Social Development Studies, 2026, Volume 2, Issue 2
https://www.bbwpublisher.com/journal/SDS
Online ISSN: 3083-3868
Print ISSN: 3083-3876

A Full-Chain Governance and Risk Control Framework for Overseas Utility-Scale Battery Energy Storage Projects

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Abstract: Can overseas utility-scale battery energy storage projects with cross-border supply chain risks, trade policy volatility, and fragmented governance be guided by a full-chain risk prevention mechanism? We develop a 3-mechanism framework based on international project governance theory and energy storage studies and test it in an extreme single-case study of a 200 MW/800 MWh North American project. The proposed framework enabled structured responses to tariff shocks, pre-shipment defects, and schedule variances: delivery control detected early misses, the quality gate prevented defects from arriving, and the escalation mechanism facilitated timely planning under policy disruption. We provide a full implementation framework for developers and EPC contractors, embed storage-related technical requirements in project management, and provide extreme-case validation of integrated risk prevention systems.

Keywords: Energy storage projects; Full-chain risk management; Escalation mechanism

Online publication: April 30, 2026

1. Introduction

1.1. Research background

The global storage industry has entered a new period of growth. BloombergNEF reported that annual storage additions outside pumped hydro averaged 112 GW in 2025, 48% more than in 2024, with 307 GWh of batteries deployed worldwide. It took only 4 years for annual additions to grow from 10 GW to over 100 GW; that is about 8 years for solar and around 15 years for wind. IEA reported that global battery storage in 2025 increased 40% year-on-year to 108 GW, up 11 times over 2021 (**Figure 1**).

In this rapidly increasing landscape, international energy storage projects (especially utility-scale plants in the United States) pose unique management challenges for international developers, EPC contractors and investors, dealing with the multi-level complexity: cross-border supply chains between China, Southeast Asia and North America; rapid policy developments; emerging safety and environmental issues that trigger community protests and lawsuits; financial structures that are sensitive to tariffs, tax credit eligibility and commodity price volatility [1].

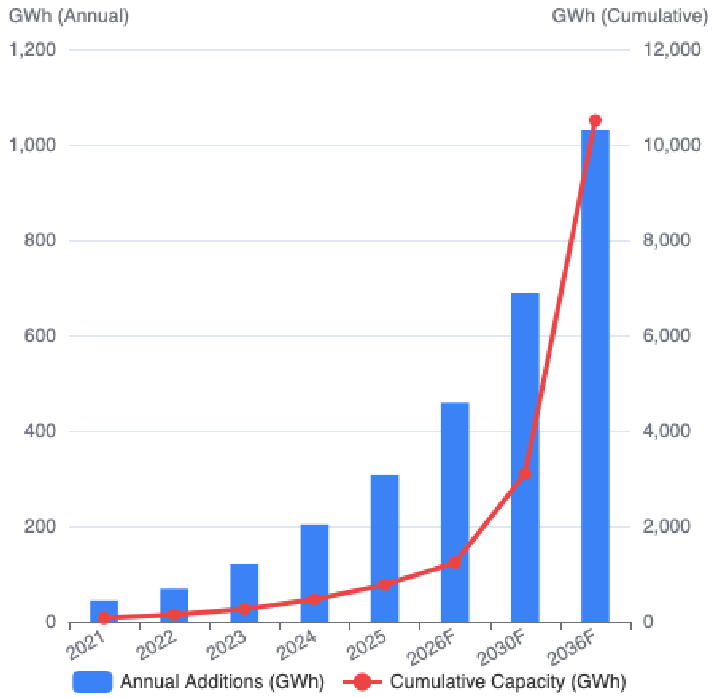

Figure 1. Global energy storage annual additions and cumulative capacity (2021–2036F).

