Battery Design Considerations

For general safety, and New York requirements

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DNV GL in Brief

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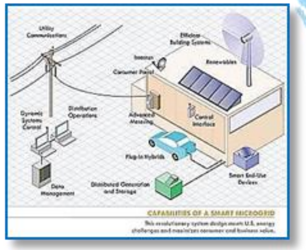
Energy

Maritime

Oil & Gas

Software

Business Assurance



Solar and Storage Applications

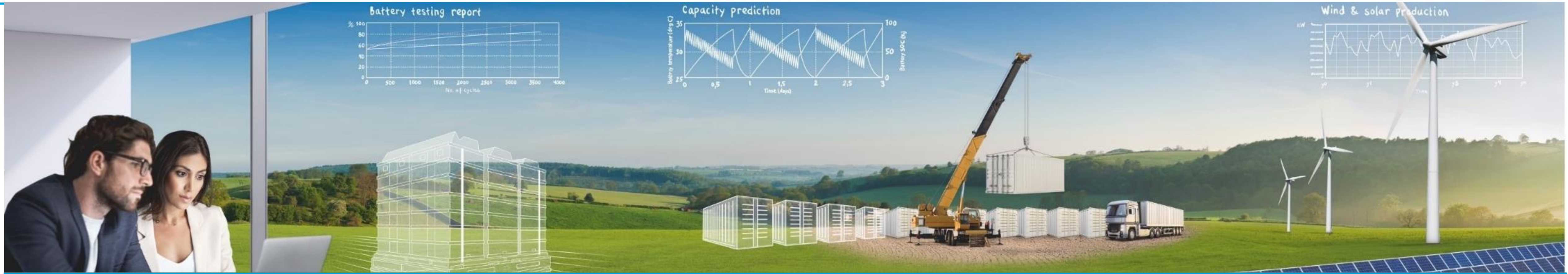
155
Year History

350
OFFICES

100
COUNTRIES

14,000
EMPLOYEES

DNV GL Energy Storage Expertise



FEASIBILITY

- Market & regulatory intelligence
- Utility grid integration
- Sizing, technology selection and business case modelling
- Technology & controls review & verification
- Standards development

TESTING

- Battery cell & module performance testing
- Battery fire safety
- Power electronic converter performance testing
- Battery controls validation testing & development
- Battery life estimation

DEVELOPMENT & ENGINEERING

- Degradation assessment & warranty verification
- Resource, energy & financial optimization
- Due diligence and independent engineering
- Project and site safety analysis & code compliance
- Procurement and contracting support

CONSTRUCTION

- Certification of equipment
- Owner's engineer
- Bank's engineer
- Factory acceptance tests
- Site acceptance tests

OPERATION

- Inspection, test and assessment of asset condition, performance & remaining lifetime
- Monitoring, operation and optimization
- Forensics
- Life extension and upgrades

