DOOSAN

Smarter BESS Decisions: Reducing Risk and Maximizing Value in an Uncertain Market

How software-led integration strengthens long-term project performance

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Executive Summary

The U.S. energy storage industry is navigating a period of recalibration. After several years of record growth, 2026 is expected to bring a temporary slowdown as developers, OEMs, and utilities adjust to new policy, sourcing, and compliance realities. Foreign Entity of Concern restrictions, domestic-content verification under the Inflation Reduction Act, and ongoing supply chain constraints reshape how projects are financed, procured, and executed.

At the same time, demand for storage's underlying value, including grid stability, renewable integration, and capacity flexibility, continues to rise. While the long-term trajectory remains strong, success now depends less on speed and more on strategic resilience.

How systems are integrated in this environment matters as much as what is installed. Proprietary "one-vendor" solutions may promise simplicity early, but often lead to rigidity, higher lifecycle costs, and limited adaptability to future standards or technologies. Leading utilities, IPPs, and developers are turning to vendor-agnostic, software-led integration models that enable interoperability, transparency, and control across diverse component suppliers to safeguard long-term performance.

Doosan GridTech's approach embodies this evolution. As a founding member of the Modular Energy Storage Architecture (MESA) Alliance, Doosan GridTech has championed open interoperability across distributed energy ecosystems for more than a decade. Its Doosan GridTech Intelligent Controller (DG-IC®) unifies battery, inverter, and renewable assets under a single interconnection point, providing real-time control and compliance flexibility. Paired with Doosan GridTech Performance Analytics (DG-PA™), an advanced analytics suite powered by TWAICE, Doosan GridTech delivers continuous operational insight, helping asset owners optimize dispatch, manage degradation, and plan augmentations with confidence.

From hybrid solar-plus-storage plants like Tailem Bend II in Australia to pioneering MESA-based systems developed with Snohomish County PUD, Doosan GridTech has demonstrated how open, standards-driven integration can adapt through market cycles and technology shifts.

The projects that will endure and thrive beyond the current market transition are those designed for flexibility and foresight. With modular control layers, standards-based interfaces, and software-first design, Doosan GridTech enables smarter BESS decisions that reduce risk, maximize value, and strengthen grid resilience for decades to come.

1. The Storage Boom Meets New Uncertainty

Battery energy storage systems (BESS) have rapidly evolved from pilot projects into critical components of modern grid infrastructure. Across the United States, utilities and developers are deploying storage to stabilize renewable generation, enhance reliability, and capture new revenue through capacity and ancillary-service markets.

The Inflation Reduction Act (IRA) sparked an unprecedented storage-boom period between 2023 and 2025, as standalone-storage eligibility, tax incentives, and investor confidence accelerated procurement at record speed. The U.S. market installed tens of gigawatt-hours of capacity annually, solidifying storage as the fastest-growing segment in the power sector. This momentum, however, also exposed structural vulnerabilities, strained supply chains, permitting bottlenecks, and an overreliance on overseas components.

The enactment of the One Big Beautiful Bill Act (OBBBA) and subsequent Foreign Entity of Concern (FEOC) restrictions marked a clear turning point, signaling the end of the IRA-driven boom period and the beginning of a compliance-driven recalibration. Earlier forecasts projected annual installations surpassing 20 GW by the mid-2020s, but updated analyses from Wood Mackenzie and BloombergNEF suggest the U.S. market may experience a brief slowdown in 2026 as developers navigate FEOC compliance, domestic-content verification, and supply-chain realignment, even as global energy-storage additions continue to rise.[1] [2]

