Application of NFPA 855 & Large-Scale Fire Testing to Fire Safety Studies for Grid Scale BESS

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Presentation Structure

1. Part 1 – Battery Energy Storage
2. Part 2 – Assessment Requirements
3. Part 3 – Large-Scale Fire Testing
4. Part 4 – Relevance of Large-Scale Fire Tests

Part 1 – Battery Energy Storage

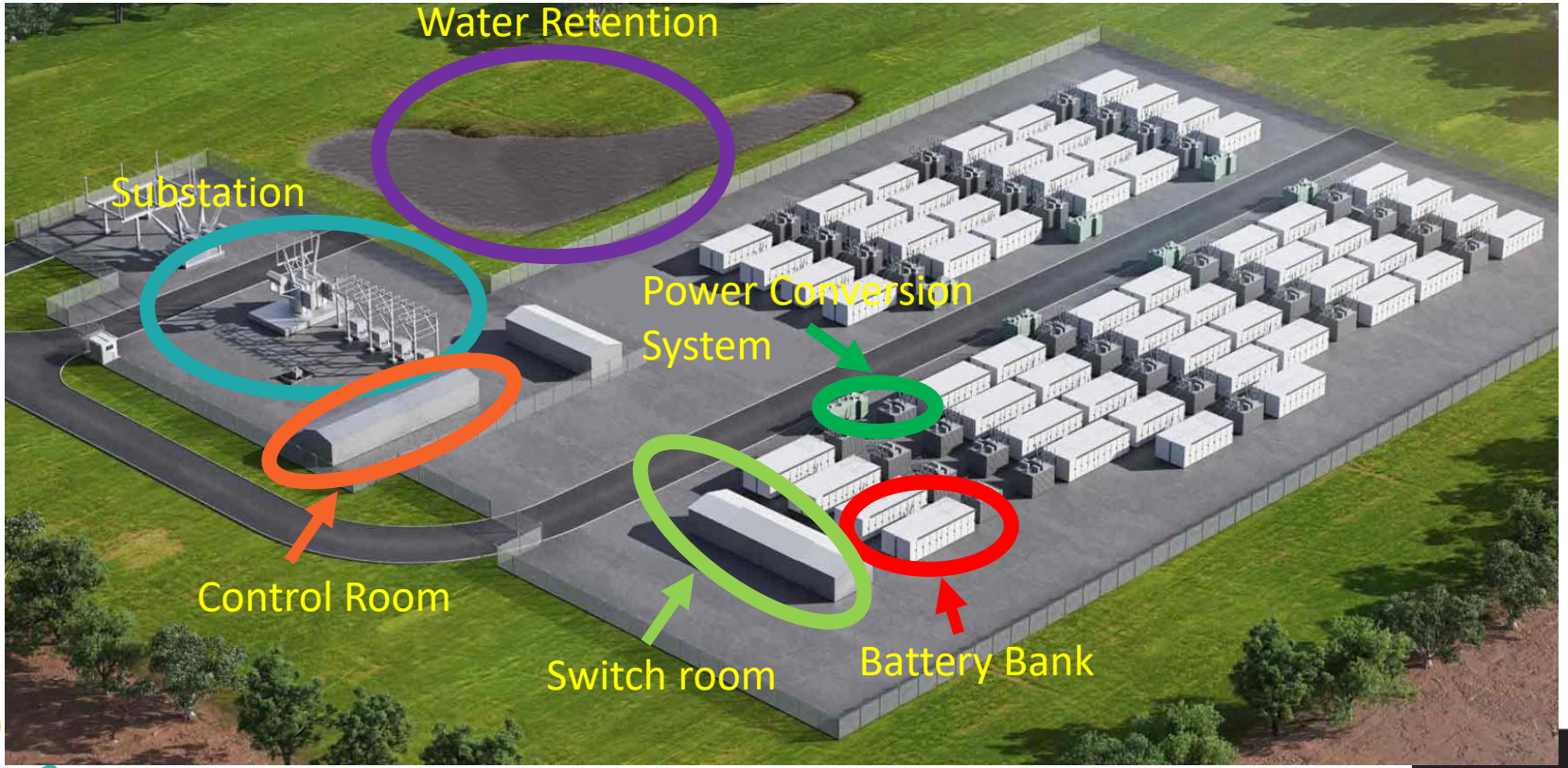
Scale of Battery Energy Storage Systems

- Battery Energy Storage System (BESS) available in a range of sizes and applications:
  - Home battery systems (<100 kWh)
  - Commercial battery systems (<1 MWh)
  - Community batteries or small-scale installations (< 5MWh)
  - Grid Scale (>5 MWh) [1]
    - ✓ Eraring, NSW – 3.18 GWh
    - ✓ Supernode, QLD – 3.096 GWh
    - ✓ Western Downs, QLD – 2.3 GWh
    - ✓ Collie, WA – 2.24 GWh
    - ✓ Richmond Valley, NSW – 2.2 GWh

Grid Scale BESS

- Grid Scale BESS systems characterised by shipping container appearance
- Each container ~ 1 MWh or greater
- Installation typically consist of:
  - Hundreds of BESS containers
  - Power conversion units containing transformers and inverters
  - Large Power Transformers
  - Control and Switch Rooms