Electrical Energy Storage Technologies

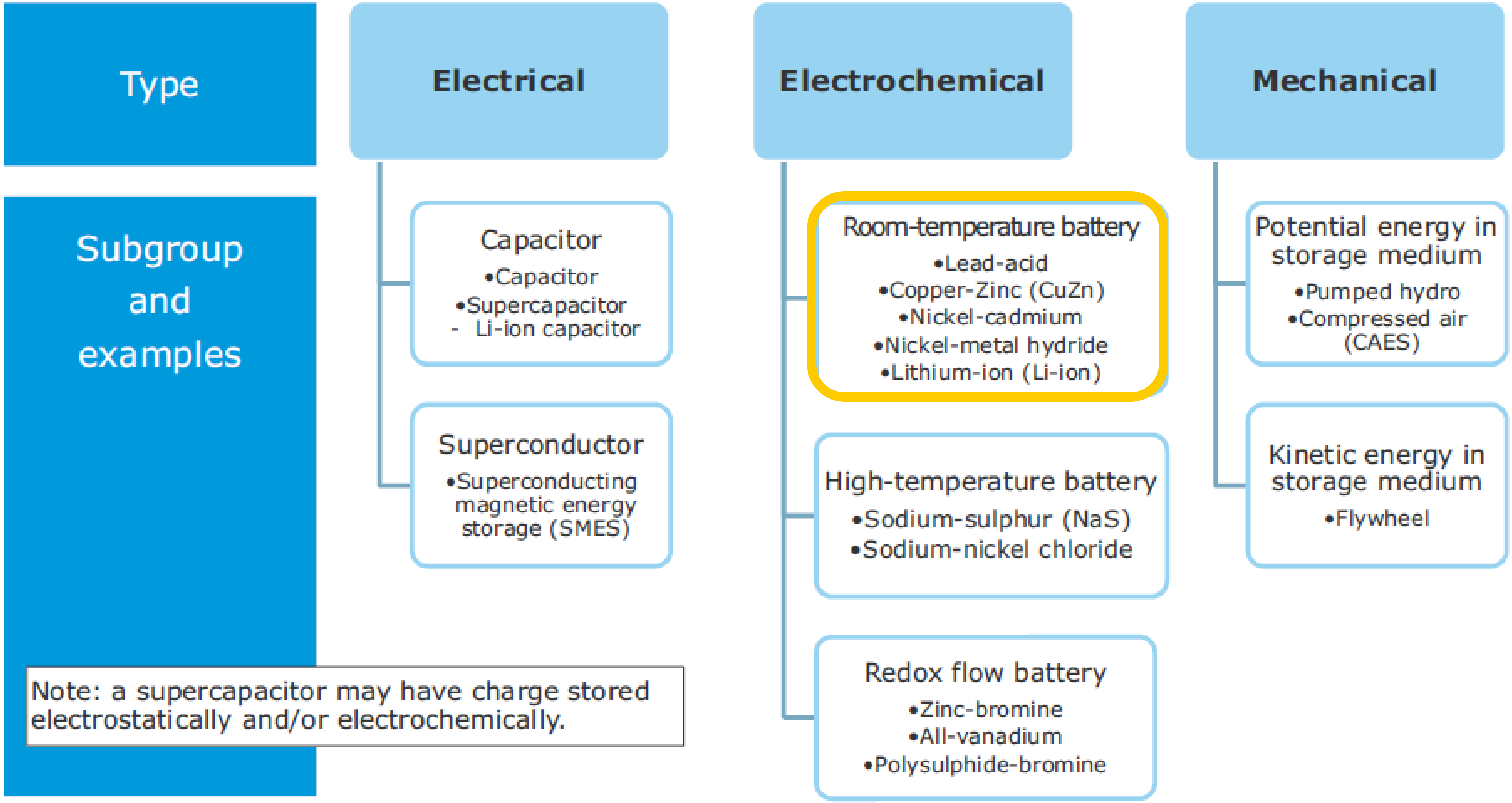


Image: DNV GL - GRIDSTOR

Energy Storage 101: Lithium Ion Cell

18 mm

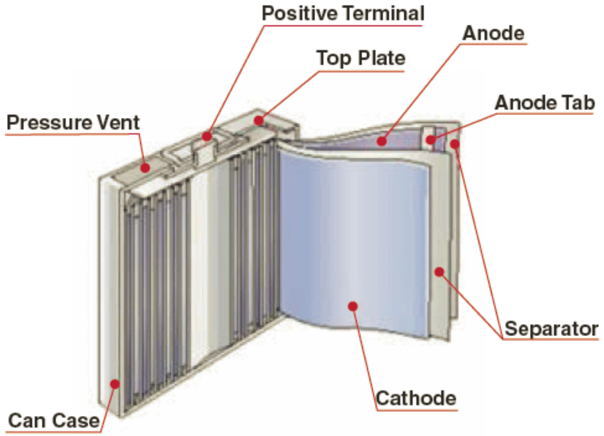
65 mm

Cylindrical

(18650)

