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Price Guarantee and Risk Game: A Study on Bidding Decision-Making Mechanism of Newly Added Renewable Energy Projects under the Reform of New Energy Feed-in Tariffs- Evidence from China

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ABSTRACT

To advance the market-oriented reform of renewable energy feed-in tariffs and ensure a smooth policy transition, China has launched a dedicated pricing settlement mechanism. Combined with market-based power transactions, this mechanism establishes a dual decision-making framework for power producers to optimize electricity allocation and operating revenue. Based on the risk-return trade-off theory, this paper constructs a decision analysis framework for the bidding activities of newly added renewable energy projects and explores the internal operating logic of relevant decision mechanisms. The results show that enterprises need to dynamically balance policy-guaranteed returns and market-oriented risk-adjusted returns in decision-making. The core influencing factors include the gap between regulated electricity prices and expected market prices, corporate risk preference, and market price volatility. When regulated prices bring considerably higher certain returns than market expectations, it is optimal for enterprises to allocate a large proportion of power volume to the regulated channel. When regulated prices are roughly equal to expected market prices, risk-averse enterprises can allocate part of power volume to the regulated channel to hedge risks and stabilize revenue. When the market presents obvious profit premiums and enterprises have strong risk tolerance, expanding the share of market transactions will help maximize total revenue. This study provides theoretical support for renewable energy power producers to design rational bidding strategies and balance revenue security and development goals amid policy transition.

Keywords: New Energy Feed-in Tariff Reform, Regulated Electricity Price, Bidding Decision-Making, Risk-Return Trade-Off, China's Electricity Market
JEL Classifications: Q42, Q41, D44, C61

1. INTRODUCTION

In 2025, the National Development and Reform Commission and the National Energy Administration jointly issued the Notice on Deepening the Market-oriented Reform of New Energy Grid-connected Electricity Prices to Promote High-quality Development of New Energy (NDRC Price [2025] No. 136, hereinafter "Document No. 136"), which explicitly requires the full integration of new energy electricity into the power market and the formation of prices through market transactions. The issuance of Document No. 136 marks a new phase in China's market-oriented reform of new energy electricity pricing, aiming to drive high-quality development of new energy through market mechanisms. To ensure a smooth policy transition, the document also introduces a sustainable pricing settlement mechanism for new energy, establishing an off-market price differential settlement system to safeguard revenue from specific electricity volumes. Provinces have actively responded by formulating implementation plans for

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Document No. 136, significantly accelerating the comprehensive integration of new energy into the power market.

Under this policy framework, renewable energy power generation enterprises face a completely new operational environment. The revenue of renewable energy projects has evolved from being solely determined by electricity prices in the past to a diversified structure composed of grid-connected electricity volume, market prices, and mechanism-based electricity prices. This necessitates optimizing electricity allocation and pricing strategies within the power market based on generation costs and analysis of both market and mechanism-based electricity prices, so as to ensure reasonable returns and sustainable development. However, the power market itself is highly complex, with interconnected behaviors among market participants. The advancement of spot markets, the national unified market, and the bidding mechanisms for renewable energy projects has further intensified systemic uncertainties and market volatility. Given the differences in the applicability of Document No. 136 policies between existing and new renewable energy projects, the strategies discussed in this paper focus exclusively on new projects. Therefore, scientifically formulating operational strategies and bidding deployment plans for new renewable energy projects within the current policy framework remains a critical challenge for these enterprises. Li (2025) further notes that project profitability hinges on core factors such as unit-kilowatt construction costs, energy storage deployment expenses, and transaction execution efficiency, and that the focus of onshore wind power project management is shifting from “resource acquisition” to “full lifecycle investment and operational management.” Consequently, the regional planning capabilities, project design expertise, transaction proficiency, and risk management skills of wind power investors will become their core competitive advantages.

