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An Institutional Response to the Coal-to-Gas Dilemma in Rural Hebei from the Perspective of Ecological Protection Compensation

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Abstract: Against the backdrop of joint prevention and control of air pollution in the Beijing-Tianjin-Hebei (BTH) region, the rural coal-to-gas (C2G) transition in Hebei has significantly improved regional air quality but has also driven up heating costs for rural households, generating a real tension between "blue sky" and "warmth." This dilemma stems from multiple causes: at the practical level, the phasing out of gas subsidies fails to offset the increased economic burden of clean heating; at the economic level, it reflects the failure to internalize environmental positive externalities; and at the legal level, it manifests as the breakdown of interest balancing across regions and inadequate institutional supply. The ecological protection compensation system offers an effective solution, justified by both jurisprudential and institutional grounds. In terms of institutional design, a horizontal compensation agreement should be concluded between the Beijing, Tianjin, and Hebei governments, compensating rural Hebei residents for the direct and opportunity costs arising from the C2G transition; the compensation standard should at least reach a reasonable level, and the principal mode of compensation should be enhanced gas subsidies.

Keywords: ecological protection compensation; coal-to-gas; interest balancing; inter-regional horizontal compensation

1. Introduction

The Beijing-Tianjin-Hebei (BTH) region lies on the eastern side of the Taihang Mountains and the southern side of the Yanshan Mountains, forming a semi-enclosed terrain in a low-wind zone within a common airshed, conditions that readily cause the accumulation and mutual transmission of pollutants [1]. For a long time, affected by an objective production structure characterized by "a heavy industrial structure, a coal-heavy energy mix, and a road-heavy transport structure," air pollution in the BTH region has been acute, severely constraining the sustainable economic and social development of the three localities.

Against the broader background of coordinated BTH development, the three localities have, based on policy arrangements such as the Outline of the Coordinated Development Plan for the Beijing-Tianjin-Hebei Region, signed a series of cooperation agreements, advancing the harmonization of regulations and standards, strengthening structural emission reduction, improving joint action mechanisms, and enhancing coordinated enforcement, thereby breaking the parochial mindset and deepening joint prevention and control of air pollution. Through normative documents such as the Implementation Rules for the Air Pollution Prevention and Control Action Plan in the Beijing-Tianjin-Hebei and Surrounding Areas (hereinafter, the "Implementation Rules"), concrete treatment schemes have been established, providing a solid institutional foundation for the Blue Sky Protection Campaign. Under this joint governance framework, the air quality of the three localities has improved markedly. In 2024, the annual average concentration of fine particulate matter (PM_{2.5}) in the BTH region reached 37 µg/m³, a

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63.7% decrease from 2013; the proportion of days with good air quality was 74.1%, a 32.2 percentage point increase; and the proportion of heavy-pollution days fell by 94% relative to 2013. Beijing's annual average PM_{2.5} concentration fell from 89.5 µg/m³ to 30.5 µg/m³, a 65.9% decrease [2].

Under the arrangements of the Outline of the Coordinated Development Plan for the Beijing-Tianjin-Hebei Region, Hebei Province is positioned as the ecological environment support zone of the region, undertaking the important mission of maintaining regional ecological security and building an ecological shield for Beijing and Tianjin. Owing to differences in production structure and functional positioning among the three localities, Hebei has shouldered the heaviest energy-transition task: according to the Implementation Rules, Hebei accounts for 48% of the coal consumption reduction required of the four provinces and municipalities of Beijing, Tianjin, Hebei, and Shandong, and therefore needs to substantially cut rural cooking and heating coal use. The rural C2G policy implemented in Hebei since 2016 is one of the key measures for air pollution control. Through the conversion of heating energy from coal to natural gas, it has effectively reduced emissions of sulfur dioxide, particulate matter, and heavy metals, playing an important role in improving air quality across the BTH region. By late 2025, the issue of "expensive rural heating in Hebei" attracted widespread public attention. Calculations show that maintaining a basic room temperature of 18C in a typical 100-square-meter rural Hebei household now requires a heating expenditure of 5,000–10,000 yuan per season, compared with less than 2,000 yuan during the loose-coal era—a near-explosive increase in the heating burden on residents. However, such high heating costs contrast sharply with the relatively low per-capita income: data from the Hebei Provincial Bureau of Statistics show that the per-capita disposable income of rural Hebei residents in 2024 was only 22,022 yuan, which is difficult to bear such expensive energy expenditure [3]. For vulnerable groups such as rural elderly receiving only slightly more than one hundred yuan per month in pension, a heating bill of several thousand yuan already breaches the threshold of basic livelihood security.

