WHEN TRUST MATTERS

Strategic planning to reduce risks with co-located battery storage

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Who are we?

DNV in storage

90+

energy storage experts globally, including modelers, engineers, statisticians, and safety professionals

15 GWh

DNV has supported battery projects with cumulative capacity greater than 15 GWh over the last decade

>6

full-scale battery energy storage system tests designed, witnessed, and reported on in the last 24 months

1000+

DNV energy storage engagements completed globally in the last 24 months

1,416 MWh

DNV supported the financing of the Gemini project, one of the largest solar+storage projects in the US

>50

lender's technical advisory assignments completed to support battery energy storage system project financing in the last 24 months

>100

system or DC rack product bankability reviews for manufacturers and integrators

50+

DNV has worked on energy storage projects in over 50 countries

DNV

BESS Procurement

Battery manufacturers and BESS integrators

- Few manufacturers produce all major subcomponents, so in-house qualification testing is critical
- Reliable BESS manufacturers and integrators have established supply-chain management and rigorous subcomponent vendor selection process
- Battery cell/module manufacturers that also supply batteries to power electronics or EV market is a plus since QC/QA programs likely more mature
- Manufacturers should be ISO 9001/14001 certified; automated manufacturing
- Other factors to consider: years in manufacturing, company financial status, total deployed capacity, and “subcomponent-agnostic” design

BRAND	PRODUCT	DC CAPACITY (MWh)*	PRODUCT PIC
CATL	TENER	6.25	
FLUENCE	Gridstack Pro	5.6	
BYD	MC Cube T	6.4	
e-STORAGE	SolBank 3.0	5.0	
SUNGROW	PowerTitan 2.0	5.0	
WÄRTSILÄ	Quantum 3	5.0	
HYPER STRONG	HyperBlock III	5.0	

IHI, res power for good, AES the power of being global, SAMSUNG, FLEXGEN, CanadianSolar, LG Energy Solution, e·on, ENGIE, Leclanché, Sabre Industries, TESLA, Panasonic, LISHEN

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New commercial and technical risks due to FEOC

The dominant Chinese equipment is ineligible for tax credits, as such, new risks arise

- Potential shortage of battery and solar cell supply
- Higher prices for tax credit eligible equipment
- New component suppliers may mean lower performance and quality
- Unproven components/suppliers with long qualification and testing timelines
- New factories often experience delays and ramp-up issues
- Uncertainty and trade-offs between domestic, importing, or Chinese equipment

Potential mitigations: More detailed diligence in supplier qualification process, guarantees and risk sharing in equipment purchase agreements, monitor progress on sub supplier qualification, product testing, and factory ramp up, schedule buffer for potential equipment delays, perform factory acceptance tests

Buy U.S., import non-PFE or buy Chinese equipment?

Advantage
Neutral or unknown
Disadvantage

Equipment purchase	Buy U.S.	Import non-PFE	Import Chinese
Eligible for base tax credit?	Yes, if done right	Yes, if done right	Leaving a lot of money on the table
Eligible for 10% domestic	Yes	No	No
Equipment cost is competitive?	No, most expensive	Less expensive than U.S.	Yes, lowest cost
Avoids most import tariff uncertainty?	Yes, but suppliers experience tariff	No, and tariffs are unpredictable	No, and tariffs are unpredictable
Proven performance and quality?	Limited manufacturing experience in the U.S.	Some companies have experience	Yes, clearly proven tech
On time equipment delivery?	No, potential for delays due to factory ramp up	Less potential for delays	On time delivery expected

Supplier Shake up in U.S.

Many of the leading BESS sales leaders in the U.S. do not yet have FEOC compliant products. Future U.S. BESS leaders will need to have FEOC compliant cells. This creates an opportunity for companies with U.S. cell production or mass production outside of China to take U.S. market share in BESS sales.

Current U.S. market leaders (2024-2026)

BESS integrators leading in the U.S. market
(many have U.S. module/container factories, but not cell factories)

TESLA
SUNGROW
FLUENCE
WÄRTSILÄ
e-STORAGE

Cell producers leading U.S. market have all been Chinese companies

CATL
HTHIUM
REPT
BYD

2027+

BESS integrators will need to source non-Chinese cells for the U.S. market: from U.S.