  - Administrative Buildings
- Australian NCC generally only applicable to administrative building, switchroom or control room.

Example BESS Site

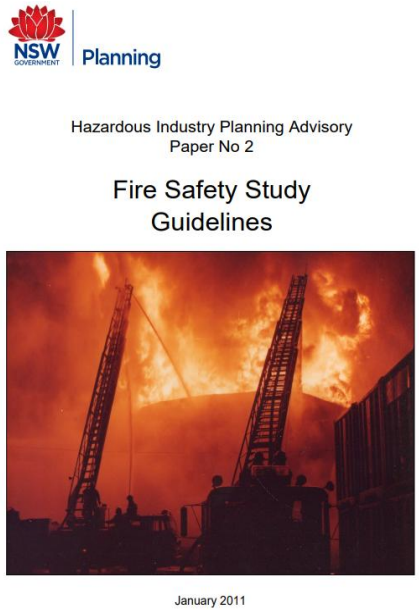


Reference: [2]

Part 2 – Assessment Requirements

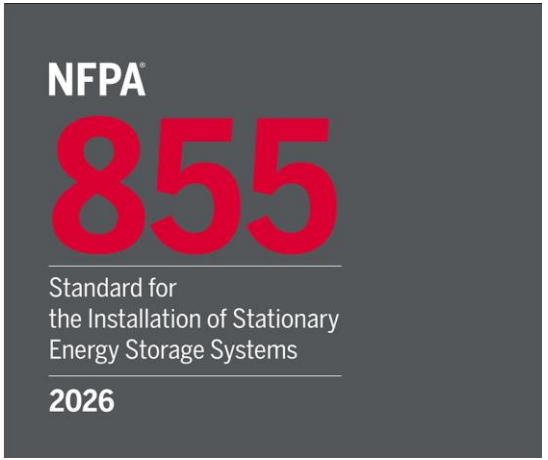
State Specific Requirements

- Each state has its own requirements for assessing BESS installations:
  - Victoria – Driven by planning approval conditions
  - New South Wales – Driven by planning approval conditions
  - Queensland – State Code 27 (Introduced late 2025)
- All of the above examples call for a risk-based assessment beyond the Australian NCC
- Fire Safety Study under NSW Hazardous Industry Planning Advisory Paper (HIPAP 2)
- Other States implementing FSS for BESS installations



Victoria Specific Requirements

- Applicable to BESS > 5 MWh and not a community battery as per FRV Guideline 55
- Comment from FRV requires a Fire Safety Study (FSS)
- FSS to be documented in accordance with HIPAP 2
- FSS required to consider:
  - CFA Renewable Energy Facility Guideline
  - NFPA 855
  - UL 9540
  - FM Global Data Sheet 5-33
- Only applicable if comment from fire commissioner is a requirement of approval