The tension between "blue sky" and "warmth" deeply reveals an imbalance between regional ecological interests and the protection of individual property and even subsistence rights. Grounded in the current legal and policy framework, this paper aims to analyze the formation mechanism of the rural C2G dilemma in Hebei and to explore how to activate the interest-balancing function of the ecological protection compensation system, so as to seek a feasible rule-of-law pathway for resolving this practical problem.

2. Causes of the Rural C2G Dilemma in Hebei

2.1. Practical Constraining Factors of the Clean-Heating Transition in the Post-Subsidy Era

The formation of the rural clean-heating dilemma in Hebei stems from the overlapping of multiple practical pressures in the post-subsidy era. Natural gas, as a highly commercialized clean energy source, has its price jointly determined by resource costs, pipeline construction, and operation and maintenance. The current residential gas price in rural Hebei remains in the range of 3.15–3.4 yuan per cubic meter, which is at a reasonable market level overall. This implies that, under the existing price formation mechanism, the room to lower gas prices through administrative means alone is extremely limited, and the cost of clean heating exhibits strong price rigidity. Meanwhile, the widespread thermal performance defects of existing rural housing further aggravate the economic burden. A large number of self-built rural houses were constructed without energy-efficiency standards, with insufficient thermal insulation of the envelope, resulting in massive ineffective heat loss during heating and significantly higher gas consumption per unit of indoor temperature than normal. At the same time, the heating equipment installed during the early phase of intensive C2G rollout is gradually entering a period of high failure incidence; the energy-efficiency degradation and maintenance costs brought about by equipment aging constitute a hidden economic burden in the clean-heating transition. Although such costs are not directly reflected in the gas unit price,

they continuously push up rural residents' actual heating expenditure in the form of repair expenses and reduced operating efficiency.

As to the implementation pathway of clean heating, rural Hebei in fact faces several technical options, each subject to constraints of varying degrees. Centralized heating is constrained by the distance from heat sources and the cost of pipeline laying, and is economically inferior in sparsely populated rural areas. Electric heating, while clean, is subject to significant electricity-price volatility, and parts of the rural power grid still struggle to support large-scale electric heating loads. Renewable options such as biomass and geothermal energy face short-term difficulties in technical maturity, equipment investment, and maintenance costs that prevent large-scale rollout. Under these constraints, replacing dispersed coal combustion with piped natural gas has become the preferred option in most regions for advancing clean heating, and possesses a certain practical rationality. However, the practical rationality of a technological pathway does not, in itself, exempt policymakers from the institutional duty to protect the legitimate rights and interests of affected groups.

Under the combined effect of the above factors, the energy transition implemented through the C2G policy inevitably brings a heavier economic burden. However, the gas-use subsidies that initially supported the clean-heating transition are markedly stage-bound. As subsidy policies are gradually phased out, in some areas the residential gas-use subsidy has dropped from about 1 yuan per cubic meter to approximately 0.2 yuan, weakening the original cost-buffering mechanism and causing heating expenditure to rise sharply in the short term. Such a subsidy arrangement, attached to specific governance projects, is closer in nature to a discretionary administrative benefit than to an institutionalized right; it lacks stable predictability and cannot serve as a reliable long-term support for rural residents' clean heating. The core of solving the clean-heating dilemma therefore lies not in lowering the cost of energy itself, but in raising gas-use subsidies to reduce the effective gas price, in upgrading the thermal performance of houses and the operational efficiency of equipment to reduce gas consumption, and, against the backdrop of limited fiscal space in Hebei Province, in building a sustainable cost-sharing and funding mechanism—an inescapable practical proposition.

2.2. The Economic Mechanism of Failed Internalization of Positive Environmental Externalities

Examined from the perspective of economic logic, the deep root of the "expensive heating" problem in rural Hebei lies in the failure to effectively internalize the positive environmental externalities of clean heating through institutional arrangements. A positive externality refers to the situation in which the productive or consumptive activity of one economic subject generates positive benefits for other economic subjects without being compensated by the latter [4].