Companies with current or planned U.S. cell factories:

LG Energy Solution
TESLA
AESC
SAMSUNG SDI

Other potential cell producers?:

SK on
Gotion

BESS Design & trends

Trends

- LFP will continue to dominate stationary storage
- No future walk-in containers
- Convergence on ~20 ft enclosures (≥ 5 MWh)
  - Assembled, tested, shipped complete (vs. larger systems which are too heavy to ship complete)
  - Quality (less field integration)
  - Increasing energy density
- Diversification of cell suppliers – especially with FEOC rules
- Temperature management system (TMS) is trending towards liquid cooled or a hybrid approach
- Future tech: taller “stacked” systems?

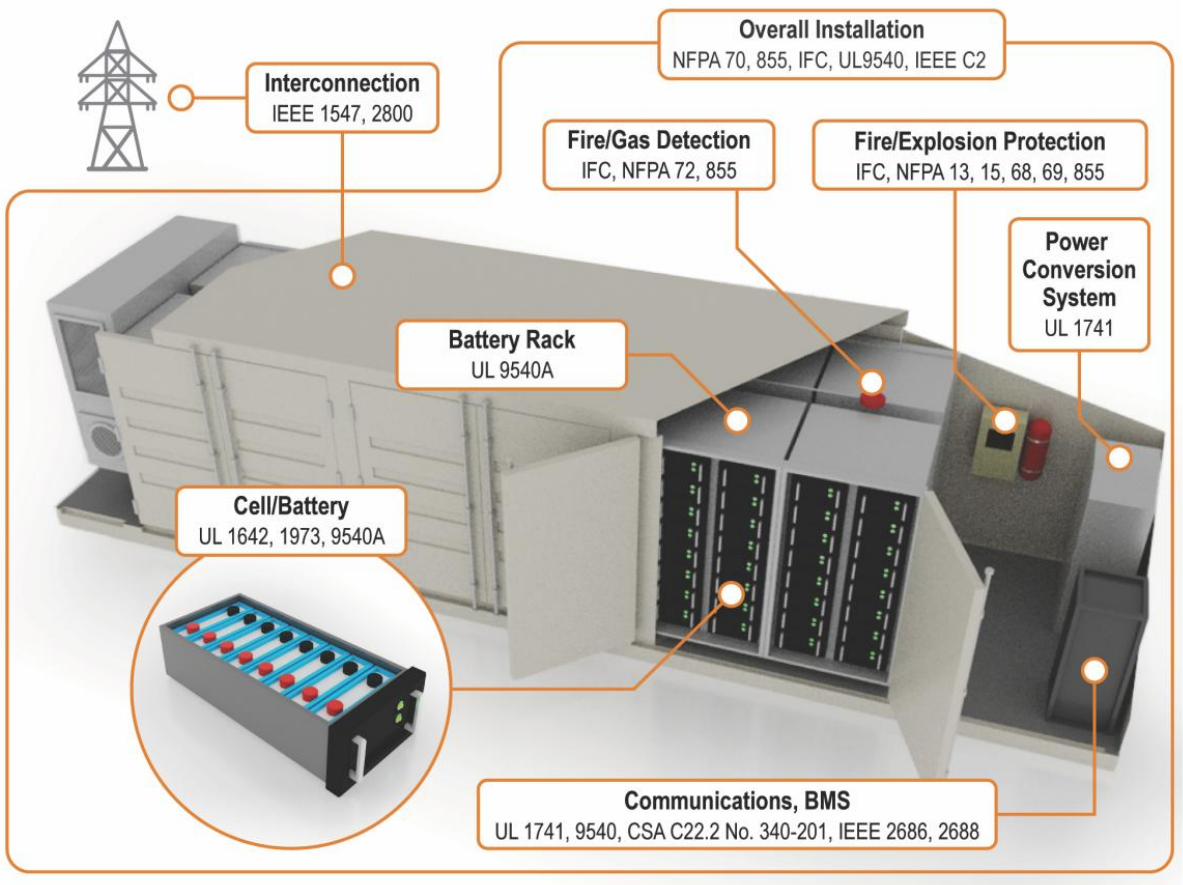
Designing for environment

- **Enclosure NEMA/IP rating** – should be suitability rated for the location and environment
- **Corrosion protection**
- **Temperatures** – thermal management system to be sized for operation in the location – both heating and cooling
- **Sand/dust** – more regular checks and replacement of filters
- **Seismic** – BESS in areas with seismic activity may require special foundations and fasteners
- **Altitude** – most systems are designed for a max altitude of 1,000m
- **Wind** – wind loading to be assessed
- **Hazardous environment**

High-level division of responsibility (example)

	Owner	BESS Supplier	EPC Contractor
Pre-Construction Permits	✓		
Construction Permits			✓
Interconnection Approval	✓		
Site Access	✓		
Site Work and AHJ Compliance			✓
Hazard Mitigation Analysis	✓		
Factory Testing		✓	
Detailed Site Studies			✓
Defining Function/Technical Requirements	✓		
Plant Controls, Protection, SCADA		✓	✓
Battery Controls		✓	
