Supplementary Materials: Calibration Basis and Data Sources for Numerical Parameters

S1. Parameter Definitions and Calibration Principles

The parameters of the numerical example in Section 4 are developed from three sources: calibration using publicly available data, derivation from model relationships, and scenario-based settings. Publicly available data are used to constrain the orders of magnitude of equipment costs, shortage losses, and policy support; parameters for which directly comparable values cannot be obtained from a single project are specified according to their economic interpretations in the model, and their effects are assessed through the sensitivity analysis, a global grid search over initial conditions, basin-of-attraction analysis, and threshold calculations reported in the main text. The unit shortage loss is additionally examined through the joint parameter uncertainty analysis and a targeted wide-range calibration check in Section 4.6.

For consistency with the revised manuscript, all calibrated model parameter values in the Supplementary Materials are presented in U.S. dollars (USD). Original CNY values reported by Chinese public sources are retained where needed and accompanied by their USD equivalents. Amounts originally reported in CNY are converted using the fixed presentation exchange rate $\text{USD}\,1 = \text{CNY}\,6.71$. The rate is used solely to standardize the displayed currency denomination and does not reinterpret the original CNY source values. Displayed converted values are rounded, whereas model calculations use the unrounded proportional conversion so that the underlying thresholds and dimensionless results are unchanged.

To give the normalized capacity scale an intuitive interpretation, this study defines one standardized emergency green-energy equipment-package unit (hereafter, "standardized unit") as a dimensionless model unit rather than directly equating it with 0.1 MW of equivalent reliable supply capacity. To facilitate order-of-magnitude conversion of engineering costs, 0.1 MW of nominal power is used only as an illustrative cost-conversion benchmark; the actual deliverable capacity still depends on wind and solar resource conditions, storage duration, capacity credit, the load profile, the control system, and emergency dispatch arrangements. Therefore, conventional-procurement capacity $S_1 = 80$, total demand during the conflict $Q = 100$, and capacity deployed through financial leasing $S_2 = 120$ are all measured in standardized units and are not assigned a fixed equivalent in MW of reliable capacity. Accordingly, the benchmark values of 80, 100, and 120 units are not intended to represent a unique physical wind-solar-storage portfolio; alternative engineering configurations may correspond to the same normalized model scale depending on local resource and system conditions. In the notation used in the main model, S_1, S_2, and Q are therefore quantitative capacity variables measured in these standardized units, not monetary variables. The parameter c is measured in USD per standardized unit, and multiplying it by a selected capacity level yields the corresponding total monetary capital expenditure.

Table S1. Calibration and setting basis for equipment, capacity, and cost parameters.

Parameter	Benchmark value	Type	Basis for calibration, derivation, or setting	Source
S_1	80 units	Financing-constrained benchmark	Quantitative conventional-procurement capacity variable measured in standardized units. Under the benchmark financing constraint, $S_1 = \frac{K}{c} = 80$ exactly when calculated using the unrounded USD-denominated parameter values. In the joint uncertainty analysis, variation in S_1 represents uncertainty in this financing-constrained capacity ceiling, with the corresponding internal-fund level implicitly adjusted according to $K = cS_1$.	Model constraint
Q	100 units	Normalization	Quantitative emergency-demand capacity variable measured in the same standardized units as S_1 and S_2; it is the benchmark for calculating capacity shortfall and shortage loss.	Model benchmark

Parameter	Benchmark value	Type	Basis for calibration, derivation, or setting	Source
S_2	120 units	Scenario setting	Quantitative financial-leasing deployment variable measured in standardized units; the benchmark satisfies $S_2 \geq Q$ and includes an emergency safety margin.	Model constraint
c	USD 93,144.56/unit	Calibration using public data	Unit construction cost measured in USD per standardized unit. Using 0.1 MW of nominal power per unit only as the cost-conversion benchmark gives USD 931.45/kW, consistent with public cost levels. Total capital expenditure is obtained by multiplying this unit cost by the selected standardized capacity.	[46,47]
L_1	USD 0.745 million/unit	Public-data magnitude and scenario setting	Using 90 d as the representative accounting window, the value is set at USD 0.745 million per unit by reference to the magnitude differences reported in public outage-cost studies and scenarios involving continuous-production interruptions for critical energy users; the GDP-to-electricity-consumption ratio is not used directly to estimate shortage losses. For robustness, L_1 is varied over USD 0.373–1.118 million/unit using a triangular distribution centered on the USD 0.745 million/unit benchmark.	[48–50]
L_2	USD 0.0745 million/unit	Scenario setting	Comprehensive idle-capacity loss over the model horizon, including depreciation, maintenance, tied-up capital, low utilization, technological obsolescence, and disposal discounts; it is not annual accounting depreciation.	Sections 4.3 and 4.4
C_3	USD 0.745 million	Scenario setting	Comprehensive operating costs after a leasing transaction is completed, including appraisal, management, operation and maintenance, insurance, and asset management.	Sensitivity analysis
C_0	USD 1.192 million	Scenario setting	Market-entry, due-diligence, equipment-prepositioning, and service-preparation costs incurred when no transaction is completed.	Section 3.6.5