1.2. Industry challenges

Although China's economy is experiencing amazing growth, overseas energy storage projects face the following challenges that threaten their sustainability, timeline and return on investment:

Supply chain fragility and trade policy uncertainty. The overall battery supply chain is concentrated in China, which manufactures more battery cells than domestic demand, causing intense competition among manufacturers. BNEF information reveals that U.S. battery production is not guaranteed to be well-connected: cathode material imports are expected to be 83%, and anode material imports 67%; in particular, critical metal processing is largely reliant on Asian supply chains. The rising tariffs (with respect to "Liberation Day" by the United States government) threaten to destabilize supply chains that depend heavily on Chinese imports and have even attempted earlier to localize manufacturing [2]. Tariffs on lithium-ion batteries are 82.4%, and solar panels are subject to 104% duties. Wood Mackenzie estimates that global tariffs are expected to be higher, and BESS installations in the US and EU could fall by up to 10% by 2035.

Cost and margin volatility. Lithium-ion pack prices dropped 8% year-on-year to $108/kWh in 2025, with stationary storage pack prices dropping 45% to $70/kwh. The global benchmark levelized cost of four-hour batteries dropped 27% year-on-year to $78/MWh in 2525, but this deflation reflects cost pressures [3]. By early 2026, the mainstream 314Ah LFP cell price in China increased from RMB 0.26–0.31/Wh at end-2025 to RMB0.36–0.35/Wh; some tier-one manufacturers were quoting above RMB -0.4/Wh. Lithium carbonate prices decreased to RUB 168 000/ton by late January 2026, with industrial products gaining 8.8% of their weekly gain [4]. BNEF expects prices to drop further to 3% below $105/kWH due to raw material costs and tariff issues.

1.3. Research gap

While international project management theory and infrastructure risk management have provided significant knowledge, some challenges are still arising in the absence of overseas utility-scale energy storage projects:

(1) Gap 1: Not a full-chain view. Previous work has focused on individual segments and has not treated manufacturing, logistics, and site delivery as complete chains. Energy storage projects include multiple cross-border handovers from a cell factory to commissioning, and each handover poses risks.

(2) Gap 2: We should not take into account energy storage technical aspects. Battery thermal runaway risk, life-cycle degradation, UL9540A certification requirements, and time window constraints of IRA tax credits need governance facilities for storage technologies.

(3) Gap 3: No dynamic policy risk management. Tariffs, FEOC rules, and ITC eligibility change very frequently; traditional static risk analysis cannot support real-time decision-making.

1.4. Research objectives

This study pursues three interconnected research objectives:

First, it provides a theoretical framework for understanding global project management and risk management of overseas utility-scale energy storage projects through ideas in international project management, infrastructure risk management and energy system deployment literature [5].

Second, it designed and tested a multiple-level risk prevention model (a double escalation, a quality gate, and a delivery control model) that enables the full chain from supply chain procurement to commissioning and connecting to the grid in a cross-border storage project [6].

Third, it proves the feasibility and extreme-testing value of the proposed framework via a case study on a North American utility-scale storage project, providing practical suggestions for practitioners coping with geopolitical risk, technology uncertainty, and operational complexity [7].

2. Literature review and methodology

2.1. Evolution and gaps in international project governance theory

Large-scale cross-border infrastructure projects increasingly rely on network coordination and multi-agent cooperation. El-Sheikh and Pryde (2010) showed that network gaps in project delivery systems make it especially challenging to succeed, with the observation that governance institutions must explicitly identify and bridge these gaps in order to guarantee information flow and decision consistency. In overseas energy storage projects, gaps arise between Chinese manufacturing teams, international logistics providers, and North American site contractors, and coordination gaps that existing hierarchies do not address.

Another challenge of privatized project implementation is accountability. Rosenberg (2017) discussed that privatized delivery models of environmental governance break accountability because contracting out hides responsibility for long-term performance and safety. For battery storage projects based on EPC contracts and equipment supply agreements across multiple countries, this fragmentation creates the risk that all parties share responsibility for latent defects, fire safety compliance, or decommissioning, a governance gap highlighted by the Moss Landing incident.