HV Systems			✓
MV Systems			✓
Battery System		✓	
BESS Fire Protection		✓	
BESS Thermal Management System		✓	
Auxiliary Power Supply			✓
Site Utility Services	✓		
Emergency Response Plan	✓		
On-site Buildings			✓
Coordinating Commissioning with Utility	✓		
BESS commissioning		✓	✓
Conducting the Performance Testing	✓		
BESS Performance		✓	✓
Training		✓	✓

Particular Specifications – BESS Codes and Standards



- BESS are Inverter connected distributed energy resources with a grid interconnection. Hence, the corresponding electrical codes and standards apply (same as other DER's).
- Additionally, BESS have technology specific safety standards and limited performance standards.
- PNNL-32789 provides a summary

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-32789.pdf

BESS Safety

How frequent are BESS failures?

System Components: Failures like BMS, HVAC, or DC/DC converters are often estimated in the range of 0.1 per year (1 in 10 years)

Infrequent Events: Failures from infrequent human error (during maintenance/installation) or physical damage (during transport/maintenance) are often estimated lower, around 0.01 per year (1 in 100 years)

Manufacturing Defects: Cell-level defects causing failure are estimated based on quality control levels (e.g., Six Sigma), often cited as ~1 failure per million cells. This becomes relevant for large sites with millions of cells.

While *initiating event* frequencies (like an HVAC failure) might be 1-in-10 or 1-in-100 years, **multiple layers of safeguards** (BMS interlocks, fuses, suppression, ventilation, etc.) significantly reduce the likelihood of these events escalating to severe consequences