In the economic sense, the environmental benefits brought by the clean-heating transition exhibit clear positive-externality characteristics: their marginal social benefit markedly exceeds their marginal private benefit [5]. The environmental improvement produced by the clean-heating transition ultimately takes the form of an overall improvement in regional air quality, with a salient non-excludability feature. Within the spatial pattern of BTH joint prevention and control, the environmental benefits created by rural Hebei's clean-heating transition spread through atmospheric flow mechanisms toward downwind areas such as Beijing and Tianjin; regardless of whether or not they bear the costs of the heating-mode transition, all subjects in the region can share the welfare gains brought by the air-quality improvement.

However, in current practice, the spilled ecological benefits generated by C2G have not effectively flowed back to the subjects who actually implemented the clean-heating transition, and the costs and benefits of environmental governance show a markedly asymmetric distribution. On the one hand, the direct costs of the clean-heating transition are highly concentrated on the group of rural Hebei residents with relatively limited economic carrying capacity; on the other hand, the ecological dividends brought by air-quality improvement are shared across a much broader scope, and their marginal social

benefit is often more significant in the densely populated and economically active urban areas of Beijing and Tianjin. Although the clean-heating transition satisfies a cost-benefit analysis at the macro level, it imposes a heavy burden on economically weaker rural Hebei residents at the micro level. Precisely because of the lack of an effective internalization mechanism for environmental positive externalities, the costs of clean-heating transition—a behavior with salient public-interest attributes—are borne in a concentrated manner, and no incentive structure matching its social value is formed at the individual decision-making level. This ultimately causes the rural "expensive heating" problem in Hebei to persist and become an important economic factor constraining the sustainable advancement of the clean-heating transition.

2.3. Failure of Interest Balancing and Insufficient Institutional Supply

The rural C2G dilemma in Hebei is not only a technical or economic problem, but also a rule-of-law issue concerning social fairness, justice, and the protection of basic rights. Viewed from the perspective of jurisprudential and institutional logic, this dilemma is not a mere deviation in policy implementation, but a concentrated reflection of the failure of interest balancing and inadequate institutional supply in regional ecological governance.

Within the BTH collaborative governance framework for air pollution prevention and control, the clean-heating transition is positioned as an important means of realizing the regional ecological public interest, yet its institutional design has failed to properly handle the allocation of rights and obligations among different regions and groups. The low-standard and progressively phased-out gas subsidies have failed to effectively compensate rural Hebei residents for the additional living costs they bear in order to accommodate environmental governance, with the result that the economic burden of ecological governance is highly concentrated on a rural group with relatively weak economic capacity, while the environmental benefits produced by air-quality improvement are shared on a much broader scope. The interest imbalance revealed by the C2G dilemma exhibits three structural features. First, the cost-bearing is highly geographically concentrated while the benefit diffusion is broad: the cost of the clean-heating transition is almost entirely concentrated on this specific rural Hebei group, whereas the resulting air-quality improvement is shared indiscriminately across the entire BTH region—Beijing and Tianjin residents are equally beneficiaries and bear no energy-substitution cost. Second, there is an unequal cost burden among similarly situated citizens: Beijing residents enjoy clean heating at a relatively low gas price, while Hebei rural residents who are compelled to complete the energy substitution bear a heating-expenditure-to-disposable-income ratio far higher than that of the former—a difference not arising from personal choice but from policy-mandated arrangements. Third, there is a dual asymmetry between cost-bearing and benefit-acquisition: rural Hebei residents are located on the upwind side, where the marginal benefit of air-quality improvement is lower than for the downwind urban population, and the gap between their contribution to regional air governance and the benefits they receive is the most pronounced among all affected groups. The development rights, property rights, and even the basic subsistence rights of rural Hebei residents have not received the institutional respect they deserve in environmental governance [6].

An important procedural reason for the above interest-balancing failure is the lack of an institutionalized stakeholder participation mechanism in the decision-making and implementation of the clean-heating transition. The C2G policy, as a typical public policy, is in essence an authoritative allocation of social resources led by public power; its formulation and implementation do not depend on consensus but on the judgment of public authority [7]. Such a one-way decision-making system excludes the participation of social forces and stakeholders, or treats social participation in a symbolic and formal manner, lacking serious consideration of social acceptance, public willingness to accept compensation, and demands for social fairness [6]. Consequently, the rights protection of rural Hebei residents was placed in a relatively marginal position at the policy-design

stage, leading to the concentrated outbreak of the contradiction between "blue sky" and "warmth".