2.2. Infrastructure risk management and its intersection with energy systems

Large-scale battery energy storage systems (BESS) pose safety and operational challenges to the conventional power production or transmission system. Lystianingrum et al. (2023) reviewed large-scale lithium-ion BESS incidents, showing thermal runaway propagation, inadequate fire control, and insufficient early warning systems as common failure modes. From incidents in South Korea, the United States, and Australia, it is observed that after the incident, the quality of the inspection during manufacturing and installation is often missed, where the proposed Quality Gate System intervenes [8].

Confronted with incident analysis, Olugbemide and Ryder (2025) performed computational fluid dynamics (CFD) evaluation of performance-based explosion protection design for BESS, and demonstrated that explosion hazards depend on module vent design, enclosure geometry, and deflagration panel placement, which are all required at Gate 4 and Gate 5 [9]. They argue that required code compliance alone is insufficient; project management must be performed through performance-level verification, which should be taken into account in the proposed Delivery Control Model quality measurements.

Turner (1999) provides basic project management concepts for BESS project management, including stage-gate reviews, clear responsibility assignment, and risk management. Turner's handbook goes back to utility-scale storage; however, its main ideas- work breakdowns, earned value management, and change control- are related to the three proposed schemes, in particular the delivery control model, by incorporating earned value metrics into the Delivery Control Model.

2.3. Supply chain resilience and trade policy risk

Other energy storage projects are also located in a global supply chain that is highly concentrated and heavily subject to trade policy decisions. Christopher and Peck (2004) proposed supply chain resilience: the capacity of a supply chain to re-engineer its original state or to move to a new (better) state after being disturbed. They propose five principles of building resilience: supply chain re-engineering, collaboration, agility, risk management, and information visibility [10]. For BESS projects, the same principles apply to the framework: the Delivery Control Model provides information visibility for manufacturing, logistics, and site zones; the Escalation Mechanism enables agile decisions during tariff shocks; and the Quality Gate System enforces cooperation among suppliers and contractors.

Sheffi (2015) also goes further to describe the way companies cope with unexpected events; he argued that the best resilience policies can combine redundancy with flexibility. For overseas storage, redundancy may involve qualifying backup providers outside China, or flexibility could involve designing battery boxes to accept cells from multiple vendors - both strategies that must be managed proactively. In Chapter 4, he showed how his framework supported accelerated shipping and partial contingency drawdown in the face of a sudden tariff disruption in a manner that mimics Sheffi's resilience policy.

2.4. Methodology

2.4.1. Phase I: Theoretical construction and model deduction

Phase I provides a framework based on the governance network view of El-Sheikh and Pryde (2010), the accountability analysis of Rosenberg (2017), and the ICT-enabled collaborative governance model of Bicking and Wimmer (2011) in order to propose three mechanisms: an Escalation Mechanism addressing network gaps and accountability gaps across organizational boundaries; a Quality Gate System embedding structured checkpoint reviews based on coordination principles from cooperative intersection management [6], and a

Delivery Control Model, which incorporates earned-value tracking with risk-adjusted forecasting based on agent-based simulation [7]. The AGILE Index approach [4] offers governance evaluation requirements in each mechanism, and deployment challenge literature (Lott et al., 2014; Wilson et al, 2009) maps the framework to energy storage-based risk levels [11].

2.4.2. Phase II: Empirical validation and mechanism testing

Phase II applies a single case study setup to a North American utility-scale storage project. The combination of concentrated Chinese supply chains, U.S. tariff exposure, and community opposition causes a "stress test" environment that shows framework robustness. Two triangulations between project reports, stakeholder interviews, and quantitative metrics demonstrate the power of theoretically based mechanisms in relation to project events and management behaviors.

3. Risk prevention framework and management mechanisms

3.1. Escalation mechanism

Escalation mechanisms define a decision hierarchy that determines how risks, issues, and decisions are raised to levels across the project's geographical and functional boundaries. In overseas storage projects, the typical escalation logic, i.e., from site management to project management to executive sponsorship, fails to take into account important decisions that must be made simultaneously from multiple countries: the manufacturing base in China, the logistics, and the deployment site.

