as energy savings. At the same time, they may obtain government technical subsidies, tax incentives, etc.; improve product competitiveness; and gain other benefits. When enterprises choose the “maintain the status quo” behavioral strategy, they can save on the costs of green technology research and development and equipment renewal. At the same time, the sudden power-rationing policy may have a great impact on the original production arrangement of enterprises, which increases the risk of enterprise default. At the same time, enterprises deal with problems in production safety, quality, and other aspects [81], as well as a decline in market share, in addition to fines and other costs.

3. Analysis of the Factors Affecting Residents' Behaviors

The resident group plays a diverse role in the power restriction process, and their behavioral decisions are also affected by many parties. Owing to the spillover nature of environmental governance, first, residents are the most direct victims of social carbon emissions. The quality of the urban environment not only is related to the living conditions of the public but also has a direct impact on the physical and mental health of residents. Second, during the power outage process, the unstable power supply greatly inconveniences residents' daily lives, and it also poses a threat to public safety. To a certain extent, it damages the interests of citizens. In addition, residents, as the second largest energy-consuming group after industrial electricity consumption, are carbon emitters in a “power restriction” event. Finally, the public is the supervisor of the implementation of the power restriction policy. Whether it is the appropriateness of the local government's implementation of the policies issued, whether the implementation process is reasonable and realistic, or whether an enterprise strictly abides by the relevant energy conservation and emission reduction regulations to carry out production and operation activities, the public sees it all. Thus, it can play a good supervisory role. Therefore, residents' behavioral decisions play a significant role in promoting energy conservation and emission reduction. When residents choose the behavioral strategy of “participation”, they need to bear the cost of the supervision and feedback for the behavior of enterprises and the process for implementing the government's policies. At the same time, the timely feedback of people's feelings is helpful for amending the process of government policy implementation and maintaining public security and social stability. It is also conducive for improving the quality of public services, enhancing the public's satisfaction with and trust in local governments [82], and enhancing social benefits. When residents choose the behavioral

strategy of “non-participation”, they do not need to pay the explicit cost, and compared with the behavior of “participation”, the supervision and feedback costs can be saved.

6. Analysis of the Three-Party Evolutionary Game of the Zhejiang Power Restriction Incident

6.1. Model Assumptions and Construction

6.1.1. Tripartite Game Relationship in the Zhejiang Power Restriction Incident

There is a dynamic relationship of mutual feedback and adjustment among the behavioral choices of the three parties involved in the Zhejiang power restriction incident. The three-party relationship is shown in Figure 3. Enterprises will not only bring economic development to the local area but also improve the performance of government departments and bring related benefits. However, excessive carbon emissions have made it difficult for the government to meet the energy-saving and emission reduction requirements, resulting in substandard performance assessments of the local government and its officials. Therefore, there is a contradiction in the choice of whether the local government implements the power restriction policy for enterprises; the economic development of enterprises can create more employment opportunities for local residents, which, in turn, affect the per capita disposable income of the local residents. At the same time, the increase in the production capacity leads to an increase in carbon emissions, affecting the living environment and health of the local residents, and there are also interests involved. Local residents enjoy the environment improved by the public services provided by the government, but at the same time, they suffer from the inconvenience and economic downturn caused by the government’s power restriction policy. The government coordinates and guides local residents to participate in the supervision and feedback of the implementation of the power restriction policy. The residents’ supervision and feedback play a role in supplementing the government’s supervisory function and in correcting deviations in the implementation process.

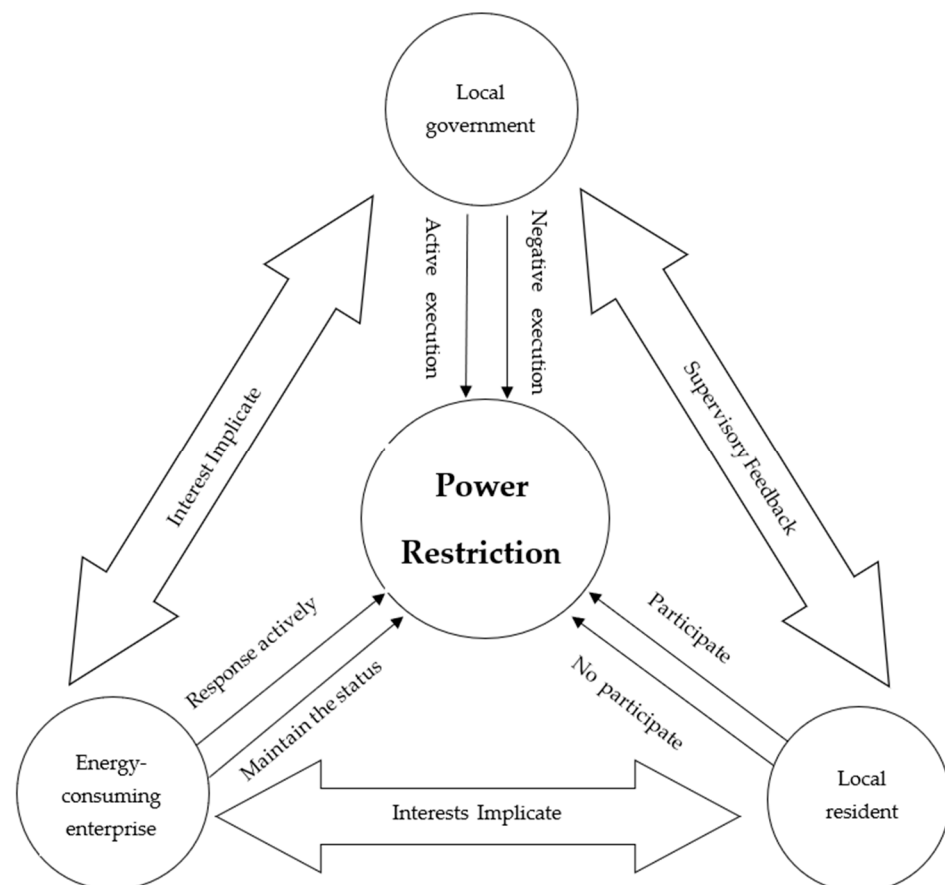


Figure 3. Stakeholder relationship diagram of the Zhejiang power restriction incident.