Beyond procedural failure, the project-based administrative governance logic on which the subsidy regime depends further amplifies the imbalance of interest distribution at the implementation level. The subsidy funds that currently support the operation of the C2G policy mainly come from time-limited governance "projects"; once a project ends or fiscal pressure increases, the subsidy standard will be reduced or terminated, and the current problem of subsidy phasing-out is a concentrated manifestation of the drawbacks of this governance model. This governance model not only causes instability in fund supply, but also tends to induce the alienation of fund use. To cope with complex performance-assessment indicators and fiscal pressures, local governments often resort to diverting funds to cover immediate shortfalls through ad hoc reallocation of project funds [8], further aggravating the instability of subsidy funds. The financial support that rural residents obtain is attached to unstable administrative discretion and lacks a definite and stable institutional underpinning.

3. Justification for Applying the Ecological Protection Compensation System to the C2G Dilemma

3.1. Definition of Ecological Protection Compensation

There has so far been no fully consistent understanding of the definition of ecological protection compensation at the level of legal theory and regulation, which is closely related to the historical plurality of relevant policy and legal terminology. For a long time, the expressions "ecological compensation," "ecological environment compensation," and "ecological protection compensation" have coexisted in national-level policies and laws, and the extension of this concept in local normative documents and practice is even broader, covering to a considerable extent various means of ecological and environmental resource protection [9]. As a representative scholarly view, Professor Wang Jin defines ecological compensation as "the behavior by which the ecological-protection beneficiary or the ecological-damage tortfeasor compensates the ecological protector or the party damaged by ecological damage by paying money, materials, or providing other non-material benefits, on the basis of comprehensive consideration of ecological protection costs, development opportunity costs, and ecological service value, by administrative, market, or other means, so as to make up for its cost expenditure and other related losses [10]". Other scholars divide it into three categories-ecological protection compensation, ecological damage compensation, and ecological damage reparation [11]-or directly understand it as "the provider of ecosystem services receiving payment from the beneficiary of ecosystem services [4]".

After the issuance of the 2016 State Council Opinions on Improving the Ecological Protection Compensation Mechanism, "ecological protection compensation" gradually replaced "ecological compensation" as the official normative expression, narrowing the scope of the concept at the regulatory level. The Regulations on Ecological Protection Compensation (hereinafter, the "Regulations") make clear that ecological protection compensation is an incentive institutional arrangement that compensates units and individuals who carry out ecological protection in accordance with regulations or agreements. Within this conceptual framework, the following basic consensus should be reached: first, the principle is that ecological beneficiaries compensate ecological protectors; second, the purpose of compensation is to make up for the restrictions on the development rights, property rights, and other rights of ecological protectors caused by ecological-environment protection; third, the ultimate goal is to achieve a sound ecological environment [12].

3.2. Jurisprudential Justification for Applying the Ecological Protection Compensation System

Compensation differs from damages: it aims to provide remedies to citizens, legal persons, and other organizations that have suffered special losses for the sake of public interest, embodying the spirit of fair burden-sharing. The essence of the ecological

protection compensation system lies in fairly allocating rights and obligations to achieve interest balancing, realizing the gain of ecological benefits and the minimization of interest conflicts in the environmental era [6]. From the perspective of justice theory and the principle of correspondence between rights and obligations, the sustained supply of ecological services stems from restrictions on the ecological protector's development rights, property rights, and other basic rights; whether the restriction is positive or negative, it will cause certain losses. Based on considerations of justice, the law should provide commensurate compensation for such "special sacrifice"; based on the correspondence between rights and obligations, the ecological protector who has suffered "special sacrifice" is entitled to a right to request that the ecological beneficiary must perform a certain compensation, namely, the ecological compensation claim right, and correspondingly, the ecological beneficiary is obliged to perform a certain payment in response to the ecological protector's request [13]. The term "special sacrifice" as used here does not refer to any general burden borne by citizens for any public-interest need; rather, it specifically refers to a burden that significantly transcends the general level of society along three dimensions: degree, nature, and distribution. With respect to the degree of burden, one should examine whether the actual impact of the relevant restriction on the counterpart's property rights and subsistence rights significantly exceeds the reasonable tolerance range of ordinary members of society. With respect to the nature of the burden, one should distinguish whether the restriction involved is a guidance at the level of consumption choice, or a compulsion at the level of basic subsistence. With respect to the distribution of burden, one should examine whether the cost-bearing and benefit-acquisition exhibit a significant structural imbalance in geographical and group dimensions. The three dimensions interact and overlap rather than being isolated from one another-deviation in any single dimension may still fall within the reasonable tolerance obligation of citizens toward ordinary social policies; only when the abnormal degree, the rigid nature, and the distributive imbalance overlap with each other can the resulting burden constitute "special sacrifice" in the jurisprudential sense.