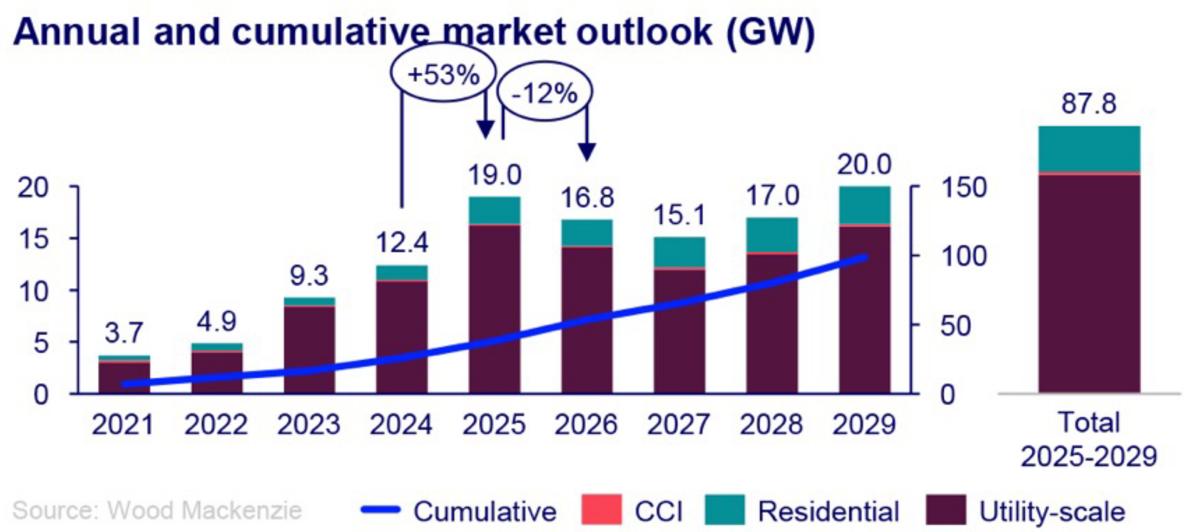

Figure 1 - U.S. grid-scale storage installations projected to dip 20-25% in 2027 amid policy and sourcing shifts, rebound by 2028 (Wood Mackenzie Q3 2025)

These shifts define both the opportunity and the uncertainty facing the U.S. energy-storage market. On one hand, they are accelerating domestic manufacturing, supply transparency, and grid modernization. On the other hand, they have tightened documentation standards and narrowed project timelines, testing the resilience of developers and system integrators alike. The next section explores how these policy changes, beginning with the IRA and evolving through OBBBA, are reshaping incentive structures and compliance requirements across the industry.

1.1. Policy Shocks and Incentive Shifts

The IRA established long-term, technology-neutral tax incentives for energy storage, allowing standalone BESS to qualify for the Investment Tax Credit (ITC) and Production Tax Credit (PTC). It also introduced “bonus credits” for domestic content, energy-community siting, and low-carbon manufacturing, turning the United States into one of the most attractive markets for grid-scale-storage investment.

The OBBBA, enacted in 2025, reaffirmed the federal commitment to clean energy but added new layers of complexity. While preserving many IRA-era incentives, it expanded Foreign Entity of

[1] Wood Mackenzie, “U.S. Energy Storage Monitor, Q3 2025”

[2] BloombergNEF forecast as reported in Utility Dive, October 21, 2025

Concern (FEOC) restrictions, limiting access to credits for projects sourcing key components from designated nations. Developers must now demonstrate that batteries, inverters, and balance-of-system hardware are free from prohibited foreign ownership, influence, or material assistance. [3] [4]

The combined effect of IRA and OBBBA is a sharper compliance landscape. Incentives remain powerful, but the margin for error has narrowed. Projects must now incorporate detailed supply-chain tracing, third-party verification, and proactive documentation to maintain eligibility, and developers that delay construction beyond "safe-harbor" deadlines risk losing credit qualification altogether. [5]

1.2. Supply-Chain and Sourcing Pressures

Even before these policy shifts, the storage supply chain was vulnerable to volatility in metals, components, and logistics. The FEOC provisions amplify these risks by effectively redrawing the sourcing map for BESS equipment.

- **Material sourcing risk -** Components containing Chinese, Russian, Iranian, or North Korean content can jeopardize tax-credit eligibility.
- **Cost volatility -** Domestic manufacturing ramps only gradually, creating short-term price pressure on compliant hardware.
- **Vendor concentration -** Consolidation within the inverter and cell-manufacturing markets limits fallback options if a supplier becomes non-compliant.

Developers are now forced to maintain dual-sourcing strategies and to favor open, standards-based integration architectures that allow component substitution without re-engineering the control layer.

1.3. Interconnection and Grid-Access Bottlenecks

At the same time, interconnection delays remain a critical bottleneck. Queue times in high-growth Independent System Operators frequently exceed three to four years, with complex studies and restudies often triggered by adjacent renewable projects. These delays not only threaten financial models but can also outlast the incentive windows defined by the IRA and OBBBA.

Flexible project design (capable of pivoting across timelines, interconnection points, and operational modes) has become a strategic necessity.

1.4. Technology Evolution and Obsolescence Risk

Storage technology is advancing faster than most procurement cycles can accommodate. Lithium-iron-phosphate (LFP) remains dominant today, but new chemistries such as sodium-ion and solid-state are emerging rapidly. Inverter and EMS firmware evolve just as quickly, driven by new grid-

[3] Hogan Lovells, "One Big Beautiful Bill Act Signed into Law: Clean-Energy Credits and New FEOC Prohibited Foreign Entities," Aug 2025.
[4] BCLP Law, "What the One Big Beautiful Bill Act Means for the Renewable Energy Industry and How It Can Adapt," Sept 2025.
[5] Utility Dive, "With Tax Credits Secured and Price Hikes Looming, Battery Storage Is Poised to Grow," July 2025.

code requirements and cybersecurity standards. Projects built around proprietary, non-upgradeable architectures face rising risk of functional obsolescence within a decade.