6.1.2. Model's Assumptions

Hypothesis 1. *The tripartite behavior of the government, enterprises, and residents is bounded rationality.*

Hypothesis 2. *The government can choose two curtailment strategies, “active implementation” and “negative implementation”, and the probabilities of the strategy selection are x and $1 - x$, respectively.*

Hypothesis 3. *The strategies of enterprises are divided into “active green transformation” and “maintaining the status quo”, and the probabilities of the two strategies are y and $1 - y$, respectively.*

Hypothesis 4. *The probabilities for residents choosing the two strategies of “participating” and “not participating” in the power restriction policy are z and $1 - z$, respectively.*

6.1.3. Related Variable Settings

Based on the assumptions above and the factors affecting the behaviors of the stakeholders, this paper designs the costs and benefits involved in the behavioral decisions of the stakeholders during the implementation of the power restriction policy as follows. The specific parameter settings are shown in Table 7 below.

Table 7. Main parameters and their meanings.

Serial Number	Parameter Symbol	Meaning
1	R_0	Basic benefits for the government when the government passively curtails electricity, enterprises maintain the status quo, and residents do not participate.
2	R_1	Environmental benefits from aggressive government curtailment.
3	R_2	Enterprises actively carry out a green transformation, with additional environmental benefits for the government.
4	R_3	Fines for businesses that maintain the status quo.
5	C_1	Enforcement costs of the government's aggressive curtailment of electricity consumption.
6	C_2	Economic losses caused by aggressive government power restrictions.
7	C_3	Government support for enterprises with an active green transformation.
8	C_4	The government actively curtails power, and the power supply is unstable, resulting in the loss of social benefits.
9	W_0	Basic income of enterprises when the government passively curtails electricity, enterprises maintain the status quo, and residents do not participate.
10	W_1	Businesses that carry out a positive green transition gain additional reputational benefits when residents engage.
11	W_2	Economic benefits for enterprises with an active green transformation when the government actively curtails electricity.
12	K_1	Transition costs for companies actively carrying out a green transition.
13	K_2	Maintaining the status quo and the economic losses of enterprises in the event of aggressive government curtailments.
14	S_0	Basic income of residents when the government passively curtails electricity, enterprises maintain the status quo, and residents do not participate.

Table 7. Cont.

Serial Number	Parameter Symbol	Meaning
15	S_1	Environmental gains for residents when the government actively curtails electricity.
16	S_2	Enterprises actively carry out a green transformation, with residents reaping environmental benefits.
17	S_3	Social benefits obtained by residents who choose to participate in the government's active power restriction.
18	L_1	Residents' supervisory feedback cost incurred when they choose to participate when the government actively curtails the power.
19	L_2	Cost of supervision and feedback for residents who choose to participate when enterprises maintain the status quo.
20	L_3	Economic losses suffered by residents during the government's aggressive power restrictions.

6.1.4. Model Building

Payment matrix construction:

1. Residents participate in the power restriction policy (Z); see Table 8 for details:

Table 8. Game payment matrix of the main body of the power restriction policy when residents participate.

Local Government	Enterprises	
	Enterprises Actively Carry Out a Green Transformation (y)	Enterprises Maintain the Status Quo ($1 - y$)
The government actively curtails electricity (x).	$R_0 + R_1 + R_2 - C_1 - C_2 - C_3 - C_4$ $W_0 + W_1 + W_2 + C_3 - K_1$ $S_0 + S_1 + S_2 + S_3 - L_1 - L_3$	$R_0 + R_1 + R_3 - C_1 - C_2 - C_4$ $W_0 - R_3 - K_2$ $S_0 + S_1 + S_3 - L_1 - L_2 - L_3$
The government eliminates the power limit ($1 - x$).	$R_0 + R_2 - C_3$ $W_0 + W_1 + C_3 - K_1$ $S_0 + S_2$	R_0 W_0 $S_0 - L_2$

2. Residents do not participate in the power restriction policy ($1 - Z$); see Table 9 for details:

Table 9. Game payment matrix of the main body of the power restriction policy when residents do not participate.

Local Government	Enterprises	
	Enterprises Actively Carry Out a Green Transformation (y)	Enterprises Maintain the Status Quo ($1 - y$)
The government actively curtails electricity (x).	$R_0 + R_1 + R_2 - C_1 - C_2 - C_3$ $W_0 + W_2 + C_3 - K_1$ $S_0 + S_1 + S_2 - L_3$	$R_0 + R_1 + R_3 - C_1 - C_2$ $W_0 - R_3 - K_2$ $S_0 + S_1 - L_3$
The government eliminates the power limit ($1 - x$).	$R_0 + R_2 - C_3$ $W_0 - K_1 + C_3$ $S_0 + S_2$	R_0 W_0 S_0

6.2. Model Solving and Analysis

6.2.1. Replicator Dynamics Equations

Based on the abovementioned payment matrix of the local government, enterprises, and residents, the analysis of their respective stabilization strategies is conducted, in turn, from the perspectives of the local government, enterprises, and residents.