In order to provide ecological benefits for the BTH region as a whole, and especially for the urban areas of Beijing and Tianjin, rural Hebei has suffered losses exceeding its social responsibility range. The clean air generated by the implementation of C2G is a typical public good; this behavior has a salient positive externality that has not been effectively internalized, and the economic burden of the clean-heating transition is almost entirely borne by the rural Hebei residents who benefit relatively little. From a legal perspective, the C2G policy does not directly deprive residents of property; rather, it changes their energy-consumption mode through policy-mandated compulsion, transferring to specific individuals the external-cost-internalization costs that should otherwise be borne by public finance, forming a policy-driven cost transfer. Although this transfer differs from the direct appropriation of property in the traditional expropriation context, its restrictive effect on residents' actual economic burden and development space is real. The development rights, property rights, and even the subsistence rights of certain groups among rural Hebei residents are thereby affected-the persistence, rigidity, and non-substitutability of heating expenditure, the abnormal reduction in disposable income, and the significant mismatch between cost-bearing and ecological-benefit acquisition across geographical and group dimensions interact and overlap, constituting "special sacrifice" in the jurisprudential sense.

The above argument for the establishment of "special sacrifice" and the resulting compensation claim may still encounter the following challenge: even if, at the jurisprudential level, it is recognized that the burden borne by rural Hebei residents due to C2G constitutes "special sacrifice," does the application of the ecological protection compensation system-as an institution with specific normative connotations-still require the prerequisite of "exceeding the performance of statutory obligations"? In other words, only the additional improvement built upon meeting environmental quality standards can constitute a legitimate object of ecological protection compensation, so as to be distinguished from the basic emission-reduction legal obligations that each subject should

perform. Although this approach makes a useful distinction between ecological protection compensation and general environmental-governance obligations, if strictly implemented, it would render the compensation system unable to operate in regions where the ecological environment has not yet met the standards, thereby running counter to its institutional purpose of resolving interest imbalance. This paper argues that the prerequisite for applying compensation should be examined comprehensively from three levels: institutional function, normative basis, and jurisprudential logic.

From the perspective of institutional function, the ecological protection compensation system is not an ex-post reward mechanism for "exceeding the performance of statutory obligations"; what it primarily regulates is how the costs incurred in pursuing public ecological interests should be reasonably shared among relevant subjects. It should be pointed out that the obligation referenced in the "compliance-threshold theory" and that referenced in the "special sacrifice" analysis differ in both subject and nature. The former is an environmental-governance duty with local governments as the obligor, judged by whether the regional environmental quality has met the statutory standards; the latter is a general social-tolerance obligation with individual citizens as the obligor, judged by whether the specific policy burden actually borne by particular citizens exceeds the general level of society. The limitation of the "compliance-threshold theory" lies in displacing the question of whether the government's environmental-governance goal has been achieved onto the question of whether the individual citizen's right to claim compensation is established. However, the compensability of the additional economic burden borne by citizens in cooperating with the C2G policy stems from the "special" nature of the burden itself, not from the "already achieved" status of the government's environmental-governance goal. In essence, the compensation system has always been concerned with "the cost paid for protecting the ecology," not with "the results achieved after protection [14]." The additional heating cost paid by rural Hebei residents does not lose its compensability simply because the BTH atmospheric environment has not yet met the more stringent national standards.

From the perspective of normative basis, Article 2 of the Regulations on Ecological Protection Compensation defines compensation as "an incentive institutional arrangement that compensates units and individuals who carry out ecological protection in accordance with regulations or agreements"; the normative focus lies in incentivizing ecological-protection behavior, and "already meeting the standards" is not set as a statutory condition for triggering compensation. With respect to horizontal compensation as a specific type, the Regulations allow local governments, based on the objective connection between benefit and protection, to autonomously determine compensation arrangements through consultation, which further confirms that the trigger for compensation lies in the occurrence of "special sacrifice," rather than in the ultimate realization of environmental-improvement goals.