1.5. What This Means for Project Strategy

In this era of overlapping incentives, compliance requirements, and rapid innovation, project resilience equals flexibility. Owners and developers must design systems that can absorb change (technological, regulatory, and market-based) without major re-engineering. Core imperatives include:

1. **Flexible architecture –** Support multiple hardware vendors and chemistries through open, standards-based integration.
2. **Transparent data models –** Adopt MESA or equivalent frameworks that ensure traceable, auditable control logic.
3. **Rigorous supply-chain governance –** Implement proactive FEOC due-diligence processes from procurement through commissioning.
4. **Incentive-aware scheduling –** Align construction start, interconnection, and commissioning milestones with policy timelines.
5. **Lifecycle adaptability –** Design for augmentation, replacement, and compliance updates across a 20-year horizon.

When flexibility is built into the control layer, every other element (procurement, compliance, performance) becomes more resilient. This is the foundational principle of vendor-agnostic, software-first integration, explored in the next section.

2. The Hidden Cost of Vendor Lock-In

Turnkey "one-stop-shop" solutions can appear to solve the growing complexity of BESS projects. One vendor, one contract, one integration path; all seemingly efficient in a market pressured by aggressive schedules and workforce constraints. Yet beneath this convenience lies a hidden cost curve that grows over the life of the project.

Vendor lock-in occurs when a system's core operating logic, its controller, communications, and data structures, are proprietary to a single supplier, preventing other components from being integrated or replaced without that vendor's permission or tools. What looks streamlined at commissioning can become an obstacle as technology, policy, and ownership evolve.

2.1. Short-Term Convenience, Long-Term Constraints

1. **Limited Technology Substitution –** Proprietary control architectures typically require that batteries and inverters come from a narrow list of "approved" OEMs. When one of those OEMs changes communication protocols, discontinues a product line, or exits the market, the asset owner faces costly retrofits or stranded capacity. For example, multiple inverter

manufacturers have already consolidated or withdrawn from U.S. utility-scale sales amid trade and FEOC pressure, leaving operators with limited-service options.[6]

2. **Opaque Control Logic and Data Access –** Closed systems restrict access to the algorithms that manage state of charge, dispatch priorities, or protection limits. Without transparency into control logic or raw telemetry, owners cannot independently validate performance, audit warranty conditions, or integrate with analytics and DERMS platforms. This "black box" model limits operators' ability to diagnose root causes of events or to comply with utility reporting obligations.

3. **Feature Stagnation and Upgrade Risk –** Software-defined behavior is only as flexible as its update policy. Proprietary controllers often follow the vendor's internal development schedule, not the project's needs. When new grid-code requirements (such as IEEE 2800 ride-through behavior) or market rules (like ERCOT's FAR or CAISO's Hybrid Resource participation model) emerge, locked systems must wait for the OEM to deliver a patch if they deliver one at all. The delay can jeopardize compliance or curtail participation revenue.[7]

4. **Data Silos and Integration Barriers** – Non-standard APIs (Application Programming Interface) and file formats prevent seamless exchange of performance data with third-party analytics, asset-management systems, or regulators. The result is duplicated monitoring infrastructure, reduced visibility, and additional reporting cost. Utilities increasingly expect standardized telemetry through open protocols such as IEEE 2030.5 or MESA-Device, something proprietary systems rarely expose natively.

5. **Costly Augmentation and Lifecycle Engineering** – Every battery project eventually faces augmentation or repowering. In a closed environment, adding new modules, chemistries, or inverters can require extensive re-certification and firmware redevelopment. These non-recurring engineering (NRE) expenses erode long-term internal rates of return (IRR). Open, standards-based architectures can incorporate new devices with minimal disruption, a decisive advantage as lithium-ion gives way to emerging chemistries like sodium-ion or hybrid flow cells.

6. **Compliance and Incentive Risk** – Lock-in also creates financial exposure when policy changes. If a proprietary component later fails to meet domestic-content or FEOC eligibility, the project may lose federal tax-credit qualification or need a full redesign to restore compliance. With the Inflation Reduction Act's manufacturing and sourcing rules tightening through 2026, integrators that rely on single-vendor hardware stacks face higher re-qualification risk.[8]

7. **Operational Dependency and Service Cost Inflation** – When spare parts, software keys, or field-service credentials are controlled exclusively by the OEM, maintenance becomes an annuity business for the vendor. Over time, O&M costs escalate, while the asset owner's independence and negotiating power decline.