Table S2. Setting basis for financial leasing contracts, government policies, and simulation parameters.

Parameter	Benchmark value	Type	Basis for calibration, derivation, or setting	Source
R_1	USD 8.942 million	Contract scenario	Comprehensive leasing charge when the conflict ends in the short term ($T_S = 2$ years), calculated on equipment capital expenditure cS2 at the leasing rate rL and including emergency dispatch and a risk premium.	Sections 3.3 and 4.1
R_2	USD 15.648 million	Contract scenario	Full rental payment under prolonged conflict ($T_L = 5$ years), calculated on cS2 at the leasing rate rL using the annuity method and including continued equipment use and risk costs.	Sections 4.3 and 4.4
β	0.4	Contract scenario	The demand side bears 40% of the idle-capacity loss when the conflict ends in the short term; under the benchmark scenario, the feasible upper bound implied by the demand-side participation constraint is approximately 0.063 without the demand-side subsidy and 0.688 with the demand-side subsidy.	Section 4.4
V_1	USD 5.961 million	Scenario setting	Net equipment residual value after a short-term end to the conflict; it is not equivalent to an accounting net residual-value ratio.	Contractual residual value
V_2	USD 0.745 million	Scenario setting	Equipment residual value after prolonged conflict.	Contractual residual value
D_0	USD 1.490 million	Baseline setting	Residual crisis-related social burden common to the compared government states; it excludes incremental shortage loss, idle-capacity loss, and policy-implementation cost. The USD 1.490 million benchmark is a scenario-based normalization.	Does not enter ΔC, the government's strategy payoff advantage

Parameter	Benchmark value	Type	Basis for calibration, derivation, or setting	Source
G_A	USD 1.490 million	Policy calibration and scenario setting	Subsidy or interest subsidy to the demand side; local discharge-volume and capacity-compensation policies provide an institutional reference, and this value is an equivalent subsidy scenario.	[51–53]
G_B	USD 0.894 million	Policy scenario	Service-capacity subsidy or risk compensation for the leasing company, used to compensate for equipment prepositioning, market development, and risk bearing.	Policy scenario
G_C	USD 0.447 million	Policy scenario	Costs of policy review, regulation, transaction organization, and performance evaluation.	Government cost item
W	USD 3.279 million	Representative policy scenario	Incremental policy-synergy benefit generated by government intervention; USD 3.279 million is used to illustrate the policy-guided equilibrium when this benefit exceeds the subsidies and policy-implementation costs and is not treated as an empirical estimate.	Sections 3.5 and 4.4
p	Model variable	Probability variable	Probability that the geopolitical conflict persists and the energy corridor remains disrupted; this is the core uncertainty variable linking the conventional-procurement benchmark decision to tripartite strategy evolution.	Non-fixed parameter
r_L	8% per year	Market calibration	Leasing rate charged by the financial leasing company, anchored to industry pricing for financial leasing (approximately 6%–10%).	Industry practice
r_B	3.5% per year	Market calibration	Bank borrowing rate used by the financial leasing company to finance equipment acquisition (approximately 3%–4%).	Market interest rate
T_L	5 years	Scenario setting	Full lease term under prolonged conflict.	Contract scenario
T_S	2 years	Scenario setting	Early-termination term when the conflict ends in the short term.	Contract scenario
F_L	Approximately USD 1.192 million	Rate-anchored financing-cost calibration	Benchmark bank financing cost under prolonged conflict. The pure five-year annuity-interest amount at $r_B = 3.5\%$ and principal cS_2 is approximately USD 1.201 million; the USD 1.192 million value is the scenario parameter used consistently in the main model and is close to this rate-based benchmark.	Rate-anchored scenario calibration
F_S	Approximately USD 0.745 million	Rate-anchored financing-cost calibration	Scenario-calibrated bank financing cost under short-term termination. The pure two-year annuity-interest amount at $r_B = 3.5\%$ is approximately USD 0.590 million; the USD 0.745 million benchmark additionally allows for early-termination, refinancing, and related financing charges.	Rate-anchored scenario calibration