Semi-cylindrical

Pouch



Prismatic

1 Ah → 100 Ah

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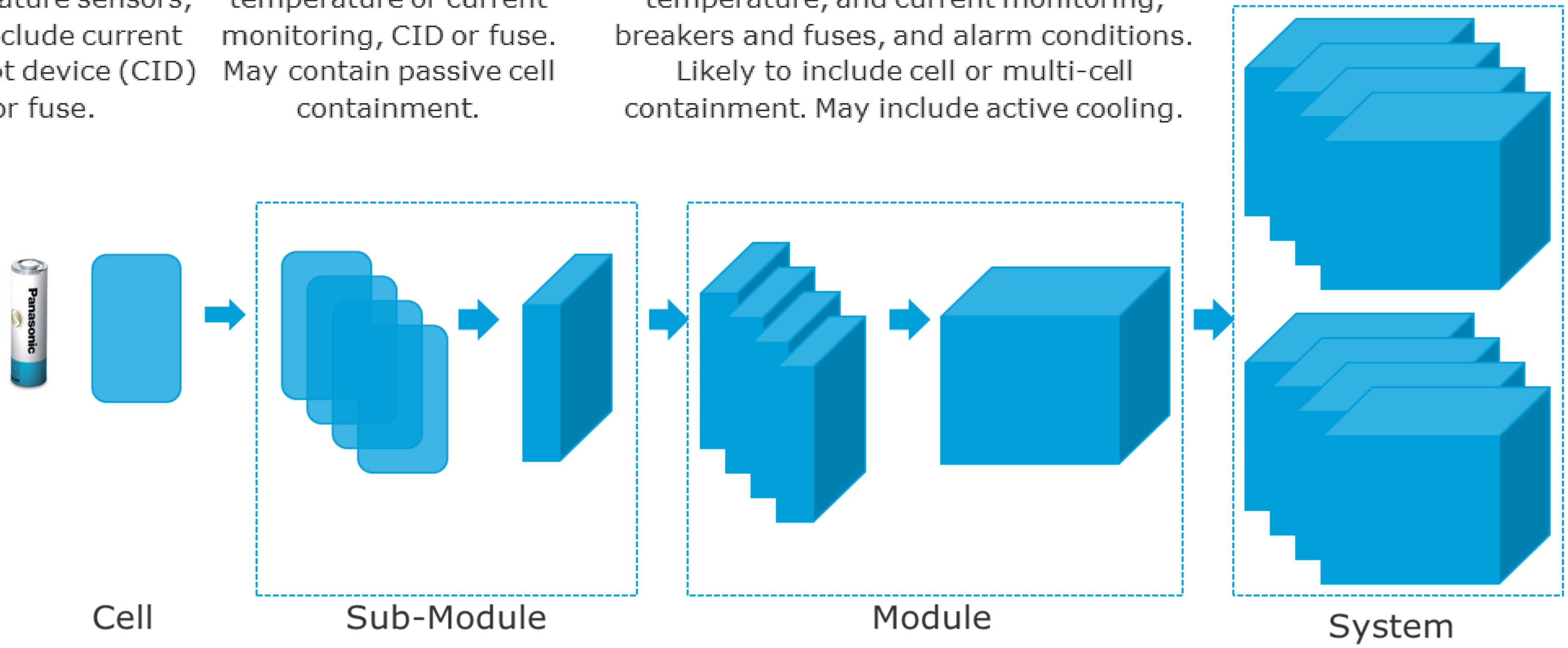
Energy Storage 101: General Battery Architecture

Will include system level BMS, voltage, current, and temperature monitoring at string and system level, mechanical and passive disconnects at string and system level, alarm conditions and intelligent control.

No electronics, may include voltage or temperature sensors, may include current interrupt device (CID) or fuse.

Little electronics, may include voltage or temperature or current monitoring, CID or fuse. May contain passive cell containment.

Sub-battery management system (BMS) or independent BMS. Likely to include voltage, temperature, and current monitoring, breakers and fuses, and alarm conditions. Likely to include cell or multi-cell containment. May include active cooling.