[6] Wood Mackenzie, "Global Battery Energy Storage Supply Chain Trends 2025"
[7] IEEE Standards Association**, "**IEEE Std 2800™-2022: Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems"
[8] U.S. Treasury, "Inflation Reduction Act Clean Energy Manufacturing Credit (45X) and Domestic Content Guidance"

2.2. The Economic Reality

A vendor-locked project might appear cheaper during EPC procurement, but across a 20-year asset life, inflexibility compounds into measurable losses:

- Higher integration cost for future technologies
- Delayed compliance with evolving grid codes
- Lost participation in ancillary-service markets due to firmware lag
- Increased downtime during component transitions
- Reduced resale or refinancing value because of opaque software dependencies

By contrast, open, standards-based integration gives developers and utilities strategic optionality, or the ability to pivot technologies, maintain transparency, and adapt economically to market and regulatory evolution.

In today's volatile policy and supply environment, flexibility is no longer a nice-to-have feature; it is an insurance policy for asset value.

Key Takeaway:

Projects that choose proprietary, vertically integrated control systems may accelerate early execution but pay for it in lost autonomy, limited interoperability, and shrinking margins over time.

Projects that choose software-led integration preserve freedom of design and access to innovation, positioning themselves for a 20-year journey through evolving markets, standards, and technologies.

3. The Case for Software Led Integration

As the energy-storage sector matures, integration strategy has become one of the most critical determinants of long-term project success. Early projects were often built around turnkey, single-vendor systems because they simplified procurement and commissioning. But in today's rapidly evolving policy and technology environment, that simplicity can quickly become a liability.

Software-led integration reverses that equation. It decouples hardware procurement from the control and software layers so that asset owners can continuously adopt better technologies, comply with evolving standards, and maintain competitive leverage across a 20-year asset life.

3.1. The Market Context

Three converging forces have made open, flexible integration essential:

1. **Accelerating Technology Turnover** – Battery chemistries, inverter topologies, and digital-control standards are changing every two to three years. Locking a project into one OEM's proprietary stack limits the ability to adopt safer chemistries, higher-efficiency converters, or grid-code upgrades introduced mid-life.

2. **Policy and Standards Evolution** – New frameworks such as IEEE 2800-2022 for inverter-based resource performance, NERC's cybersecurity directives, and market-specific interoperability rules (CAISO, ERCOT, and others) require periodic software updates and dynamic testing. Projects built on open, standards-based control layers can update functionality through configuration rather than wholesale redesign.

3. **Financial and Ownership Flexibility** – In a merchant or hybrid-contract environment, developers often sell or refinance projects within a few years of COD. Open integration preserves asset value by ensuring that data, logic, and interfaces remain transferable and transparent for future operators or investors.

3.2. Foundations of an Open Standards Architecture

Doosan GridTech's integration philosophy is rooted in open standards that ensure interoperability from the device level to the market interface:

- **MESA-Device and MESA-ESS** define standardized information models and command sets for batteries, power-conversion systems, and site controllers. These frameworks reduce one-off engineering effort and allow mix-and-match component selection without rewriting control code.[9]
- **IEEE 2030.5 and DNP3** provide secure, utility-grade communication between the site controller and SCADA, EMS, or DERMS platforms. They enable real-time visibility and dispatch without proprietary gateways. [10]
- **SunSpec** supports broader DER communication and protective-relay coordination, ensuring alignment with international utility standards. [11]
- **IEEE 2800-2022** introduces uniform interconnection and performance criteria for large inverter-based resources. A site controller designed for 2800-aligned behavior can autonomously execute voltage- and frequency-ride-through functions and report standardized telemetry during disturbances. [12]

When these frameworks are embedded in the controller's architecture, as they are in Doosan GridTech's DG-IC®, the result is a system that can evolve with both hardware and regulation.

3.3. Advantages of Software Led Integration

1. **Technology Neutrality** – Projects can integrate the optimal combination of batteries, inverters, and auxiliary systems based on performance or price, not vendor exclusivity.
2. **Regulatory Confidence** – Built-in support for MESA, IEEE, and SunSpec standards ensures compliance with emerging interconnection and reporting rules without waiting for custom firmware.
3. **Operational Adaptability** – Dispatch algorithms, curtailment logic, and safety envelopes can be adjusted through configuration, allowing operators to respond quickly to tariff or market-rule changes.
4. **Cybersecurity Consistency** – Open, well-documented protocols enable unified authentication, encryption, and event logging across mixed OEM environments, which are essential for meeting NERC CIP expectations.