2. LITERATURE REVIEW

A growing body of literature has explored the risks and returns associated with renewable energy participation in electricity markets. Quan (2025) developed an electricity price revenue model based on net present value and genetic algorithms, concluding that market-based mechanisms can reduce electricity price risk. Chen (2025) employed a stochastic dynamic programming approach, incorporating electricity price volatility and output uncertainty to construct a computational framework comprising revenue functions, robust optimization, and conditional value-at-risk constraints. Wang et al. (2025) proposed flexible pricing mechanisms and a multi-tier trading system, applying contracts for difference and guaranteed quantity without guaranteed price policies, establishing capacity markets and ancillary service compensation mechanisms, and integrating digital technologies such as AI-based power forecasting, blockchain traceability, and virtual power plants, thereby providing a reference for coordinating medium- and long-term trading with spot trading in renewable energy markets.

In the broader field of electricity market research, scholars have also extensively investigated various decision-making problems faced by power generation enterprises (Wang and Gao, 2021; Zhang et al., 2022; Li et al., 2026). During the initial stages of electricity market development, research methods predominantly focused on intuitive data analysis approaches (Wang et al., 2019; Jiang and Hu, 2018). Such methods were employed to analyze power plant bidding strategies due to their ease of understanding and application, aligning with the cognitive and practical needs of the early market phase. As electricity markets gradually matured, scholars began introducing more sophisticated theories and tools that better capture market dynamics. Xu et al. (2023) applied game theory to construct mathematical models simulating strategic interactions among market participants, while Chai et al. (2022) attempted to simulate and forecast market bidding behavior using artificial intelligence techniques, reflecting a deepening trend in research methodologies alongside market evolution.

Despite the valuable insights these studies offer for electricity market decision-making, the majority remain focused on medium- and long-term trading analysis for conventional energy sources. Systematic research addressing the electricity allocation and bidding decisions of renewable energy generation enterprises within the specific transitional policy context of the sustainable pricing settlement mechanism remains lacking, with further model construction and mechanism analysis still needed. To this end, this paper aims to construct a decision analysis framework tailored to renewable energy enterprises, revealing their bidding logic under the dual influence of mechanism-based electricity prices and market-based electricity prices, in order to provide theoretical support for renewable energy generation enterprises to achieve stable operations and enhanced profitability during the policy transition period.

3. DATA AND ESTIMATION TECHNIQUES

3.1. Data and Variable Description

The decision model developed in this paper is designed for new renewable energy generation projects operating under the dual framework of market-based transactions and the sustainable pricing settlement mechanism introduced by Document No. 136. The key variables are defined based on the institutional setting and data availability. Table 1 summarizes the two types of electricity prices relevant to the analysis. The mechanism price, denoted by Pmech, is a fixed value exogenous to the generator. As argued by Kell et al. (2023) in the context of the UK Contract for Difference auctions, the strike price is externally determined for bidding firms, a logic that corresponds closely to the pricing rule of China’s mechanism. The market price, Pmarket, is a composite random variable formed by the medium- and long-term contract price Pmed and the spot price Pspot. Both Pmed and Pspot are stochastic, with their expectations and variances estimated from historical data or forecasting models. The overall market price is constructed as the weighted average of these two components according to the shares of medium- and long-term contracts and spot transactions within the total market volume.

The corresponding electricity volume variables are presented in Table 2. The proportion of total generation allocated to the mechanism settlement is denoted by β, which is bounded between a lower limit βmin and an upper limit βmax, typically specified

Table 1: Electricity price types and data descriptions

Electricity price type	Data description
Mechanism price *Pmech*	Fixed value. Exogenously given to generators, following the institutional logic of CfD auctions (Kell et al., 2023).
Market electricity price *Pmarket*	Medium and long-term price *Pmed*: Random variable; expectation and variance can be estimated from historical data or forecasts.
	Spot price *Pspot*: Random variable; expectation and variance can be estimated from historical data or forecasts.

Table 2: Types of electricity and data description

Electricity type	Data description
Mechanism volume proportion β	β ∈ [β(min), β(max)], set by provincial transition rules.
Market volume proportion 1ar	Medium and long-term volume: Determined by contracts signed by the enterprise.
	Spot volume: Residual quantity that clears the generation balance flexibly.

by the provincial implementation plans for Document No. 136. The remaining share 1-β is sold in the power market and is further divided into a medium- and long-term contracted portion and a spot market portion. The spot volume acts as a flexible residual that adjusts to clear the total generation after accounting for the mechanism and contracted volumes.