Fire Risk Assessment

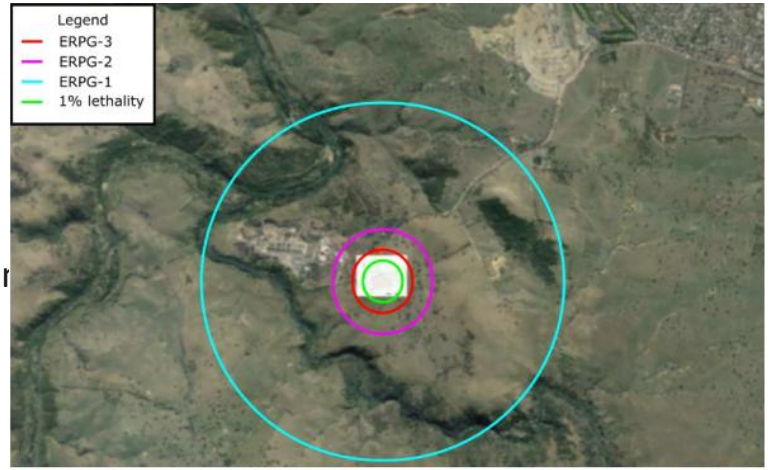
- ISO 31000 risk assessment process
- Qualitative assessment incorporating semi-qualitative assessment.
- Assessment covers all equipment on site including BESS Containers
- Considers consequence and likelihood to determine residual risk.
- Not a purely consequence driven assessment.
- Largely subjective.

Likelihood	Consequence Level				
	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Significant (5)
Almost Certain (E)	1E	2E	3E	4E	5E
Likely (D)	1D	2D	3D	4D	5D
Possible (C)	1C	2C	3C	4C	5C
Unlikely (B)	1B	2B	3B	4B	5B
Rare (A)	1A	2A	3A	4A	5A

Low Risk	Moderate Risk	High Risk	Very High Risk

Fire Safety Study

- Consequence based assessment focused on impact distance and contours
- For a BESS site it assesses:
  - Explosion / over pressure event
  - Thermal radiation
  - Toxic plume and exposure
- Used to inform design of fire safety system including hydrants in relation to:
  - Location
  - Water supply (i.e. simultaneous flow requirements)
  - Redundancy
- NSW use the FSS to develop the Emergency Response Plan (ERP) and Emergency Services Intervention Package (ESIP) for the site.



Part 3 – Large Scale Fire Testing

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BESS Fire – Victoria Big Battery, Australia (30 July 2021)

BESS Fire – Escondido, USA (5 September 2024)

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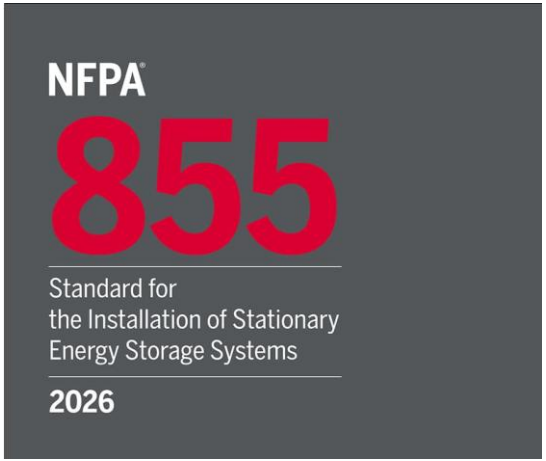
NFPA 855:2026