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[9] MESA Alliance, Modular Energy Storage Architecture Standards Overview
[10] IEEE, IEEE 2030.5 Standard for Smart Energy Profile Application Protocol
[11] SunSpec Alliance, Information Models for Distributed Energy Resources
[12] IEEE, IEEE 2800-2022 – Standard for Interconnection and Interoperability of Inverter-Based Resources

5. **Lifecycle Economics** – Standardized data and interfaces lower integration costs, simplify future augmentation, and improve serviceability, directly enhancing net present value.

3.4. Turning Standards into Strategy

Standards alone do not deliver value, but implementation does. Doosan GridTech's DG-IC® operationalizes these frameworks through modular software layers and a library of pre-validated device drivers. This allows integrators and utilities to commission new systems faster, reduce custom code, and ensure deterministic control performance under all grid conditions.

By maintaining a vendor-neutral stance, Doosan GridTech enables project owners to make procurement, performance, and policy decisions independently of the control system vendor. That independence is the foundation of long-term resilience: when technologies, tariffs, or ownership structures change, the system evolves instead of being replaced.

Validated Through Real-World Simulation

To ensure every control strategy performs as designed under true-to-grid conditions, Doosan GridTech validates its DG-IC® site-controller software through Hardware-in-the-Loop (HIL) testing using Typhoon HIL's real-time simulation platform. This process emulates dynamic grid events such as frequency deviations, voltage transients, protection sequences, and hybrid-plant dispatch scenarios so engineers can fine-tune logic and verify IEEE 2800-aligned performance before field deployment.

By identifying interoperability and protection-response issues early, HIL testing reduces commissioning risk, shortens project timelines, and strengthens the reliability of every software-led integration delivered to utilities and developers worldwide.

4. Software-Led Integration in Action

True integration is more than connecting equipment. It is about coordinating diverse technologies, data streams, and operating objectives in real time, within evolving grid conditions. That orchestration happens through software.

While many energy storage projects focus on hardware selection (battery chemistry, inverter type, PCS configuration), the software layer is what determines how intelligently a project behaves once energized. This layer translates grid commands into local control actions, enforces operational constraints, optimizes dispatch for market and asset objectives, and ensures that all subsystems respond safely and predictably.

Doosan GridTech's DG-IC® site controller and DG-PA™ analytics suite powered by TWAICE form the core of this software-led integration framework. Together, they turn storage assets from passive capacity into dynamic, self-optimizing energy resources.

4.1. DG-IC®: Intelligence at the Site Level

The DG-IC® (Doosan GridTech Intelligent Controller®) is a real-time site-level control platform designed to manage every grid-connected device, batteries, inverters, renewable generation, switchgear, and meters, within a single point of interconnection. It acts as the plant's digital command center, balancing grid requirements, owner objectives, and equipment safety simultaneously.

Core Control Capabilities

1. **Real-Time, Sub-Second Dispatch** - DG-IC® can regulate active and reactive power with millisecond response times, enabling precise frequency regulation, voltage support, and grid-code compliance. This level of responsiveness is essential for utilities that depend on BESS to stabilize frequency during transient events and for developers bidding into ancillary-service markets where response times define profitability.[13]
2. **Constraint Enforcement and Protection** - The controller enforces safe operational limits; temperature, voltage, current, and state-of-charge, using configurable parameters derived from OEM specifications. These rules prevent over-charging or over-discharging while maintaining warranty compliance.
3. **Multimode Coordination (Mode Stacking)** - DG-IC® can execute multiple control objectives at once. For instance, following a day-ahead dispatch curve while reserving headroom for frequency regulation. This "mode stacking" allows project owners to extract multiple value streams from one asset without compromising safety or performance.
4. **Hybrid-Plant Optimization** - In hybrid facilities, DG-IC® unifies the resource portfolio under one control hierarchy. It coordinates curtailment, ramp-rate limits, and state-of-charge management so that renewables and storage operate cohesively under a single interconnection agreement.
5. **Open, Standards-Based Communication** - Built on MESA, SunSpec, and IEEE 2030.5 standards, DG-IC® communicates seamlessly with both downstream components (battery and inverter) and upstream systems (SCADA, DERMS, ISO market gateways). This architecture eliminates custom point-to-point engineering and enables future component substitutions with minimal rework.[14]
6. **Cybersecurity and Reliability by Design** - DG-IC® incorporates secure authentication, encryption, and event logging consistent with utility cybersecurity practices. Role-based access control and redundant computing architectures ensure operational continuity even during communication interruptions or hardware faults.