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Energy Storage Technology

Image Credit: Nissan

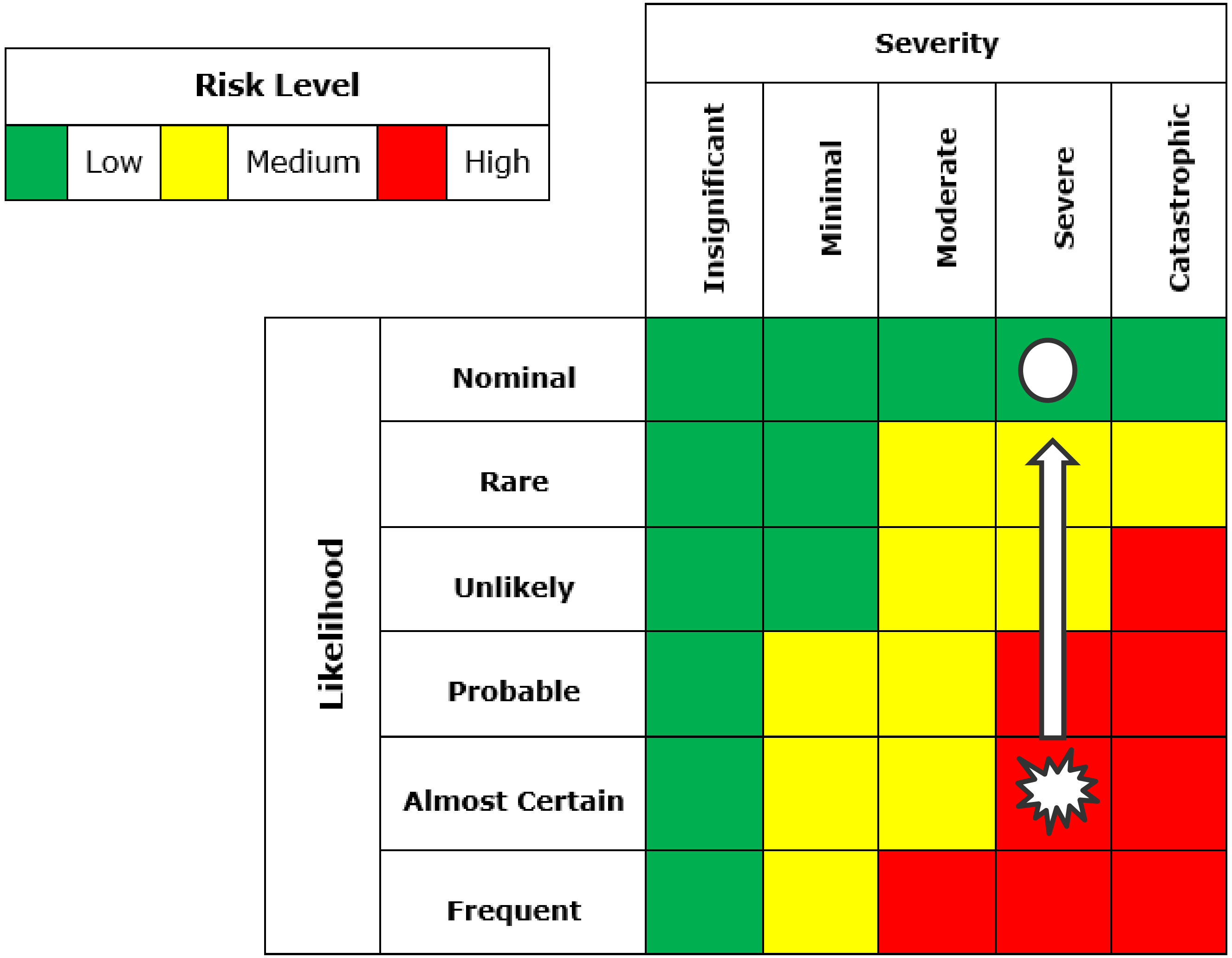
Image Credit: Tesla

Key Storage Design Principles

- Develop for functionality and safety
  - Chemical properties
  - Electrical considerations
  - Mechanical and physical considerations
- Lifecycle phases
  - Design and process planning
  - Manufacturing
  - Transport and warehousing
  - Installation and commissioning
  - Monitoring, operations and maintenance
  - End of life and decommissioning

Understanding risk – and AHJ concerns

- Hazards' impact includes both
  - Consequence
  - Frequency
- Risk is assessed based on all potential hazards
- Once risk is understood, mitigation measures can be put in place to reduce risk