Frequency* Scale

0.1 / year ←→ 1 failure expected every 10 years

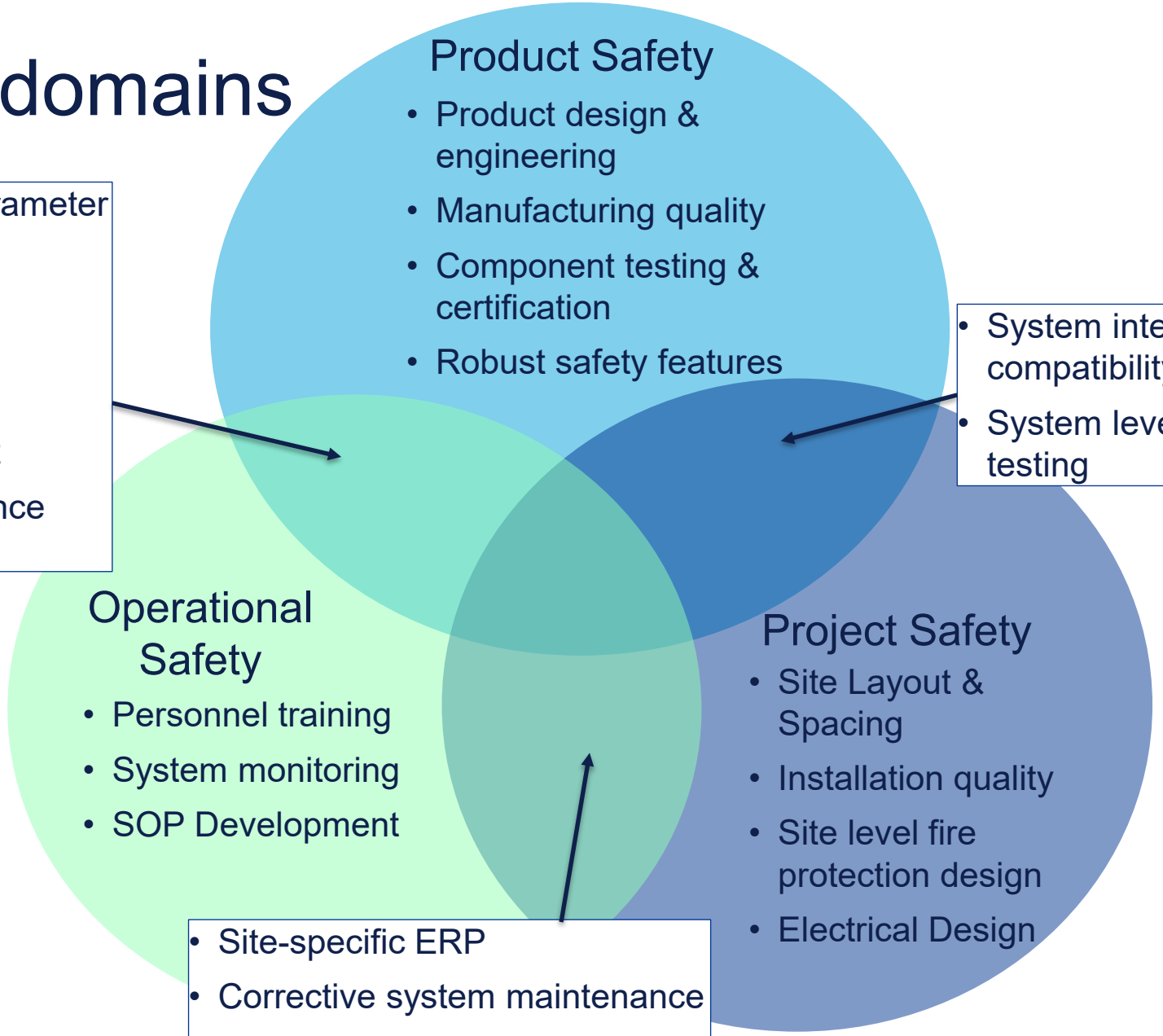
0.01 / year ←→ 1 failure expected every 100 years

*Frequencies are *estimates* based on historical reliability data

Mitigation domains

Lifecycle safety Management

- BMS utilization and parameter setting
- Adhering to operating guidelines
- Product diagnostics
- Firmware management
- Preventative maintenance and testing



- System integration and compatibility
- System level certification and testing

- Site-specific ERP
- Corrective system maintenance
- Alarm response
- Site access and data logging