4.2. DG-PA™: Predictive Analytics and Asset Intelligence

While DG-IC® governs the real-time layer, DG-PA™ (Doosan GridTech Performance Analytics) focuses on long-term performance.

Powered by TWAICE battery analytics, DG-PA™ merges field data, physics-based degradation models, and digital-twin simulation to reveal what is happening inside the battery at any given time and what will happen next.[15]

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[13] U.S. Department of Energy, **"**Battery Energy Storage Systems Report**"** (Nov 2024)
[14] MESA Standards Alliance, "MESA-ESS and MESA-Device Overview"
[15] TWAICE, "Battery Analytics for Energy Storage Systems"

DG-PA™ Capabilities

- **Battery-Health Forecasting –** DG-PA™ estimates remaining useful life (RUL) and capacity fade by analyzing temperature, C-rate, and state-of-charge cycles.
  Operators can see how daily dispatch strategies affect long-term degradation.
- **Warranty and Performance Tracking –** The platform tracks cycle counts and usage patterns against warranty thresholds, automatically flagging when assets near contractual limits. This visibility helps asset owners maintain compliance and avoid costly warranty disputes.
- **Anomaly Detection and Early Fault Alerts –** Machine-learning algorithms flag abnormal trends, such as sudden impedance changes, cell imbalances, or sensor drift, long before traditional SCADA alarms trigger. These predictive insights allow maintenance teams to act proactively rather than reactively.
- **Augmentation and Replacement Planning –** DG-PA™ models how adding or replacing modules will affect system performance, enabling accurate financial and engineering planning for capacity expansions.
- **Operational Optimization –** By feeding degradation data back into DG-IC®, the analytics layer adjusts dispatch strategies to extend battery life while maintaining required market performance.

The result is a closed feedback loop between control and analytics: DG-IC® executes operational commands while DG-PA™ analyzes outcomes, forecasts impact and refines the next operating cycle.

Integration Benefits Across Stakeholders

Stakeholder	Key Value
Utilities	Real-time reliability, standards compliance, and cybersecurity alignment
Developers & IPPs	Vendor independence, flexible augmentation paths, predictable lifetime costs
Grid Operators	Transparent data exchange and verifiable performance under IEEE 2030.5 / 2800 frameworks
Investors	Reduced operational risk, improved asset longevity, stronger long-term revenue certainty

By embedding open standards, configurability, and analytics into every layer, Doosan's software-led integration transforms BESS projects into future-ready grid assets.

Instead of re-engineering control logic with every technology cycle, owners can evolve their systems through software updates, reducing risk, extending life, and accelerating time to market.

Why It Matters

In today's market, differentiation increasingly depends on software, not hardware. As grid codes tighten and markets evolve toward performance-based compensation, the intelligence embedded in the controller and analytics layer determines whether a project merely meets interconnection requirements or delivers sustained value through adaptability and insight.

Doosan GridTech's DG-IC® site controller has been proven in utility-scale and hybrid applications worldwide, delivering reliable, standards-based control across complex assets and markets. Building on that foundation, DG-PA™, powered by TWAICE's field-proven analytics platform, adds advanced predictive-modeling capabilities that give asset owners greater visibility into battery health, performance trends, and augmentation planning.

Together, these software solutions enable projects to remain flexible, transparent, and compliant as technologies and regulations evolve, helping operators maximize long-term performance in a changing energy landscape.

5. Real-World Examples

Open standards and software-driven integration are not theoretical abstractions; they are already delivering measurable results for utilities and developers globally. Two flagship projects, Tailem Bend II in South Australia and Snohomish County PUD's MESA 1 & 2 in Washington State, clearly demonstrate how Doosan GridTech's vendor-agnostic control architecture advances hybrid-plant performance, interoperability, and lasting industry standards.

5.1. Tailem Bend II BESS: Coordinated Control for Solar + Storage[16]

Figure 2 - Tailem Bend II Hybrid BESS, South Australia

Location: South Australia **|** **Project Type:** Hybrid PV + BESS under a single interconnection

Integrator & Software: Doosan GridTech, DG-IC® site controller

The Tailem Bend II BESS Project added a 41.5MW battery to an existing 87MW solar farm, creating a hybrid system with one interconnection to the grid.[17]

DG-IC® serves as an integrated controller for both generation and storage assets, overseeing charge/discharge operations, curtailment, and dynamic modes to maximize revenue, enhance grid stability, and ensure compliance with grid codes. The system architecture permits PV and BESS to function with a degree of autonomy while maintaining coordinated synchronization at a single point of grid connection.[18]