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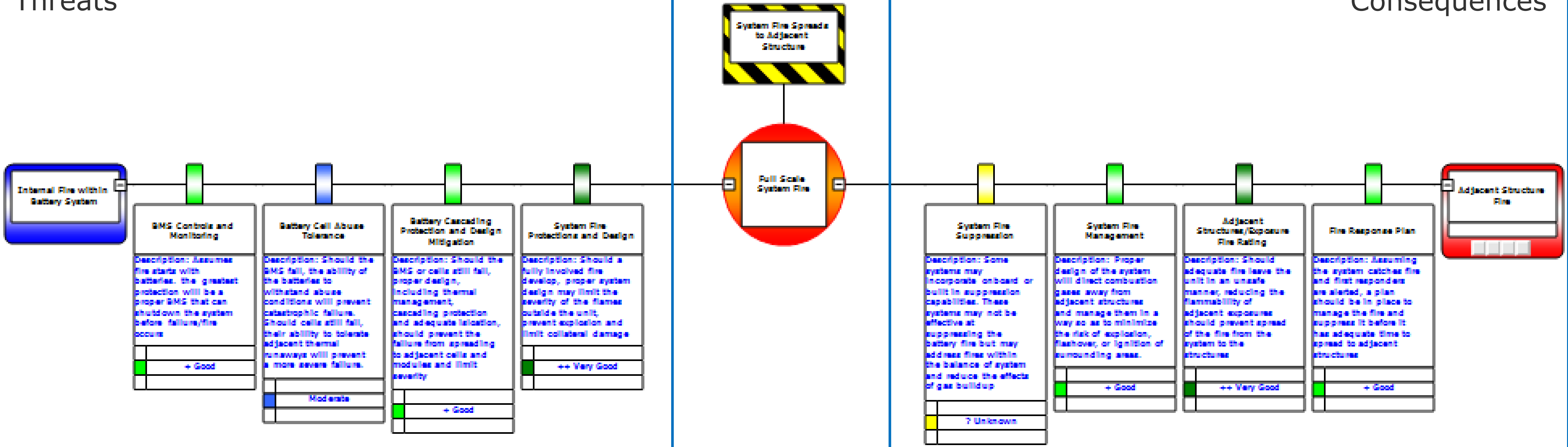
Failure and risk analysis

Threats

Hazard Event

Consequences



Barriers preventing threat inception from reaching “hazard” event

Barriers to mitigate “hazard” event once it has occurred

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Current and Developing Standards

- *There is no single definitive set of standards currently in force for all energy storage systems*
- Current and developing standards:
  - NYC Requirements
  - NEC 2017
  - IFC – 2018 and 2021 (draft)
  - IBC – 2018
  - NFPA 855 (draft)
  - UL body of certification requirements / standards as applicable
  - DNV GL GRIDSTOR Recommended Practices; PQP and destructive testing
  - Standards are being co-opted from other electrical, chemical, and safety standards or are being developed as specific to storage concerns by but not limited to the following groups:
    - ACI, ANSI, ASCE, ASHRAE, ASME, ASTM, DOT, ICC, IEC, IEEE, ISO, NEC, NESC, NEMA, NETA, NISTIR, NRTL, OSHA, and UN.