Let U_x and U_{1-x} represent the mathematically expected returns of the local government choosing the “active implementation” power restriction policy strategy and “passive implementation” power restriction policy strategy, respectively. $\bar{U}_x$ indicates the average mathematically expected returns of the local government choosing the mixed strategy of the “active implementation” and “passive implementation” power restriction policy strategies based on the matrix above. Then, U_x , U_{1-x} , and $\bar{U}_x$ are expressed as follows in Equations (1)–(3), respectively:

$$U_x = \begin{pmatrix} (R_0 + R_1 + R_2 - C_1 - C_2 - C_3 - C_4)yz \\ + (R_0 + R_1 + R_3 - C_1 - C_2 - C_4)(1-y)z \\ + (R_0 + R_1 + R_2 - C_1 - C_2 - C_3)y(1-z) \\ + (R_0 + R_1 + R_3 - C_1 - C_2)(1-y)(1-z) \end{pmatrix} \quad (1)$$

$$U_{1-x} = \begin{pmatrix} (R_0 + R_2 - C_3)yz + (R_0)(1-y)z \\ + (R_0 + R_2 - C_3)y(1-z) + (R_0)(1-y)(1-z) \end{pmatrix} \quad (2)$$

$$\bar{U}_x = xU_x + (1-x)U_{1-x} \quad (3)$$

Then, the replicator dynamics equation of the local government can be expressed by Equation (4) as follows:

$$\begin{aligned} F(x) &= \frac{dx}{dt} = x(U_x - \bar{U}_x) = x(1-x)(U_x - U_{1-x}) \\ &= x(1-x)(R_1 + R_3 - C_1 - C_2 - R_3y - C_4z) \end{aligned} \quad (4)$$

Similarly, U_y and U_{1-y} represent the mathematically expected returns of an enterprise choosing the “active green transformation” strategy and the “maintaining the status quo” strategy, respectively. $\bar{U}_y$ represents the average mathematically expected return of an enterprise choosing the mixed strategy of the “active green transformation” and “maintaining the status quo” based on the matrix above.

Then, the replicator dynamics equation of the enterprises can be expressed by Equation (5) as follows:

$$\begin{aligned} F(y) &= \frac{dy}{dt} = y(U_y - \bar{U}_y) = y(1-y)(U_y - U_{1-y}) \\ &= y(1-y)(C_3 - K_1 + W_2x + K_2x + R_3x + W_1z) \end{aligned} \quad (5)$$

Similarly, U_z and U_{1-z} represent the mathematically expected incomes of residents who choose the “participation” and “non-participation” power reduction policy strategies, respectively. $\bar{U}_z$ represents the average mathematically expected return of residents who choose the mixed strategy of “participation” and “non-participation” based on the matrix above.

Thus, the replicator dynamics equation of the residents can be expressed by Equation (6) as follows:

$$\begin{aligned} F(z) &= \frac{dz}{dt} = z(U_z - \bar{U}_z) = z(1-z)(U_z - U_{1-z}) \\ &= z(1-z)(-L_2 + S_3x - L_1x + L_2y) \end{aligned} \quad (6)$$

6.2.2. Evolutionarily Stable Strategies of Tripartite Subjects

1. Evolutionarily Stable Strategy of the Local Government

According to Equation (4), we know that the replicator dynamics equation of the local government is $F(x)$.

For $F'(x)$, the first-order derivative, we obtain the result according to Equation (7) as follows:

$$F'(x) = \begin{pmatrix} R_1 + R_3 - C_1 - C_2 + 2C_1x + 2C_2x - C_4z \\ -2R_1x - 2R_3x - R_3y + 2C_4xz + 2R_3xy \end{pmatrix} \quad (7)$$

According to the theory proposed by Friedman [83], when x satisfies $F(x) = 0$, $F'(x) < 0$, and x represents the ESS adopted by the local government during the implementation of the power restriction policy. The value of the parameters in the equation will affect the stability of the replicator dynamics equation. Thus, the stability analysis of the local government's behavior in the implementation of the power restriction policy is conducted as follows:

If $R_1 + R_3 - C_1 - C_2 - R_3y - C_4z = 0$, that is, $y = -\frac{C_1 + C_2 - R_1 - R_3 + C_4z}{R_3}$, it can be known that $F(x) = 0$, which represents the boundary line of the stable state.

If $y > -\frac{C_1 + C_2 - R_1 - R_3 + C_4z}{R_3}$ then $F(x) = 0$, and two stable points at $x = 0$ or $x = 1$ can be obtained.

If $R_1 + R_3 - C_1 - C_2 - R_3y - C_4z < 0$ then $y > -\frac{C_1 + C_2 - R_1 - R_3 + C_4z}{R_3}$, and it can be known that $F'(0) < 0$ when $x = 0$, and $F'(1) > 0$ when $x = 1$. Thus, $x = 0$ is a stable strategy, indicating that the local government's choice of the active power restriction during the implementation of the power restriction policy is unstable, and the choice of the passive power restriction is in a stable state. In contrast, if $R_1 + R_3 - C_1 - C_2 - R_3y - C_4z > 0$, that is, $y < -\frac{C_1 + C_2 - R_1 - R_3 + C_4z}{R_3}$, it can be known that when $x = 0$, there is $F'(0) > 0$, and when $x = 1$, there is $F'(1) < 0$. Thus, $x = 1$ is a stable strategy, indicating that in the implementation process of the power restriction policy, the local government chooses to eliminate power restrictions, and the strategy is unstable. It will choose active power restrictions to achieve a stable state.