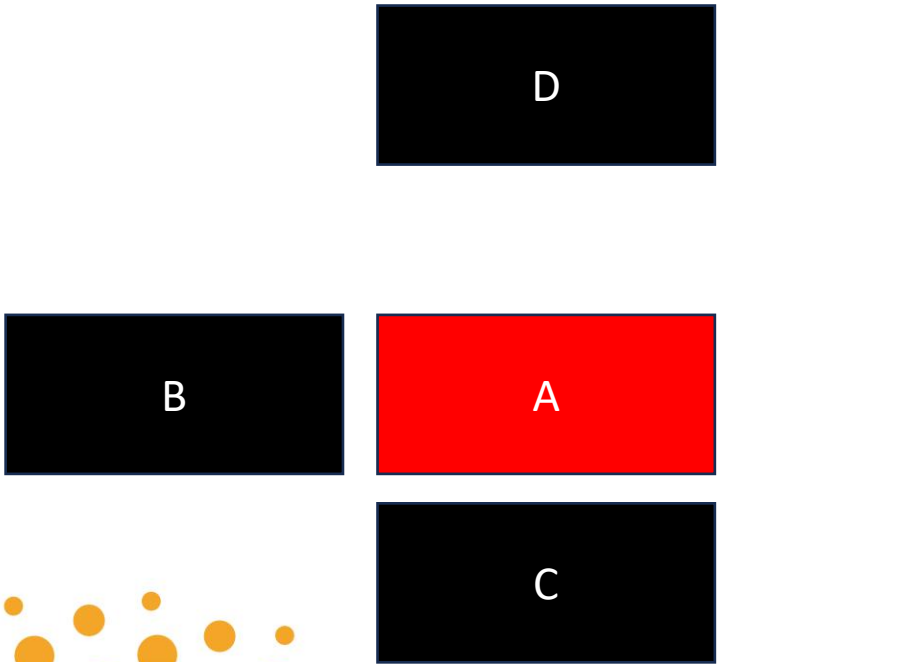
- NFPA 855:2026 – Clause 9.2 – Testing to be conducted to UL 9540A for:
  - Cell level testing; and
  - Module level testing
  - Unit level – required if flammable gas present in cell or module level tests
- Large-scale fire tests required in addition
- Unit level test does not equal Large-scale test
- Cell Level – determine the gases produced
- Module Level – determine the spread of fire within
- Large-scale – determine spread of fire between BESS containers



Types of Battery Testing

Reference: [3]

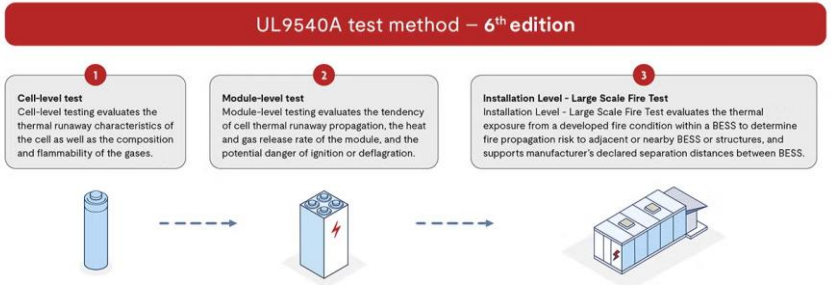
What is a Large-Scale Fire Test?



Container A to Target	Common Distances
Aisle Spacing (A to D)	3 – 4 m
Face to Face (A to C)	50 – 300 mm
End to End (A to B)	50 – 300 mm
Container to Wall	3 m

UL 9540A & CSA/ANSI C800 Testing

- Large-scale tests require Engineering Judgment
- Considerations:
  - Container contents
  - Ventilation condition
  - Active fire systems
  - State of charge
  - Environmental conditions
- Not one size fits all
- Aim – validate as the worst credible scenario