S2. Conversion and Verification of Public-Data Parameters

S2.1. Unit Construction Cost of Capacity

The China Renewable Energy Engineering Cost Management Report 2025 issued by the Water Resources and Hydropower Planning and Design General Institute, together with related public information, reports that the average unit construction cost of onshore wind power in 2025 was approximately CNY 4,100/kW, equivalent to USD 611.03/kW at the fixed presentation exchange rate used in this study [46]. CNESA statistics on energy-storage projects awarded in 2025 report an average EPC bid price of CNY 1,043.82/kWh for 2 h lithium iron phosphate storage, equivalent to USD 155.56/kWh [47]. Using 2 kWh of storage for each 1 kW of nominal wind-power capacity for an order-of-magnitude cost conversion gives:

$$611.03 + 2 \times 155.56 = 922.15\ USD/kW \quad \text{(S1)}$$

USD 922.15/kW differs by approximately 1.0% from the USD 931.45/kW adopted in this study, supporting the order-of-magnitude reasonableness of c. This calculation is used only to calibrate the cost of the standardized equipment package and does not imply a fixed ratio among the nameplate

capacities of wind, solar, and storage; actual projects must be reconfigured according to resource conditions, storage duration, capacity credit, and load profiles.

S2.2. Unit Shortage Loss

In 2024, China's gross domestic product was CNY 134.9084 trillion, equivalent to USD 20.1056 trillion at the fixed presentation exchange rate [48], and total electricity consumption was 9.8521 trillion kWh [49]. These publicly available macroeconomic data provide only a rough order-of-magnitude benchmark for output per unit of electricity consumption and cannot be directly interpreted as shortage losses; the ratio is reported solely as background information:

$$20.1056 \times 10\text{^}12\ USD\ /\ (9.8521 \times 10\text{^}12\ kWh) \approx 2.04\ USD/kWh \quad \text{(S2)}$$

To construct a calibrated numerical example that combines public-data magnitudes with scenario parameters, this supplementary document uses 90 d as a representative accounting window for a prolonged conflict and 0.1 MW of critical load as an illustrative conversion basis for one standardized unit. This basis is used only to calculate unserved energy and the associated loss magnitude and does not imply that a model unit has a fixed engineering equivalent. The corresponding unserved energy is:

$$0.1\ MW \times 24\ h/d \times 90\ d = 216\ MWh = 216{,}000\ kWh \quad \text{(S3)}$$

This equals 216 MWh (216,000 kWh). Rather than estimating shortage losses directly from the GDP-to-electricity-consumption ratio, this study draws on public outage-cost research showing differences by customer type, outage duration, and unserved-energy scale [50], and combines it with scenarios for critical energy users, including continuous-production interruptions in industrial parks, equipment shutdown and restart, defective products, and contract-performance losses, to set $L_1 =$ USD 0.745 million/unit (approximately USD 3.450/kWh). This value is used in a calibrated numerical example constructed from publicly available data magnitudes and scenario parameters; it is neither an official statistic nor an empirical estimate for a single project.

To reflect this calibration uncertainty explicitly, Section 4.6 does not treat $L_1 =$ USD 0.745 million/unit as a fixed empirical estimate. Instead, L_1 is assigned a triangular distribution with a lower bound of USD 0.373 million/unit, a mode of USD 0.745 million/unit, and an upper bound of USD 1.118 million/unit. Under the same illustrative 216,000 kWh basis, this range corresponds to approximately USD 1.725–5.175/kWh. The bounds are deliberately broad scenario limits rather than statistical confidence intervals. A targeted low/benchmark/high scenario check in Section 4.6 further reports how the adoption thresholds and the risk-sharing boundary change across this range.