2. Evolutionarily Stable Strategies of Enterprises

According to Equation (5), we know that the replicator dynamics equation of the enterprises is $F(y)$.

At this point, the first-order derivative of $F(y)$ is obtained according to Equation (8) as follows:

$$F'(y) = \begin{pmatrix} C_3 - K_1 + K_2x + R_3x + W_2x - 2C_3y + 2K_1y \\ +W_1z - 2K_2xy - 2R_3xy - 2W_2xy - 2W_1yz \end{pmatrix} \quad (8)$$

Therefore, according to the theory above, when y satisfies $F(y) = 0$ and $F'(y) < 0$, y represents the ESS adopted by enterprises during the implementation of the power restriction policy. The value of the parameters in the equation will affect the stability of the replicator dynamics equation. Thus, the stability analysis of the enterprises' behaviors in the implementation of the power restriction policy is conducted as follows:

If $C_3 - K_1 + W_2x + K_2x + R_3x + W_1z = 0$ then $z = -\frac{C_3 - K_1 + K_2x + R_3x + W_2x}{W_1}$, and it can be seen that $F(y) = 0$, which means the boundary line of the stable state.

If $C_3 - K_1 + W_2x + K_2x + R_3x + W_1z \neq 0$ then $F(y) = 0$, and two stable points at $y = 0$ or $y = 1$ can be obtained.

If $C_3 - K_1 + W_2x + K_2x + R_3x + W_1z < 0$, that is, $z < -\frac{C_3 - K_1 + K_2x + R_3x + W_2x}{W_1}$, it can be known that $F'(0) < 0$ when $y = 0$, and $F'(1) > 0$ when $y = 1$. Thus, $y = 0$ is a stable strategy, which indicates that the power reduction policy is implemented. If enterprises choose the active green transformation in this process, this strategy is unstable, and if they choose to maintain the status quo, the strategy is stable.

Conversely, if $C_3 - K_1 + W_2x + K_2x + R_3x + W_1z > 0$, that is, $z > -\frac{C_3 - K_1 + K_2x + R_3x + W_2x}{W_1}$, it can be known that $F'(0) > 0$ when $y = 0$, and $F'(1) < 0$ when $y = 1$. Thus, $y = 1$ is a stable strategy, indicating that in the implementation process of the power restriction policy, if enterprises to choose to maintain the status quo, this strategy is unstable, and if they choose to carry out an active green transformation, this strategy achieves a stable state.

3. Evolutionarily Stable Strategies of Residents

According to Equation (6), we know that the replicator dynamics equation of the residents is $F(z)$.

At this point, the first-order derivative of $F(z)$ is obtained according to Equation (9) as follows:

$$F'(z) = L_2y + 2L_2z + 2L_1xz - 2S_3xz - 2L_2yz \quad (9)$$

Therefore, according to the theory above, when z satisfies $F(z) = 0$ and $F'(z) < 0$, z represents the ESS adopted by the residents during the implementation of the power restriction policy. The value of the parameters in the equation will affect the stability of the replicator dynamics equation. Thus, the stability analysis of the residents' behaviors in the implementation of the power restriction policy is conducted as follows:

If $-L_2 + S_3x - L_1x + L_2y = 0$, that is, $x = -\frac{L_2 - L_2y}{L_1 - S_3}$, it can be known that $F(z) = 0$, which represents the boundary line of the stable state.

If $-L_2 + S_3x - L_1x + L_2y \neq 0$ then $F(z) = 0$, and two stable points at $z = 0$ or $z = 1$ can be obtained.

If $-L_2 + S_3x - L_1x + L_2y < 0$, that is, $x > -\frac{L_2 - L_2y}{L_1 - S_3}$, it can be known that $F'(0) < 0$ when $z = 0$, and $F'(1) > 0$ when $z = 1$. Thus, $z = 0$ is a stable strategy, which indicates that in the implementation of the power reduction policy, if the residents choose to participate in the process, this strategy is unstable, and if they choose not to participate, a stable state can be achieved.

If $-L_2 + S_3x - L_1x + L_2y > 0$, that is, $x > -\frac{L_2 - L_2y}{L_1 - S_3}$, it can be known that $F'(0) > 0$ when $z = 0$, and $F'(1) < 0$ when $z = 1$. Thus, $z = 1$ is a stable strategy, which indicates that in the implementation of the power reduction policy, if the residents choose not to participate in the process, this strategy is unstable, and if they choose to participate, a stable state can be achieved.

6.2.3. Replicator Dynamics Equilibrium Point Judgement

In a dynamic game, the probability that three groups of stakeholders choose a particular strategy (x, y, z) depends on time (t) . Thus, $x(t)$, $y(t)$, and $z(t) \in [0, 1]$ represent the dynamic probabilities of these strategies. Thus, the ternary domain solution of the evolutionary game is $[0, 1] \times [0, 1] \times [0, 1]$. When $t = 0$, the initial values are set to $x(t = 0) = x(0)$, $y(t = 0) = y(0)$, and $z(t = 0) = z(0)$ for any initial point $(x(t), y(t), z(t)) \in [0, 1] \times [0, 1] \times [0, 1]$, and any point (x, y, z) on the solution curve of the three-party evolutionary strategy corresponds to mixed strategy combinations for evolutionary games.