Escalation Architecture. The mechanism defines four escalation tiers:

(1) Tier 1: Operational response. Issues solved in one functional domain, with domain leads ignoring cross-functional escalation, are resolved within 24 hours.

(2) Tier 2: Cross-functional coordination. Problems solved in two or more functional domains, with cross-Functional coordination within 48 hours, with plans to resolve them, with pre-specified resolution, are solved within 48 hours.

(3) Tier 3: Strategic decision. A material financial contribution, regulatory implications, or high schedule risk impact on the project leadership team, senior leadership from the developer, EPC contractor, and key equipment suppliers. Response time of 5 days.

(4) Tier 4: Crisis management. Safety events, major regulatory events, force majeure, or financial impact exceeding 15% of project budget prompt immediate convening of the Crisis Management Team, with board participation and external legal and communications support.

3.2. Quality gate system

Quality Gate System structures projects through a series of stage-gate reviews that require clear requirements before the project can move to the next level. This method addresses a typical failure mode of an overseas storage project: the compression of quality assurance under tight demand when equipment made overseas comes into the site with untapped defects that take years to identify.

Gate Architecture. Five quality gates are defined spanning the project lifecycle:

Gate 1: Design freeze and Procurement. Requirements: completion of system design review with grid operators; finalization of equipment specifications (UL 9540A status); supplier qualification audit completion; tariff exposure analysis in the next and future trade policy scenarios; procurement commitments as well as technical, regulatory and trade compliance requirements.

Gate 2: Manufacturing completion and pre-shipment inspection. Requirements for manufacturing completion with a factory acceptance test for all major equipment with witnessed testing for important products; production batch quality audit with cell-level traceability certification; packaging and shipping configuration approval for marine transportation; export documentation. This can be the final opportunity to detect and mitigate quality issues before equipment leaves manufacturing.

Gate 3: Site Readiness and Equipment Receipt. Requirements are site civil works completion with check against design specifications; inspection protocol activation with visual inspection, insulation resistance testing, and capacity validation of a statistically valid sample; storage and handling procedure approval and local permitting and interconnection agreement finalization.

Gate 4: Installation completion and qualification. Requirements include installation quality verification with manufacturer specification; communication system test; fire suppression system certification by authority with jurisdiction; pre-commissioning test procedure approval, that the physical installation satisfies all technical and safety requirements before powering.

3.3. Delivery control model

The delivery control model provides performance management with risk-adjusted forecasting in manufacturing, logistics and deployment scenarios. The proposed model consists of the following essential elements (**Table 1**).

Table 1. KPI Dashboard (Four Dimensions)

Dimension	Key Indicators	Target Range	Data Source
Financial	CPI	0.95–1.05	ERP/Procurement system
Schedule	SPI (Schedule Performance Index)	0.95–1.05	P6 schedule
Quality	Gate pass rate, FPY	>95%	Quality management system
Risk	Risk exposure value, % active risks	Risk reserve consumption < planned	Risk register

EVM Integration:

CV (Cost Variance) = EV – AC

SV (Schedule Variance) = EV – PV

TCPI (To-Complete Performance Index) = (BAC – EV) / (EAC – AC)

4. Case study: North American utility-scale project

4.1. Case context

The case project is a utility-scale battery energy storage system with a nameplate capacity of approximately 200 MW / 800 MWh, developed in a wholesale electricity market in North America. Equipment is supplied by tier-one manufacturers based in China. EPC execution is by an international contractor, and project financing includes a tax equity partnership to monetize investment tax credits under applicable legislation [12].

4.2. Risk event 1: Tariff shock

(1) Risk Event: In April 2025, the country government announced considerable tariff increases on an

extensive range of imports, such as energy storage. The effective tariff rate on the major equipment imports of the project ranged from a low double-digit percentage to approximately 35%. The estimated cost on the procurement budget ranged between \$12–15 million, approximately 8–10% of total equipment cost and 4–5% of project cost.