From the perspective of jurisprudential logic, treating "meeting the standards" as a prerequisite for compensation would also lead to a circular dilemma: if compensation can be triggered only after ecological improvement has reached the established standards, then in regions where the ecological situation is relatively severe and most in need of institutional incentives to promote improvement, compensation is unavailable precisely because the standards have not been met; the absence of compensation will in turn further suppress the ecological-protection input and the residents' willingness to cooperate in that region, making the ecological-improvement goals harder to attain. The introduction of the ecological protection compensation system in the field of air-pollution governance should adhere to a normative structure that takes special sacrifice as the basis of the compensation-claim right, interest balancing as the operational mechanism, and the promotion of ecological protection as the institutional purpose, so that the system can play its institutional function even during the transition period when the ecological environment has not yet fully met the standards. The application of the ecological protection compensation system should therefore be actively pursued to provide preferential protection for the rights of the vulnerable group of rural Hebei residents,

fairly allocate rights and obligations among regions and groups, and achieve interest balancing. Establishing a "who protects, who benefits" interest orientation and transforming external administrative compulsion into the endogenous motivation of rural residents is the long-term strategy for maintaining the balance between "blue sky" and "warmth."

3.3. Institutional Justification for Applying the Ecological Protection Compensation System

On June 1, 2024, the Regulations on Ecological Protection Compensation ("Regulations"), China's foundational and comprehensive administrative regulation on ecological protection compensation, came into force, integrating the previously scattered ecological-protection-compensation norms contained in various laws, regulations, and policy documents and laying a unified institutional foundation for the Chinese ecological protection compensation system. The Regulations provide that ecological protection compensation may be carried out through mechanisms such as fiscal vertical compensation, inter-regional horizontal compensation, and market-based compensation.

Fiscal vertical compensation targets units and individuals that carry out the protection of important ecological-environment elements and that carry out ecological protection in ecologically important areas such as key ecological-function zones, ecological-protection red lines, and nature reserves. The important ecological-environment elements refer to entities such as forests, grasslands, and wetlands, and do not include the atmosphere; the rural Hebei C2G transition is therefore difficult to be interpreted as the protection of an important ecological-environment element. Although the requirement of "carrying out ecological protection" in the latter part is relatively loose, only some twenty counties and districts in Hebei Province are included in key ecological-function zones, and the categories are mostly water-source conservation. There are therefore obvious difficulties in pursuing the fiscal-vertical-compensation pathway. Under the market compensation mechanism, introducing for C2G a trading mechanism similar to carbon-emission rights or pollution-discharge rights that centers on the control of total emissions would face significant institutional predicaments: the operation of such a mechanism depends on a high-precision MRV (monitoring, reporting, and verification) system, while rural heating emissions are typically highly dispersed and non-point in nature, making the institutional cost difficult to match the environmental-governance benefit; moreover, the subjects of compensation are mainly enterprises with emission-reduction needs, and the main ecological beneficiaries of clean air do not pay for it-this pathway also finds it hard to perform the interest-balancing function.

Inter-regional horizontal ecological protection compensation is conducive to promoting cost-sharing, benefit-sharing, and cooperative governance among regions, fully mobilizing the enthusiasm of all parties, and constitutes an important pathway for practicing the concept that "lucid waters and lush mountains are invaluable assets [15]". Implementing inter-regional horizontal compensation is the optimal choice for resolving the C2G dilemma: its conditions of application are relatively loose, and at the value level it better fits the requirement of interest balancing. This mechanism allows governments of ecologically benefiting regions and ecologically protecting regions to carry out compensation through consultation, and higher-level governments may coordinate compensation arrangements among lower-level governments, granting greater institutional flexibility in implementation; at the same time, the Regulations set a fallback clause on the regions of application of horizontal compensation, allowing local governments to apply it flexibly. Therefore, in the C2G dilemma, the application of inter-regional horizontal compensation does not encounter obvious institutional obstacles at the normative level. Given that the positive externalities generated by the clean-heating transition in rural Hebei are largely enjoyed by the urban areas of Beijing and Tianjin, having the ecologically benefiting regions bear the corresponding compensation responsibility accords with the beneficiary-pays principle and the basic requirement of distributive justice. Moreover, inter-regional horizontal compensation does not preclude central-level overall support; the urban areas of Beijing and Tianjin do not need to bear

the full consideration of clean air, and horizontal ecological protection compensation helps to realize interest balancing among regions and groups on a broader scale. Of course, relying on the fallback clause to apply horizontal compensation still involves a certain degree of normative uncertainty; in the long run, explicitly including atmospheric protection in the enumerated scope of horizontal compensation is the fundamental path to removing institutional obstacles.