S2.3. Policy Support

Local policies provide revenue channels for energy-storage projects, including discharge-volume compensation, capacity compensation, and market revenues. The policy in Inner Mongolia stipulates that eligible independent new energy-storage projects may receive compensation for electricity discharged to the public grid, with the 2025 standard set at CNY 0.35/kWh, equivalent to USD 0.0522/kWh at the fixed presentation exchange rate used in this study; once determined, the annual standard applies to eligible projects for 10 years, but this does not mean that the same standard applies to new projects in subsequent years [51]. Reports by the National Energy Administration indicate that many regions are improving revenue mechanisms for energy storage through capacity leasing, spot markets, ancillary services, and capacity compensation [52]. Gansu has raised the reliable-capacity compensation standard for coal-fired power to CNY 330/(kW·year), equivalent to USD 49.18/(kW·year), and also provides compensation for the reliable capacity of grid-side independent new energy storage; however, because this standard is primarily designed for coal-fired power, its applicability to independent storage remains unclear [53].

Accordingly, G_A and G_B should not be interpreted as direct copies of any specific local-policy amounts; rather, they are equivalent subsidy scenarios specified with reference to the current intensity of policy support. Their reasonableness is jointly assessed against the demand-side participation

condition, the leasing-company profitability condition, the government's net-benefit condition, and the basin-of-attraction and threshold analyses in Section 4.4.

S2.4. Financial Leasing Pricing and Financing Costs

The financial leasing company uses equipment capital expenditure of cS_2 as the principal and charges the demand side a leasing rate of $r_L = 8\%$ per year. Under prolonged conflict, the annuity-based total principal and interest over $T_L = 5$ years is approximately USD 14.0 million; after adding emergency-dispatch charges and a risk premium, $R_2 =$ USD 15.648 million. If the conflict ends after $T_S = 2$ years, the early-termination charge is $R_1 =$ USD 8.942 million. At the bank financing rate $r_B = 3.5\%$ per year, the pure annuity-interest benchmarks are approximately USD 1.201 million over five years and USD 0.590 million over two years. The model retains $F_L =$ USD 1.192 million and $F_S =$ USD 0.745 million as scenario-calibrated financing costs. The five-year value is close to the annuity benchmark, whereas the short-term value allows for early-termination, refinancing, and related financing charges. Both are held fixed for consistency with the main-text simulations. Under the benchmark contract and cost parameters, including the 4.5 percentage-point spread between the leasing and financing rates, Π_L remains positive over [0,1]. Monetary amounts in this payoff expression are measured in USD million.

S3. Scope of Applicability and Limitations of the Parameters

The purpose of the Supplementary Materials is to show that the parameters of the numerical example have realistic orders of magnitude, explicit derivation relationships, and interpretable scenario logic, rather than to claim that all parameters are drawn from a single real-world wind-solar-storage project. The unit construction cost c and the unit shortage-loss benchmark L_1, together with the market-rate and policy-support benchmarks, have relatively clear public-data or methodological bases; the remaining capacity, contract, residual-value, operating-cost, and policy-synergy parameters are primarily scenario parameters specified to test the theoretical mechanisms. The benchmark parameters reproduce the critical probabilities and threshold results reported in Sections 4.1 and 4.4, for which the corresponding calculations are already provided in the main text and are therefore not repeated here.

From a model-scope perspective, the benchmark decision model uses a two-state representation of conflict duration and a stylized capacity-cost relationship; the continuous-capacity robustness check relaxes the discrete 80/120 choice but does not represent continuously varying conflict intensity or project-level dispatch. The tripartite evolutionary game, in turn, treats strategy proportions as aggregate bounded-rationality adjustment and does not estimate actor-specific learning speeds, institutional delays, one-off bargaining, or within-population heterogeneity. These limitations should be considered when transferring the calibrated thresholds to specific projects.

The "0.1 MW nominal-power conversion benchmark" and the "90 d accounting window" provide only an illustrative mapping between normalized parameters, public-data magnitudes, and scenario settings; they do not imply a fixed MW equivalent of reliable capacity. Once project data are available, the parameters can be re-estimated from equipment and leasing contracts, critical-load valuations, residual values, operation and maintenance costs, and subsidy settlements, and alternative leasing forms can be compared. The findings should therefore be interpreted as mechanism- and threshold-based conclusions within reasonable parameter ranges rather than as project-specific point predictions.