UL Standards / Testing Requirements

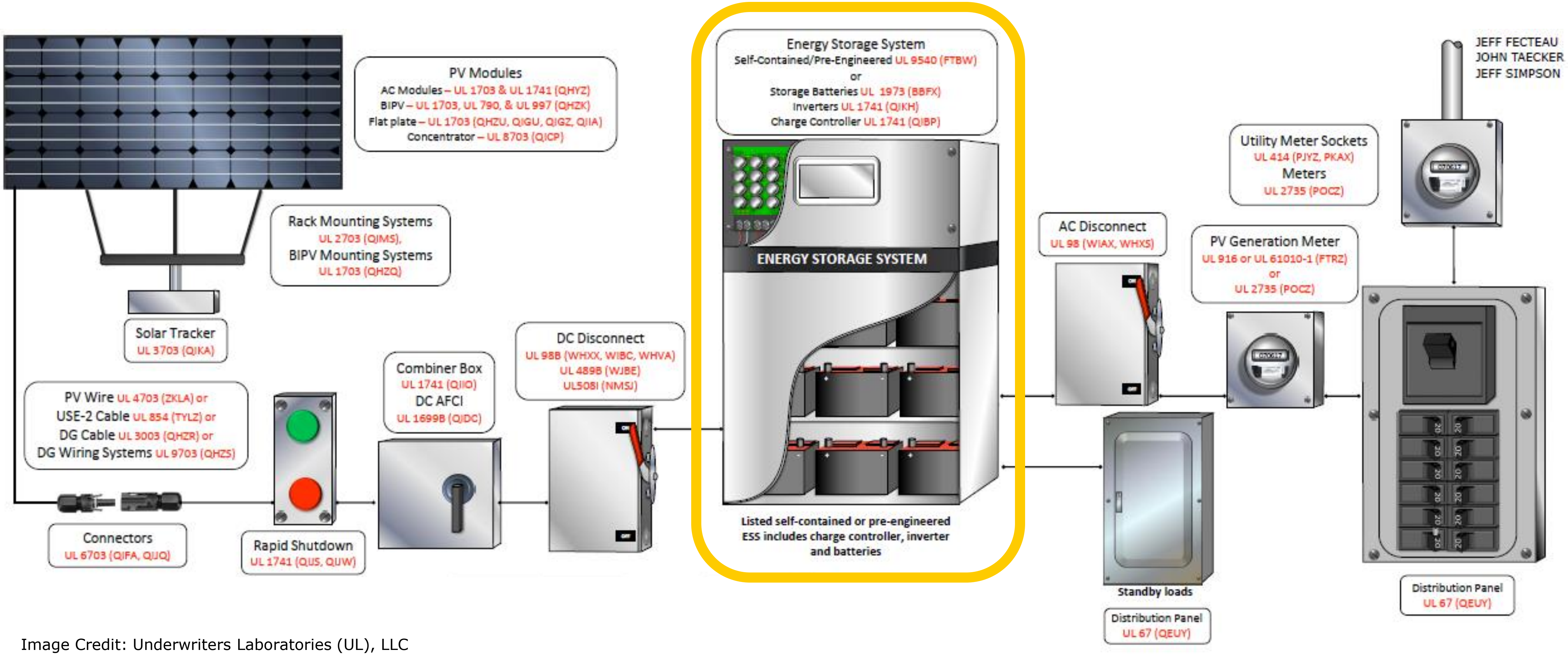

Image Credit: Underwriters Laboratories (UL), LLC

From SPI, "Energy Storage System Installation Codes" presented by J. Fecteau, J.Taecker, J.Simpson

UL Standards / Testing Requirements

- UL 1741, 2nd edition – Standards for Inverters, Converters, Controllers and Interconnection System Equipment for Use with DER
  - Construction verification
  - Protections against injuries to persons
  - Performance, rating, and markings
  - Rapid shutdown equipment and systems
  - Grid support utility interactive inverters and converters

  - Supplement A, Rule 21: Testing for ability to manage a volatile grid, originating from California

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UL Standards / Testing Requirements

- UL 1642, 5th edition - Standard for Lithium Batteries
  - General performance testing and preparation
  - Electrical tests (short circuit, abnormal charge, forced discharge)
  - Mechanical tests (crush, impact, shock, vibration)
  - Environmental tests (heat, temperature, low pressure)
  - Fire exposure test (projectile)
- UL 1973, 2nd edition – Standard for Batteries for Use in Stationary, Vehicle Aux Power, and LER Applications
  - Construction
  - Performance (Deeper dive electrical, mechanical, environmental tests; tolerance to internal cell failure or ‘cascading protections’)
  - Manufacturing

UL Standards / Testing Requirements

- UL 9540, 1st edition – Standard for Energy Storage Systems and Equipment
  - Construction (types, safety analysis, connections, grid interaction, code compliance)
  - Performance
    - Electrical (Normal operations, voltage, grounding, etc)
    - Mechanical (Safety of moving parts, chemical leakage)
    - Environmental (Full container appropriateness for specific locations)
  - Manufacturing and installation specific criteria
- UL 9540a, 3rd edition – Standard for Safety Test Method for Evaluating Thermal Runaway Fire Propagation In Battery Energy Storage Systems ("Large scale testing")
  - Cell, module, and system forced thermal runaway – measure temperature at which venting occurs, composition of gases released, heat flux, and impact on nearby systems
  - Installation level – effectiveness of sprinklers and fire protection

Implications for New York

- The adoption of national or international standards will support streamlining of processes and requirements
  - Move from systems being assessed on a one-off basis by AHJs to a more standardized process
- Current standards provide a baseline - field history and body of test data will expand as more systems are installed
  - The proof will provide more confidence in current standards, or more development and specificity for future standards

Thank you

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