4. Institutional Pathway: Resolving the C2G Dilemma through Ecological Protection Compensation

The key to resolving the current C2G dilemma lies in fairly allocating rights and obligations through the ecological protection compensation system and forming a stable long-term mechanism for fund supply. Translating ecological protection compensation from an abstract concept into governance effectiveness requires answering four core questions: the subjects of compensation, the scope of compensation, the standard of compensation, and the mode of compensation.

4.1. Subjects of Compensation

Determining "who compensates" and "who is compensated" is the primary prerequisite for the operation of the ecological protection compensation system. The principle that "the beneficiary compensates, and the protector is compensated" succinctly summarizes the allocation of rights and obligations in ecological protection compensation and is the basic observance for achieving interest balancing. In the C2G dilemma, the rural Hebei residents who carry out C2G and thereby reduce pollutant emissions are the ecological protectors: while providing clean air, they bear a sharply increased heating burden. Beijing and Tianjin urban residents are the main beneficiaries of C2G; in addition, the ecological beneficiaries also include the rural Hebei residents themselves and an indeterminate majority of the whole country. In theory, therefore, the urban residents of Beijing and Tianjin as well as the whole society should compensate the rural Hebei residents who implement C2G. Because the protectors and beneficiaries are numerous and the beneficiaries are indeterminate, a one-to-one direct compensation between beneficiary and compensated is in fact not operationally feasible; the government, as the representative of the public interest, naturally becomes the implementation subject of ecological protection compensation [12]. In this context, the Beijing and Tianjin municipal governments, representing the urban residents of Beijing and Tianjin who benefit most, should sign a horizontal compensation agreement with the Hebei provincial government, with Beijing and Tianjin paying ecological protection compensation to Hebei; the central government, representing the whole society, should provide certain support for this horizontal compensation; after receiving the funds, Hebei should compensate the individuals who implement C2G.

4.2. Scope of Compensation

The scope of ecological protection compensation refers to the totality of the behaviors or activities that, under given socio-economic conditions, should be compensated or rewarded according to law or agreement on account of restrictions on development rights, property rights, and other rights suffered in the course of ecological protection. According to the Regulations, the scope of a horizontal compensation agreement is discretionary, and may mainly include direct costs arising from ecological protection, opportunity costs arising from restriction of rights, as well as institutional incentives and consensual reciprocation. With respect to the present case, the direct and opportunity costs arising from C2G are concentrated in the additional equipment-reconstruction costs, heating costs, and equipment maintenance and replacement costs. In addition, special funds should be used to support the improvement of the thermal-insulation performance of rural housing so as to reduce ineffective energy consumption, which is more economically efficient in the long run. If further incentive for the C2G behavior is required, certain incentive-fund arrangements may be appended to the compensation agreement; however, given fiscal capacity and the fact that regional environmental quality has already

improved significantly, it is inappropriate to set excessively high requirements at the current stage.

4.3. Standard of Compensation

Determining the standard of compensation is one of the most difficult problems in the theory and practice of ecological protection compensation. With the scope of compensation limited to the direct and opportunity costs arising from C2G, the core question is the proportion of these costs to be borne by Beijing, Tianjin, and the central government. The principal models of compensation standards for the restriction of specific rights in countries around the world are mainly of three types: first, full compensation; second, reasonable compensation; third, equitable compensation. Among them, full compensation focuses on the protection of the right-holder, reasonable compensation focuses on the maintenance of public interest, and equitable compensation is the judgment reached after weighing the private interests of the right-holder against the public interest [13]. Given the actual fiscal capacity of China, an excessively high ecological-protection-compensation standard should not be hastily applied, and the principle should be from reasonable compensation to equitable compensation. Because the spilled ecological benefits of C2G are difficult to calculate, in terms of the specific method of determining the compensation standard, the Contingent Valuation Method (CVM) may be adopted to examine the willingness to pay (WTP) of the BTH localities and the whole society for the clean air output of C2G. According to the differences in willingness to pay among the regions after removing the influence of economic level and other factors, the benefit degree of each region is judged, and the allocation of compensation obligations is thereby determined; subsequently, the compensation standard is reasonably determined according to the willingness-to-pay amount and the actual fiscal capacity, so as to at least realize reasonable compensation for the additional costs incurred by rural Hebei residents due to C2G.