When all the dynamic equations are equal to zero, the described equilibrium point for the local government, enterprises, and residents will no longer evolve in probability. Therefore, the equilibrium point of the equation is obtained according to Equation (10) as follows:

$$\begin{cases} F(x) = \frac{dx}{dt} = x(1-x)(R_1 + R_3 - C_1 - C_2 - R_3y - C_4z) \\ F(y) = \frac{dy}{dt} = y(1-y)(C_3 - K_1 + W_2x + K_2x + R_3x + W_1z) \\ F(z) = \frac{dz}{dt} = z(1-z)(-L_2 + S_3x - L_1x + L_2y) \end{cases} \quad (10)$$

Based on the equations above, it is easy to determine that the three-party game system has 8 pure-strategy partial equilibrium points on the plane $\Omega = \{x, y, z, 0 < x, y, z < 1\}$. That is, these special equilibrium points constitute the boundary of the deterritorialization of the ternary evolution. In addition, when the conditions in the equation system are satisfied, there may be an equilibrium point for mixed strategy E9 in the system as follows:

$$\begin{cases} R_1 + R_3 - C_1 - C_2 - R_3y - C_4z = 0 \\ C_3 - K_1 + W_2x + K_2x + R_3x + W_1z = 0 \\ -L_2 + S_3x - L_1x + L_2y = 0 \end{cases}$$

Let the solution of the equation be

$$\begin{cases} x = x^* \\ y = y^* \\ z = z^* \end{cases}$$

That is, there may be an equilibrium point, E9 (x^*, y^*, z^*), for a mixed strategy.

According to the research of Friedman [83], the stability of the equilibrium point of the evolutionary system can be judged by the local asymptotic stability analysis method of the Jacobian matrix, and the partial derivatives of the equations with respect to x, y , and z can be obtained. The judgement matrix is as follows:

$$J = \begin{bmatrix} \begin{pmatrix} R_1 + R_3 - C_1 - C_2 \\ +2C_1x + 2C_2x - 2R_1x \\ -2R_3x - R_3y - C_4z \\ +2C_4xz + 2R_3xy \end{pmatrix} & R_3x^2 - R_3x & -C_4x + C_4x^2 \\ \begin{pmatrix} K_2y + R_3y + W_2y \\ -K_2y^2 - R_3y^2 - W_2y^2 \end{pmatrix} & \begin{pmatrix} C_3 - K_1 + K_2x + R_3x \\ +W_2x - 2C_3y + 2K_1y \\ +W_1z - 2K_2xy - 2R_3xy \\ -2W_2xy - 2W_1yz \end{pmatrix} & W_1y - W_1y^2 \\ S_3z - L_1z + L_1z^2 - S_3z^2 & L_2z - L_2z^2 & \begin{pmatrix} -L_2 - L_1x + S_3x \\ +L_2y + 2L_2z \\ +2L_1xz - 2S_3xz \\ -2L_2yz \end{pmatrix} \end{bmatrix}$$

In the evolutionary game among multiple groups, the pure-strategy equilibrium is a strict Nash equilibrium [84]. Thus, it is only necessary to verify the asymptotic stability of 8 pure-strategy equilibrium points. Based on Lyapunov's first method, the corresponding equilibrium points are divided into three situations: a stable point, an unstable point, and a saddle point [82]. If the corresponding equilibrium point is to be a stable point, the real parts of all the eigenvalues of the Jacobian matrix must be negative. If the corresponding equilibrium point is to be an unstable point, all the eigenvalues of the Jacobian matrix must be satisfied. All the real parts are positive. If the corresponding equilibrium point is to be a saddle point, it is necessary to satisfy the condition such that the real parts of all the eigenvalues of the Jacobian matrix are both positive and negative [85]. The pure-strategy equilibrium point and the eigenvalue analysis of the evolutionary game are shown in Table 10.

Table 10. Pure-strategy equilibrium points and eigenvalues of the evolutionary game.

Equilibrium Point	Eigenvalues		
	φ_1	φ_2	φ_3
$E_1 = (0, 0, 0)$	$C_3 - K_1$	$-L_2$	$R_1 - C_2 - C_1 + R_3$
$E_2 = (0, 0, 1)$	L_2	$C_3 - K_1 + W_1$	$R_1 - C_2 - C_4 - C_1 + R_3$
$E_3 = (0, 1, 0)$	0	$K_1 - C_3$	$R_1 - C_2 - C_1$
$E_4 = (0, 1, 1)$	0	$K_1 - C_3 - W_1$	$R_1 - C_2 - C_4 - C_1$
$E_5 = (1, 0, 0)$	$S_3 - L_2 - L_1$	$C_1 + C_2 - R_1 - R_3$	$C_3 - K_1 + K_2 + R_3 + W_2$
$E_6 = (1, 0, 1)$	$L_1 + L_2 - S_3$	$C_1 + C_2 + C_4 - R_1 - R_3$	$C_3 - K_1 + K_2 + R_3 + W_1 + W_2$
$E_7 = (1, 1, 0)$	$S_3 - L_1$	$C_1 + C_2 - R_1$	$K_1 - C_3 - K_2 - R_3 - W_2$
$E_8 = (1, 1, 1)$	$L_1 - S_3$	$C_1 + C_2 + C_4 - R_1$	$K_1 - C_3 - K_2 - R_3 - W_1 - W_2$