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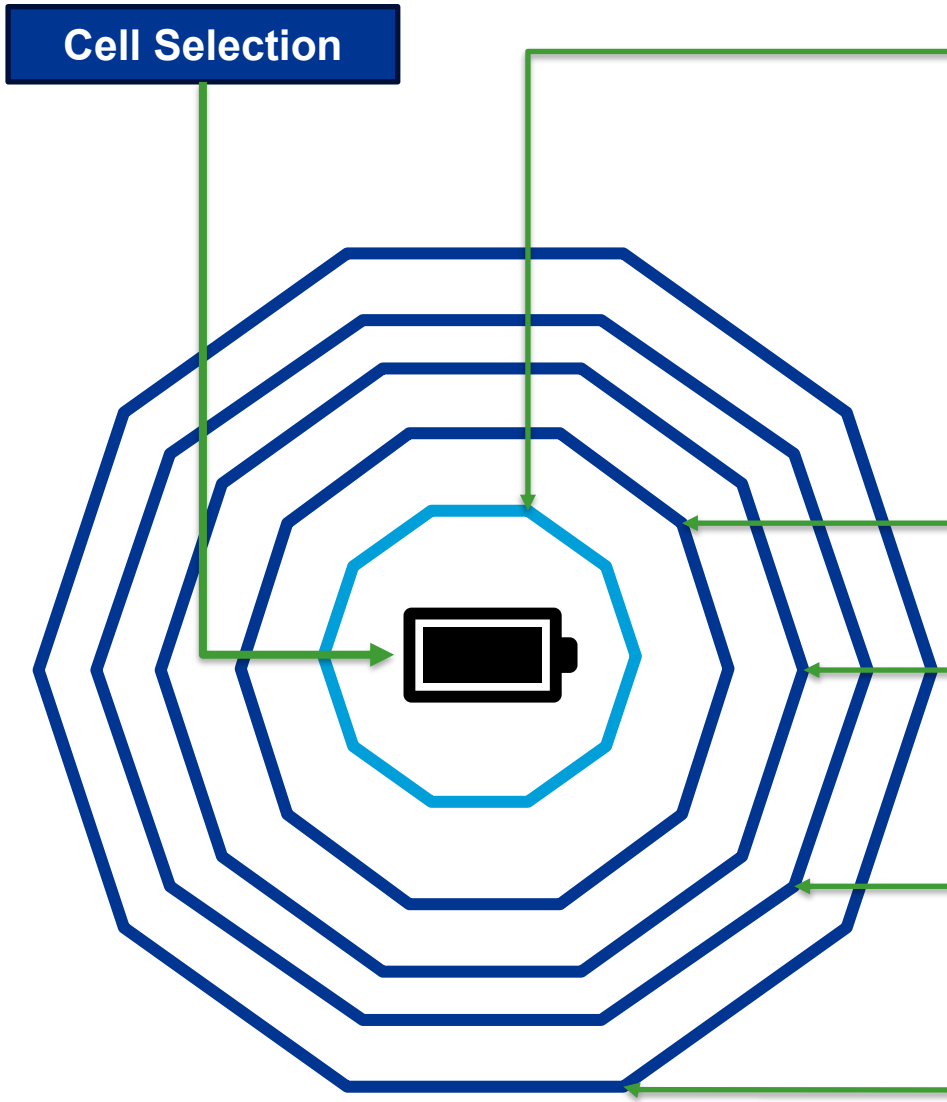
Product-level mitigation



Cell Selection

Battery management System

Fire / smoke / gas detection system

Fire Suppression System

Explosion prevention system

Explosion Protection System

Other subsystems critical to safety

Thermal Management System

Battery enclosure

Electrical insulation, isolation and harness design

Key Takeaway: Many systems and safeguards must fail before batteries experience a catastrophic failure event.

Project-level mitigation strategies

Spacing: Adhering to code requirements (NFPA 855) for separation distances between BESS enclosures, property lines, and public ways to limit fire propagation. NFPA 855 has guidelines on spacing requirements informed by UL 9540 A testing

Site Layout: Ensuing adequate and clear egress paths from any location on site to a muster point. Having enough spacing for a water apparatus to access the Project site.

Fire safety design

- Gas or aerosol fire suppression systems may be effective at extinguishing electrical fires, water-based suppression is more effective at cooling the batteries. HOWEVER, current guidance is to let the battery burn and employ defensive firefighting measures.
- Some authorities demand a fire detection system and water supply near the BESS. Water sources must have adequate supply (NFPA 1142)
- Fire rated equipment – equipment should be fire rated, consider higher fire ratings for remote locations

BESS Major Agreements

Considerations when negotiating agreements

Omissions and discrepancies are common across agreements

Offtake agreements: Metering points, testing responsibilities, schedule alignment, operating constraints, and consistent terminology

Supply agreements: Should include a capacity degradation guarantee, factory acceptance tests with third-party witnessing, commissioning and performance testing requirements, workmanship and/or serial defect warranty (12 – 24 months)

EPC agreements: division of responsibility (shown earlier), aligned with the expected useful life of the project and augmentation plans, commissioning and performance testing requirements, defect and workmanship warranties for 1 to 3 years, spare parts

Thank you!

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