In addition to the above price and volume data, the model requires an estimate of the market price variance Var[Pmarket], which represents the key source of revenue uncertainty and can be derived from historical market volatility. The risk aversion coefficient λ is another essential input and may be obtained through corporate surveys or inferred from the enterprise e past decision behavior. All these data are either directly observable or can be reasonably estimated, making the decision framework operational for policy analysis and practical strategy formulation.

3.2. Model Specification

The decision problem of a renewable energy enterprise is to choose the optimal mechanism volume proportion so as to maximize its expected utility, given the trade-off between risk and return. The model is built upon the Markowitz mean-variance framework and is specified as follows:

$$\max R(\beta) = \sum [\beta \times Pmech + (1-\beta) \times Pmarket]\# \tag{1}$$

$$E[R(\beta)] = \beta \times Pmech + (1-\beta) \times E(Pmarket)\# \tag{2}$$

$$U(\beta) = E[R(\beta)] - \frac{\lambda}{2} \times Var[R(\beta)]\# \tag{3}$$

$$E[R(\beta)] = E(Pmarket) + \beta^* Pmech – E(Pmarket)\# \tag{4}$$

$$Var[R(\beta)] = (1-\beta)^2 \times Var(Pmarket)\# \tag{5}$$

$$\beta^* = 1 + \frac{Pmech - E(Pmarket)}{\lambda \times Var(Pmarket)}\# \tag{6}$$

$$\beta^* = \begin{cases} \beta \;\; min \quad if\ \beta^* < 0 \\ \beta^*, if\ \beta(min) \le \beta^* \le \beta \;\; max\ \#\# \\ \beta \;\; max\ , if\ \beta^* > \beta(max) \end{cases} \tag{7}$$

Where:

R(β): The per-unit revenue of the generation enterprise (a constant value)

β: The proportion of total electricity allocated to the mechanism settlement, bounded by β (min) and β (max) (%)

Pmech: The fixed mechanism price (a constant value, yuan/kWh)

Pmarket: The composite market price, a random variable (a constant value,yuan/kWh)

E[~],Var[~]: The expectation and variance operators, respectively

λ ≥ 0: The Arrow-Pratt risk aversion coefficient

U(~): The mean-variance utility function.

Equation (1) defines the revenue function as a linear combination of the mechanism price and the market price, weighted by the allocation proportion β. The constraint restricts β to the policy-determined feasible interval. For a risk-neutral enterprise, the objective simplifies to maximizing the expected revenue, as given by Equation (2). Since (2) is linear in β, the optimal choice reduces to a corner solution: If *Pmech > E(Pmarket)*, the enterprise should set *β = β (max)*; if *Pmech < E(Pmarket)*, it should set *β = β (min)*; and if the two are equal, any β in the feasible range yields the same expected revenue.

When the enterprise is risk-averse (λ ≥ 0), the decision criterion becomes the mean-variance utility function shown in Equation (3). Substituting the expression for expected revenue (Equation [4]) and the variance of revenue (Equation [5]) into (3) yields a concave quadratic function in *β*. The variance of revenue depends solely on the variance of the market price and the square of the market share 1. β reflecting the fact that the mechanism price is risk-free. The unconstrained optimum is obtained by maximizing (3) with respect to β, giving the interior solution in Equation (6). The optimal mechanism proportion β* increases with the risk premium *Pmech–E(Pmarket)* and decreases with both risk aversion λ and market price variance *Var*[*Pmarket*], When *Pmech* = *E*(*Pmarket*), the unconstrained optimum is β* = 1, implying full participation in the mechanism if it offers a risk-free return equal to the expected market return. Equation (7) incorporates the policy bounds by truncating the unconstrained solution to the interval [*β*(*min*), *β*(*max*)].