6.3. Analysis of the Conditions to Be Satisfied by Tripartite Collaborative Governance

By analyzing the stability of the behavioral strategies of the local government, enterprises, and residents, that is, the tripartite stakeholders, it will be found that the ESSs of the tripartite subjects are not always stable but are a dynamic evolutionary process, influencing each other until reaching the “optimal solution” equilibrium. For the implementation of carbon reduction policies, the three parties in the game form a three-party-coordinated governance mechanism to reach a consensus on energy conservation and emission reduction goals. Participating in the implementation of the carbon reduction is the optimal solution. At this time, the system conforms to the Lyapunov stability theory [85]; then, $(x, y, z) = (1, 1, 1)$ is the asymptotic stable point of the system. Therefore, this section focuses on discussing the evolutionary process of the three-party game in the $E_8 = (1, 1, 1)$ situation, understanding the effect of the interaction among the three parties and the roles of the different parameters on the evolutionary path to provide a basis for the government. This lays a theoretical foundation for solving performance management problems when implementing carbon reduction policies.

Based on Lyapunov’s first method, the stability analysis of the equilibrium point shows that when the eigenvalue of $E_8 = (1, 1, 1)$ is negative, the asymptotic stability of the harmonious co-governance of the three parties can be achieved.

Substituting $E_8 = (1, 1, 1)$ into the Jacobian matrix above, the Jacobian matrix can be rewritten as follows:

$$J = \begin{bmatrix} L_1 - S_3 & 0 & 0 \\ 0 & C_1 + C_2 + C_4 - R_1 & 0 \\ 0 & 0 & K_1 - C_3 - K_2 - R_3 - W_1 - W_2 \end{bmatrix}$$

On this basis, we obtain the following equations:

$$\begin{aligned} \varphi_1 &= L_1 - S_3, \quad \varphi_2 = C_1 + C_2 + C_4 - R_1; \\ \varphi_3 &= K_1 - C_3 - K_2 - R_3 - W_1 - W_2 \end{aligned}$$

For the local government, local enterprises, and residents to reach an agreement on energy conservation and emission reduction goals and form a collaborative relationship, it can be seen that $\varphi_1 = L_1 - S_3 < 0$. When the residents participate, it is necessary to reduce the cost of the residents’ supervision and feedback to the government and to improve the process of the residents’ participation as much as possible. The social benefits obtained are the net benefits for increasing the participation of the residents under the government’s active power reduction; it can be seen from $\varphi_2 = C_1 + C_2 + C_4 - R_1 < 0$ that when the sum of the implementation cost, the economic loss, and the loss of social benefits caused by the unstable power supply is less than the environmental benefits obtained by the active power reduction strategy, the government can transform to an evolutionarily stable state.

From $\varphi_3 = K_1 - C_3 - K_2 - R_3 - W_1 - W_2 < 0$, from the perspective of enterprises, it can be seen that the transformation cost of enterprises, when actively responding to the policy of the green transformation, is less than the sum of the incomes obtained from the government's policy support, power restriction exemptions, and residents' consumption preferences, as well as the costs for passively maintaining the status quo and the pursuit of the maximum profits, only enterprises that are environmentally oriented will choose to actively respond to policies and carry out a green transformation.

In previous government performance appraisals, more attention was paid to the social benefits for the government itself and the economic benefits influenced by enterprises. By analyzing the conditions that must be met for the three parties to coordinate and realize co-governance, it can be seen that residents also play an important role. Based on the relevant parameters of the eigenvalues φ_1 , φ_2 , and φ_3 , in future research, the relevant indicators can be refined, especially resident-related indicators that are extremely quantified in existing local government performance appraisals.

6.4. Policy Analysis and Performance Optimization Suggestions

6.4.1. Analysis of Policy Implementation Issues

According to the asymptotic stability analysis results of each subject's strategy in the evolutionary game model, the realization path of the stable strategy of "active electricity curtailment by the government, active green transformation by enterprises, and participation by residents" is drawn (see Figure 4). At present, the Chinese government is still in the process for exploring and improving the implementation of energy conservation and emission reduction policies. There are still many problems in the government's performance of its functions and in handling the relationship between stakeholders. To seek more realistic methods and complete policy improvement suggestions, in this study, we compared the path that led to "the government's active power restriction, enterprises' active green transformation, and residents' participation" with the situation in the Zhejiang power restriction incident. We compare and explore the key factors for the local government, local enterprises, and residents to achieve a win-win cooperation.

Comparing the Zhejiang power restriction incident and the evolutionary path of the target model, the main problems can be summarized as follows:

1. The role of the government itself is insufficient. This is mainly reflected in the following points: The formulation of assessment targets lacks scientific rigor and flexibility. Reasonable emission reduction targets are not set in accordance with the structural characteristics of the energy consumption and the economic development needs of different regions. The performance appraisal has lost its role in promoting the government's governance. During policy implementation process, we are faced with the ever-changing economic and ecological environments, and it is difficult to interact with and provide feedback to multiple parties in a timely manner;
2. The government's incentives and punishments for enterprises are not strong enough. As a result, the enthusiasm of enterprises for the transformation is not high, and they are more willing to maintain the status quo, use high-energy-consuming equipment, and rush to complete overseas Christmas orders;
3. There is a lack of measures to encourage and guide residents to participate. Residents lack access to government policy implementation processes and performance information. Residents play different roles at this time. They not only are the beneficiaries of energy conservation and emission reduction but also bear the inconveniences caused by this policy in life and work. There are needs for policy guidance and supervision and feedback mechanisms from local governments to identify needs and actively participate in collaborative governance.