[16] Doosan GridTech, Tailem Bend II Hybrid Project Case Study

[17] Vena Energy, Tailem Bend II Hybrid Project

[18] PV Know How, "Tailem Bend 2 Hybrid Project adds 41.5 MW BESS"

Key Technical Outcomes:

- **Single-Interconnection Optimization** – The solar and storage units share grid connectivity and are managed cohesively to maximize outputs.
- **Dynamic Dispatch Coordination** – Sub-second control coordination via standards-based interfaces helps synchronize solar vs battery dispatch.
- **Augmentation Flexibility** – The modular control design supports future expansion or substitution of battery or inverter components without needing to redesign solar control logic.
- **Operational Compliance** – The system is designed to meet grid-disturbance standards (e.g., ride-through behaviors) while providing telemetry to grid operators.
- **Cost Efficiency** – Sharing infrastructure and permitting across PV + BESS reduces redundant grid interfaces and regulatory burden.

In January 2025, Vena Energy announced the successful commissioning of the battery portion of Tailem Bend II, noting that the hybrid architecture enables independent operation of solar and battery behind one grid connection.[19] This project stands as a global reference for integrated solar + storage control under a unified architecture.

5.2. MESA 1 & 2: Pioneering MESA & Utility-Scale Storage[20]

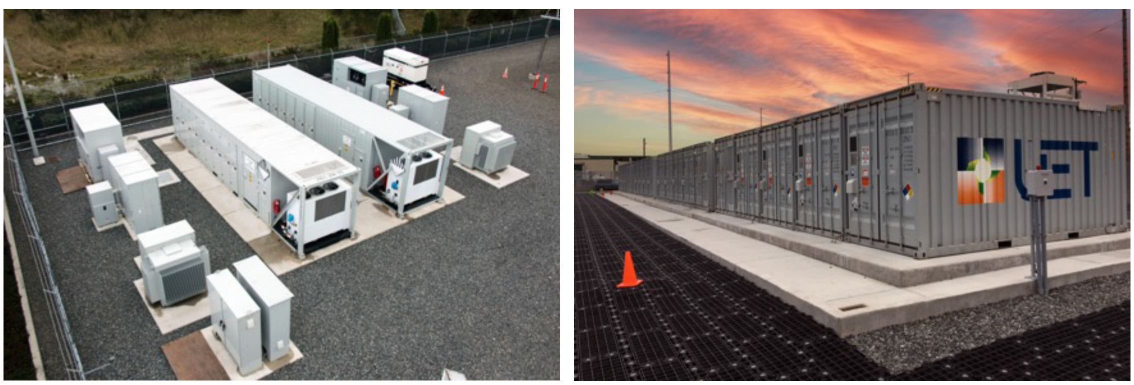

Figure 3 - MESA 1 & 2, Everett, Washington

Location: Everett, Washington, USA **|** **Project Type:** Utility-scale BESS demonstration portfolio

Integrator & Software: Doosan GridTech, DG-IC® site controllers

Snohomish County Public Utility District's (SnoPUD) early storage programs are among the most cited examples of modular, standards-based multi-vendor integration in the U.S. The utility's projects serve as a live testbed for MESA (Modular Energy Storage Architecture) principles.

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[19] Energy-Storage.news, "Vena Energy adds 41.5 MW BESS to PV"

[20] Doosan GridTech, MESA 1 & 2 BESS Portfolio Project Case Study

Project History & Specifications:

- **MESA-1 –** Two lithium-ion battery systems, each 1MW / 0.5MWh. One unit was supplied by LG Chem, the other by GS Yuasa with Parker PCS, all integrated under the MESA architecture.[21]
- **MESA-2 –** A vanadium redox flow battery of 2.2MW / 8MWh supplied by UniEnergy Technologies, deployed to validate flow chemistry in a modular standard framework.[22]

Doosan GridTech delivered and integrated all three storage systems under DG-IC®, employing MESA-compliant interfaces and linking them to the utility's SCADA and scheduling systems.

Key Technical Outcomes:

- **Multi-vendor interoperability –** Batteries, inverters, and DG-IC® communicate using MESA-ESS and MESA-Device models, enabling seamless component replacement or variety.
- **SCADA / Scheduling integration –** DG-IC® links to SnoPUD's utility communication systems for unified scheduling and control across ESS assets.
- **Lifecycle insights –** The pilot systems were operated through their usable lifetimes, providing rich data on performance, safety, and interoperability that informed industry adoption.
- **Standards validation –** The projects proved that open standards (MESA, telemetry, control) could work in real utility settings, reducing perceived risk for subsequent deployments.
- **Legacy impact –** Even though earlier ESS systems may no longer be operational, the architecture and lessons from SnoPUD remain foundational to later Doosan DG-IC® control design philosophies.