The Contingent Valuation Method has limitations in practice, such as the strong subjectivity of survey results and the difficulty of directly translating them into a legally binding compensation amount. To address this, the following arrangements may be made at the level of agreement design: the WTP survey results should serve as a reference and be combined with objective indicators such as actual cost accounting and historical subsidy data to determine the initial compensation amount; the horizontal compensation agreement should include a periodic renegotiation clause so as to dynamically adjust the compensation according to changes in air quality and the level of economic development; and the specific accounting may be undertaken by an independent third-party assessment institution jointly commissioned by the three localities, so as to enhance the credibility and stability of the compensation standard.

4.4. Mode of Compensation

The current modes of ecological protection compensation in China mainly include monetary compensation, in-kind compensation, capacity-building compensation, and policy compensation, among which monetary compensation is the most commonly used and the most practical for the compensated subjects. However, in the C2G dilemma, the compensation funds from Beijing, Tianjin, and the central government cannot be directly distributed to individual residents in monetary form; instead, they should be reflected in the heating-gas price through subsidies. The reason for adopting this mode of compensation is that the ecological benefits of C2G are accumulated through the continuous use of the less-polluting natural gas: residents with higher heating demand use more natural gas, and the ecological benefit generated by the energy substitution is correspondingly greater. Compensation should therefore be made on the basis of gas consumption, and subsidizing the gas price is the best scheme for achieving this orientation. In addition, embedding compensation in the gas price helps to reduce the marginal use cost of clean heating, strengthen the incentive for residents to continue using natural gas, prevent the "return to coal" risk that may arise from a decoupling of

compensation and behavior under simple monetary compensation, and promote the long-term stable operation of the C2G policy.

However, a subsidy mechanism solely based on gas consumption carries a certain distributive risk: relatively well-off rural households with larger housing areas and higher gas consumption will obtain higher total subsidies, while economically disadvantaged vulnerable groups who cannot afford heating costs and thus reduce gas use will benefit only to a limited extent, generating an inherent tension with the institutional goal of preferentially protecting disadvantaged groups. To remedy this deficiency, it is recommended that a tiered subsidy structure be introduced in the compensation scheme: the base tier sets a per-household benchmark gas-consumption amount, within which gas enjoys a higher subsidy standard so as to guarantee the basic heating needs of all rural households; the degressive tier applies a moderately lower subsidy standard to gas consumption exceeding the benchmark, so as to avoid excessive favoring of high-consumption groups; and the safety-net tier provides heating-rescue funds to vulnerable groups such as rural subsistence-allowance households and elderly persons living alone, on top of the base subsidy, thereby achieving targeted protection. This tiered structure, while maintaining the basic logic that links compensation to ecological-protection behavior, effectively corrects the distributive bias of purely quantitative subsidies.

In addition to gas-price subsidies as the principal mode of compensation, in-kind compensation may also be used as an auxiliary means to upgrade the thermal-insulation performance of houses, thereby reducing gas-consumption intensity and consequently easing fiscal pressure. At the same time, capacity-building compensation and policy compensation may also serve as auxiliary means, ultimately forming a diversified compensation pattern with price subsidies at the core and other compensation modes cooperating in support.

5. Conclusion

The heating crisis triggered by the rural C2G transition in Hebei profoundly reveals the conflict between individual interests and ecological public interests. The ecological protection compensation system should be used to compensate the rural Hebei residents who bear "special sacrifice." Against the background of coordinated BTH development, there are already successful precedents in the region, such as the ecological protection compensation of the Chaobai River basin. In response to this dilemma, on the basis of broad participation of stakeholders, a horizontal compensation agreement should be concluded between the Beijing-Tianjin and Hebei governments, extending the currently widely used basin ecological protection compensation to the field of atmospheric protection, so as to achieve interest balancing between ecological protectors and ecological beneficiaries and a win-win outcome of blue sky and warmth. From the perspective of long-term legislation, the current Regulations on Ecological Protection Compensation take basin ecology as the main reference in their provisions on the scope of application of horizontal compensation, and atmospheric protection can only invoke the fallback clause, which carries a certain degree of normative uncertainty. It is therefore recommended that, in the process of compiling the Ecological Environment Code or revising the Regulations on Ecological Protection Compensation, the joint prevention and control of air pollution regions be explicitly included in the scope of application of horizontal compensation, so as to fundamentally remove institutional obstacles.

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