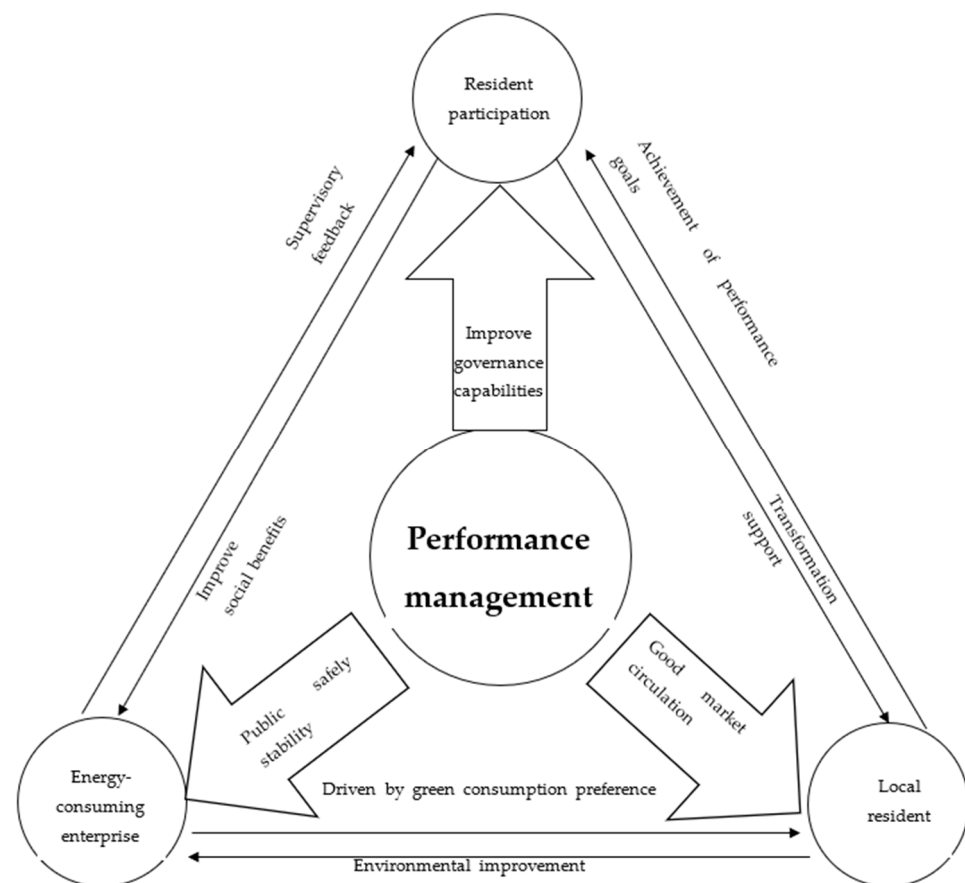


Figure 4. The realization path of the evolutionarily stable strategy of the tripartite co-governance.

6.4.2. Government Performance Optimization Suggestions

1. The government should improve the performance management mechanism of the energy conservation and emission reduction governance and maintain the normalization of the supervision and accountability. It should provide continuous upward feedback channels to increase the enthusiasm of local governments to participate in the construction of a circular economy. In terms of the assessment's time dimension, it is necessary to establish a dynamic assessment model or increase the frequency of assessments to be consistent with the assessments' objectives. Frequent interactive feedback efforts generate more performance information that can help governments to identify performance deficiencies by comparing the governments' own current and past records, as well as their own records with those of peer governments. Such comparisons can help to alert management teams of the need to catch up [86]. In addition, a system for using performance appraisal results needs to be further established. For example, in the first stage of an unqualified assessment, the responsible department should be required to submit a causal analysis and an improvement plan. In the second stage of an unqualified assessment, when submitting the improvement plan, the higher-level government should consider adjusting the target content and resource allocation [87] to drive the achievement of performance goals. Of course, in performance appraisal accountability, it is necessary to prevent adverse selection caused by excessive control and subsequent punishment to prevent similar cases from happening again;
2. Enterprises' behaviors for maintaining the status quo of production cannot be left to chance, nor can a one-size-fits-all power cut be carried out. To design a top-level management mechanism, the high-energy-consuming industry is divided based on the characteristics of the industry, graded power restriction, and peak power restrictions. At the same time, government performance goals, responsible persons,

budget expenditures, contributions to goals, and performance evaluation results are disclosed and updated to allow companies to understand the progress in achieving various strategic goals and carrying out specific government projects. Companies can use this information to predict the government's behavior and make behavioral decisions that are beneficial to them;

3. Public services provided by the government require the active participation of citizens, especially those who directly use the services [88]. Local residents are one of the direct victims and managers of carbon emissions. The management of carbon emissions from production activities requires strong supervision by residents, while reducing carbon emissions from daily consumption requires residents to adhere to a green lifestyle, and the government's correction of the policy implementation process requires effective supervision by residents. By stimulating public participation in governance, corporate social responsibility and public awareness can be enhanced, supervision costs can be effectively reduced, and the power of the public can be maximized [12].