5.3. Proven Principles, Tangible Impact

Both Tailem Bend II and the MESA portfolio showcase how software-defined, open-standards control can deliver real project advantage:

- The ability to manage solar + storage behind one interconnection while maintaining modular flexibility.
- Demonstrated compliance with advanced grid response behaviors.
- Interoperability across multiple OEMs, avoiding vendor lock-in.
- Control architectures that support evolving system design, component substitution, and operational control over decades.

Each example reinforces a key principle: when control is open, intelligent, and software-defined, the asset owner, not the vendor, remains in control.

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[21] MESA, MESA-1 deployment of Li-ion modules by LG Chem / GS Yuasa and Parker PCS

[22] TD World, MESA-2 vanadium flow battery specs in SnoPUD portfolio

6. Designing for the Future

As energy storage becomes an essential pillar of modern grid architecture, projects must be designed to withstand the constant evolution of technologies, regulations, and market conditions. Integration decisions made today will determine whether tomorrow's assets can adapt, expand, and continue to deliver value under new policies, tariffs, and operating environments.

The long-term growth trajectory for utility-scale storage remains strong, but the path ahead is uneven. Wood Mackenzie recently warned that U.S. grid-scale deployments could contract by nearly one third by 2027 amid policy uncertainty and shifting supply conditions. [23] After several record-setting years, U.S. deployments are expected to pause in 2026 as developers navigate Foreign Entity of Concern (FEOC) restrictions, domestic-content verification, and supply-chain realignment under the Inflation Reduction Act. Analysts project installations to rebound in 2028, with total installed capacity approaching 65GW, reaffirming storage as a cornerstone of the modern power sector. [24]

In short, volatility is now the baseline. Policy shifts, procurement constraints, and evolving interconnection and performance standards will continue to redefine how energy-storage systems are designed and operated. To succeed, resilience must be built into every layer of a project's architecture, from procurement strategy to software integration.

Systems built for the future incorporate four key principles:

1. **Upgradeability** – Modular site controllers and standards-based interfaces allow the integration of next-generation inverters, chemistries, or balance-of-plant components without rewriting control logic.
2. **Transparency** – Standardized data models such as MESA and SunSpec ensure operators maintain full visibility and control, with no "black box" dependencies.
3. **Interoperability** – Compliance with IEEE 2030.5, MESA, and emerging IEEE 2800-aligned behaviors allow seamless communication with SCADA, DERMS, and grid operator systems across evolving markets.
4. **Longevity** – Predictive analytics, such as those offered by DG-PA™, powered by TWAICE, enable asset operators to anticipate degradation, manage warranties, and extend usable life.

From a strategic perspective, open integration is a hedge against volatility:

- **Regulatory Resilience –** Projects designed to meet or exceed MESA and IEEE standards are faster to certify and less likely to face expensive retrofits as interconnection and performance codes evolve.
- **Procurement Flexibility –** Vendor independence empowers developers and IPPs to source competitively without sacrificing performance or compliance.

[23] Energy Storage News, "U.S. Grid-scale BESS Market Could Shrink by Almost a Third in 2026"

[24] Utility Dive, "U.S. Utility-scale Energy Storage to Double and Reach 65 GW by 2027, EIA"

- **Portfolio Consistency –** Standardized control and telemetry protocols simplify operations across multi-site or multi-ISO portfolios.
- **Lower Lifecycle Cost –** Avoiding proprietary firmware, licensing fees, and integration rewrites reduces total cost of ownership and increases long-term IRR.

6.1. Doosan GridTech's Vision

As a founding member of the MESA Alliance, Doosan GridTech continues to lead the industry in advancing open standards and modular system design. The company's software platform is built on an open standards-based architecture to ensure interoperability among energy storage and distributed energy resources. Its DG-IC® site controller enables real-time intelligence aligned with MESA, IEEE 2030.5, and IEEE 2800 guidelines, while DG-PA™, powered by TWAICE, transforms operational data into predictive insights that enhance reliability and performance.

Together, these tools deliver a control ecosystem built not around any single vendor, but around the grid itself.

Built for the Grid. Trusted in the Field.

The energy transition depends on the decisions made today. Choosing open standards, software-led integration is not merely a technical preference; it is a strategic commitment to flexibility, independence, and long-term value. With a decade of field experience and a deep heritage in open interoperability, Doosan GridTech empowers utilities, developers, and IPPs to build energy storage systems that not only meet today's standards but also define tomorrows.