3.3. Scenario Analysis and Decision Matrix

The decision rules derived above can be translated into a practical scenario analysis based on the relative magnitude of the mechanism price and the expected market price. Table 3 presents the recommended bidding strategies for risk-neutral and risk-averse enterprises across three typical scenarios. When the mechanism price exceeds the market expectation, a high β is advisable in both cases, as the mechanism not only offers a higher expected return but also eliminates market price risk. When the two prices are approximately equal, a risk-neutral firm is indifferent, while a risk-averse firm may still find it beneficial to allocate a portion to the mechanism if market volatility is high, effectively obtaining a risk hedge at zero expected cost. When the mechanism

Table 3: Scenario analysis and decision recommendations

Condition	Decision under risk neutrality	Decision under risk aversion
Pmech>E *(Pmarket)*	Choose $\beta = \beta$ (max)	Maintain high β; this provides the best combination of high return and low risk.
Pmech mec (Pmarket)	Any β is acceptable.	If market volatility is high, allocate part of the output to the mechanism to obtain a free risk hedge.
Pmech <E *(Pmarket)*	Set β = (min) (i.e., avoid the mechanism).	If market volatility is low, keep $\beta = 0$; if volatility is very high, calculate a positive β to sacrifice a small amount of expected return for a large risk reduction.

price is below the market expectation, a risk-neutral firm would fully opt for the market. A risk-averse firm, however, must evaluate market volatility: If volatility is low, maintaining $\beta = 0$ maximizes utility; if volatility is very high, a positive β should be computed using Equation (6), trading a small reduction in expected revenue for a substantial decrease in risk exposure.

4. CONCLUDING REMARKS

This paper has developed a theoretical analytical framework based on the risk obtain a free risk hedge. Matically examine the bidding decision-making mechanisms of renewable energy power generation enterprises under the mechanism-based electricity pricing system. The analysis reveals that the optimal bidding strategy is not determined solely by the absolute level of electricity prices, but rather depends on a systematic evaluation of three key factors: The deviation between the mechanism price and market expectations, the enterprisedding decision-making mechanisms of renewable energy power generation enterprinism price is significantly higher than the market expectation, both risk-neutral and risk-averse enterprises are best served by a high proportion of mechanism-settled electricity, as this offers a combination of higher expected returns and lower risk. When the two prices are approximately equal, risk-averse enterprises may still benefit from partial participation in the mechanism if market volatility is high, using it as a cost-free risk hedge. When the mechanism price falls below market expectations, full participation in the market is optimal for risk-neutral enterprises, whereas risk-averse enterprises must carefully weigh market volatility: a small allocation to the mechanism can be justified when volatility is extreme, trading a modest reduction in expected revenue for a substantial reduction in risk exposure.

These findings carry important practical implications for both market participants and policy designers. For new energy generation enterprises, the transition triggered by Document No. 136 demands a fundamental shift in decision-making paradigms—from reliance on policy-guaranteed prices and grid integration to active participation in competitive markets. Enterprises should establish a multi-dimensional framework that coordinates the allocation of electricity volumes among the mechanism channel, medium- and long-term contracts, and the spot market. In doing so, the environmental premium embedded in green electricity trading should be incorporated as a key variable influencing the overall revenue structure. Furthermore, enterprises are encouraged to build diversified risk-sharing cooperation mechanisms with end-users and electricity retailers, for instance by including guaranteed floor prices coupled with surplus revenue-sharing clauses in bilateral agreements. Meanwhile, the integrated development of new energy projects driven by user demand can serve as a vehicle for exploring innovative models such as direct green electricity connectivity. Core competitiveness will increasingly rest on improved output forecasting accuracy, quantitative market risk management capabilities, and enhanced operational efficiency that translates efficiency gains into revenue growth. For market operators and designers, increasing trading frequency can help prevent decision-making delays caused by market volatility, ensuring that participants have sufficient windows to adjust their positions. Improvements to the settlement system are equally essential: enhanced profit-and-loss attribution functions would enable market entities to precisely identify the sources of their earnings and costs in each market segment, while detailed disclosure aligned with the settlement package database would make revenue and expenditure flows fully traceable, rendering decisionisionimplications for.

It should be acknowledged that the analytical framework developed in this study abstracts from several real-world complexities, such as plant-level technical constraints, strategic interactions among market players, and the evolving nature of policy rules. Future research may extend the model to incorporate these elements and apply it to empirical data from specific provincial markets. Nevertheless, the risk-return trade-off logic and the resulting scenario-based decision rules offer a systematic starting point for renewable energy enterprises navigating the policy transition and for market designers seeking to create a stable and efficient pricing environment.

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