(2) Mechanism Response: The event triggered a Tier 3 increase for the Escalation Mechanism. The Project Steering Committee discussed, in three days, the real-time cost impact analysis of the Delivery Control Model's cost system. The group discussed four response choices: pay for contingency, renegotiate supplier pricing, speed up shipping to match tariff effective dates, or remove tariff effective timings.

(3) Outcome: Accelerated shipping saved an estimated \$4–5 million in tariff exposure for equipment already in production. The contingency drawdown remained within planned reserve levels. Exclusion applications were submitted but not granted during the project's active period. The project achieved commercial operation on schedule, although final equipment costs increased by approximately 3.8% above the original budget.

4.3. Risk event 2: Pre-shipment quality defect

(1) Risk Event: In Gate 2 (Manufacturing completion and pre-shipment), quality testing observed that a certain batch of battery modules had an insulation resistance failure rate of 3–4 % below the acceptable value of >1%. The defect had not been detected in routine factory acceptance test because the test did not include humidity preconditioning (a condition that later turned out to be essential to this module).

(2) Mechanism Response: A Tier 2 level was escalated due to the defect. A meeting was held within 48 hours between manufacturing, quality, engineering, and logistics. Quality Gate System required Gate 2 not to be closed until the problem was resolved. Root cause analysis found micro-damage to sealing rings during cell transport.

(3) Outcome: The project had about a 10-day delay during manufacturing, but the schedule model used by Delivery Control Model suggested that this delay could be partially recovered during logistics or site installation.Net recovery was 8 days.

4.4. Risk event 3: Manufacturing schedule variance

(1) Risk Event: At week 8 of manufacturing, the timing of the delivery control model's schedule performance index (SPI) dropped to 0.92, and a yellow alarm was raised, which was caused by the lack of production capacity of a key component (battery management system motherboards) at one supplier.

(2) Mechanism Response: The Delivery Control Model early warning alerted the project manager and recommended three corrective actions according to expected value. The project team picked the first one: place a resident engineer at the supplier's site and allow a temporary secondary line. This decision was made without further increases. The weekly management pace tracked SPI recovery using the KPI dashboard.

(3) Outcome: Within four weeks, SPI fell to 0.98. The temporary line added approximately 15% of its production during the peak. The resident engineer had less quality rework at this supplier. The schedule variability did not drift to the logistics or site zones, as cascading delays did not follow them. The total cost of intervention was approximately 180K, compared to approximately 1.2 million in potential delay costs if the variance remained unchanged.

5. Conclusion

5.1. Theoretical contributions

Our paper makes three theoretical contributions. First, we provide a full-chain governance framework, i.e., where manufacturing, logistics, and site zones are integrated, which deals with fragmentation in the current infrastructure risk research, where each segment is usually isolated. Second, we embed storage-specific technical requirements into a general project governance framework to show that domain-specific constraints can have an impact on generic governance. Third, we experiment in extreme cases under policy shock and supply chain disruption and show that the framework's explanatory power extends to high-voltage, high-concentration environments commonly observed in traditional project management research.

5.2. Practical contributions

Three viable outputs: For international developers, EPC contractors, and investors in overseas storage projects, our three-mechanism toolset provides a flexible governance template for different contract structures. The storage-specific risk label (UL9540A, fire suppression system approval, tax credit safe harbor deadlines, FOC compliance) reduces the potential for regulatory or technical surprises. The risk-adjusted forecast can provide more realistic contingency planning and data-driven escalation.

5.3. Limitations and future research

This is one extreme case; the results might not hold for smaller budgets. The anonymization required for commercial confidentiality limits the visibility of some financial and operational data. We tested our approach to three risks, but did not consider other risks such as cyberattacks, force majeure, or end-of-life decommissioning. Different regimes might test the system external validity. A quantitative pre-post study of performance before and after using the system would return on investment. AI controls (e.g., using AGILE Index to benchmark escalation decisions) may provide the path toward semi-automated risk management.

Disclosure statement

The author declares no conflict of interest.

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