Local governments need to expand external supervision channels for residents' participation in the following ways: first, they should continue to optimize specific ways for the public to participate in the collaborative governance of energy conservation and emission reduction. For example, the performance feedback mechanism should include public satisfaction in the government's performance management system. Alternatively, local governments should provide residents with voting, opinion collection, hearings, speeches, and other diversified forms to offer residents a wide range of channels for democratic participation, democratic decision-making, and democratic supervision. Second, local governments should strengthen environmental protection awareness as well as the media and social groups' supervision of energy conservation and emission reduction. If the public continues to pay attention to news about environmental pollution, the news media can act as an unofficial supervision department, which has a certain inhibitory effect on the negative emission reduction behaviors of high-energy-consuming enterprises to maintain the status quo [89]. Finally, local governments should improve the disclosure systems of the environmental protection information and government performance information to ensure residents' right to know and participate, compensate for the shortcomings of the regulatory mechanism [12], and help to improve citizens' satisfaction with the government [90].

7. Conclusions

7.1. Summary

In China, which is the world's largest developing country and carbon emitter, driven by medium-high economic growth, carbon emissions continue to rise. Furthermore, owing to the enormous volume of emissions, the international pressure to reduce emissions is growing. Therefore, the realization of carbon peaking and carbon neutrality is a broad and profound economic and social reform. As the main starting point for achieving the dual-carbon goal, research on energy conservation and emission reduction holds great theoretical and practical significance for further promoting ecological civilization construction. In the processes of energy conservation and emission reduction, the contradiction in the interests of multiple subjects is the focus of research, which involves the practical problem of the game among the interests of the subjects. Therefore, based on the specific case of the conflict among the energy conservation and emission reduction goals and economic development represented by the power cut event in Zhejiang Province at the end of 2020, this paper analyzes the core interest subjects, the current situation, and the existing problems in the government's performance management system from the perspectives of the interest demands and strategic choices of the subjects. Additionally, it analyses the root causes of the problems by conducting an evolutionary game analysis. This study seeks to make the interest of each subject obtain the optimal benefits of the balance point, and it proposes countermeasures for optimizing the government's performance management and other suggestions. This study finds that in the process for realizing sustainable development goals and green development, the government faces difficulties, such as the lack of scientific

rigor and flexibility in the formulation of assessment targets. At the same time, there are problems such as the lack of interactive feedback from the government and the imperfect internal control of the government. Promoting the selection of the behavioral strategies of the stakeholders involved in the implementation of domestic policies plays a key role in the implementation of energy conservation and emission reduction measures. Therefore, first, the government maintains the normalization of the supervision and accountability, emphasizing interactive feedback work and the utilization of results. Second, it carries out classified governance in accordance with the characteristics of enterprises and industries, and it designs a reasonable power restriction mechanism. Finally, the government actively guides residents to participate in supervision and provides residents with multiple feedback methods and suggestions.

In theory, this paper combines the evolutionary game model to analyze in depth the real management problems faced by the government in the process for implementing carbon emission reduction policies, and it introduces enterprises and residents as stakeholders to form a three-way game. Moreover, from the perspective of costs and benefits, the different roles played by enterprises and residents in the process and the different impacts on the implementation of government policies are considered. The behavioral factors of stakeholders are analyzed from the perspective of dynamic deduction, which provides a new way for the government to improve performance management. It is suggested that the interactive feedback of the enterprises and residents should be incorporated into the performance management of local governments, and an effective responsibility and pressure transmission mechanism should be established using performance appraisals to help the internal control of the government and promote the realization of China's dual-carbon goal.

In practice, as a developing country, compared with developed countries, China has less time and a larger amplitude to achieve the "dual-carbon" goal, and the challenges and complexities that must be dealt with are unprecedented. China's carbon emission reduction policy is based on appropriate references to the European Union and other developed countries. By analyzing the case of Zhejiang power rationing, this paper designs a collaborative governance mechanism for the energy conservation and emission reduction system, and it further provides relevant countermeasures and suggestions for the behavioral decision-making and performance management of local government entities in achieving the binding assessment targets of energy conservation and emission reduction. China has fully considered its own national conditions and systems, and it can provide other countries and organizations, including developing countries, with China's carbon emission reduction ideas.

7.2. Limitations and Prospects

The limitations of this study mainly include the following three points, which can be addressed in future research.

First, owing to the complex relationship between various stakeholders and the lack of quantitative research on the implementation of environmental policies, this paper does not use statistical analysis methods. Rather, it uses typical examples to compare the results of mathematical models. Therefore, future research can consider using the method of carbon calculation to measure the effect of carbon reduction and select simulation data to simulate and analyze the evolutionary game model.

Second, this case study investigates a single case in Zhejiang, China, and based on the generalization of the literature, there may be some deviation from the actual performance. However, this paper conducts a cost-benefit analysis of the interest relationships and behavioral strategies of all the parties involved in the processes of the government's energy conservation and emission reduction strategies and, thus, has a certain referential significance. Subsequent research can adopt diversified, cross-regional, and multi-case research methods.

Finally, the case studies in this paper are mainly based on external public information. In the process for analyzing the performance management of the Zhejiang provincial government, there may be factors that have not been considered, and the reasoning of the decision-making process may not be comprehensive, which limit secondary research. Future research can consider diverse research evidence, such as that obtained through large sample surveys, interviews with policy subjects, and interviews with government officials. Future research can perform an in-depth excavation of the connotations of energy conservation and emission reduction policies and further refine and improve the system design path and policy improvement measures.

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