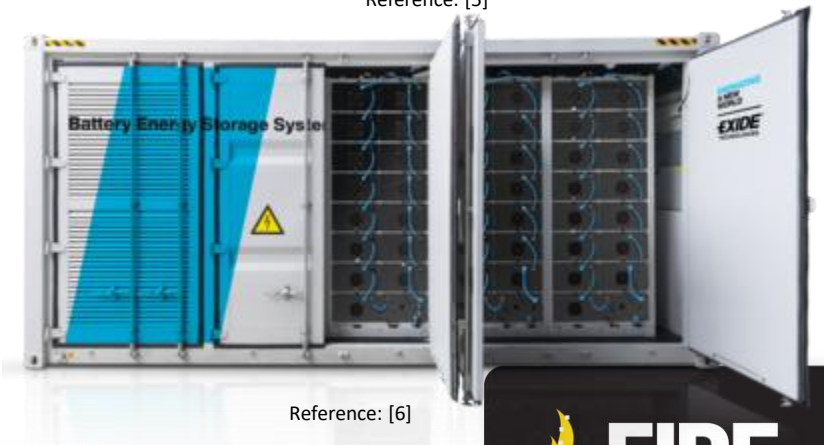


Reference: [4]

Module Population

- ANSI/CSA C800 – *"Adjacent units shall have at least one live battery module located in the most likely area to be affected by a large fire"*
- UL 9540A – *"Target enclosure may be provided empty, partially populated, or fully populated with modules"*
- Placement of sensory equipment is reliant on Engineering Judgment.
- Enclosure of origin – Fully populated

Reference: [5]



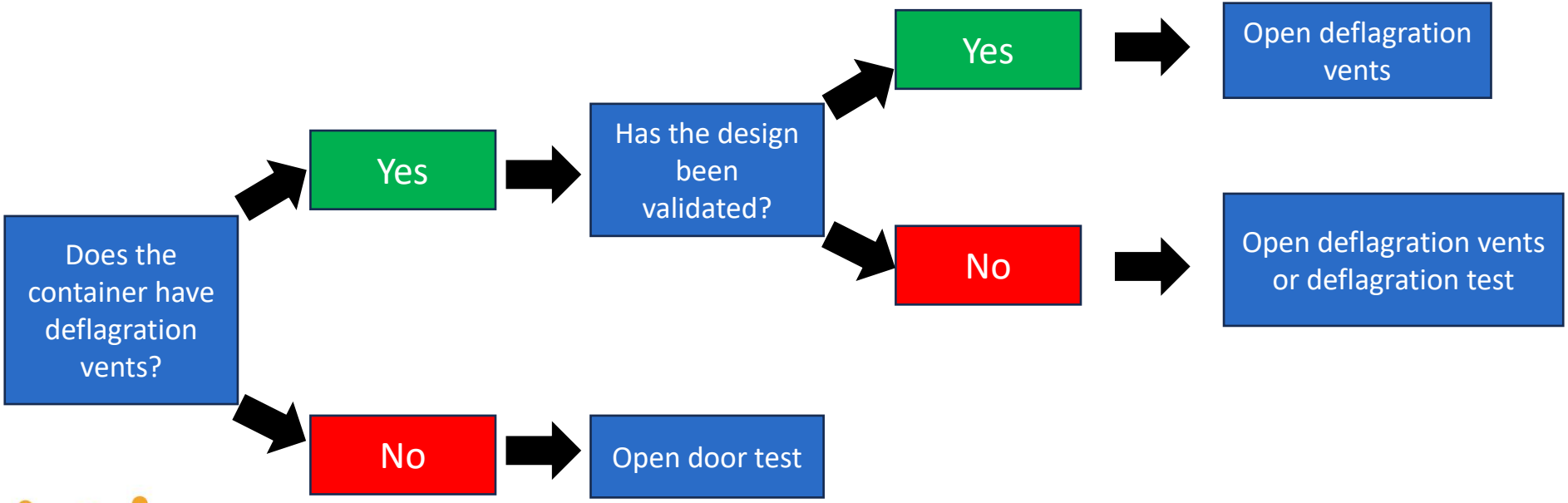
Reference: [6]

Ventilation Conditions

- ANSI/CSA C800 – Passive deflagration vents to remain open for initiating enclosure and closed in target.
- UL 9540A – Allows for four options:
  - Deflagration vents open
  - Open inlet and outlet of NFPA 69 system
  - Doors Open (one or more)
  - Deflagration test – determine best test conditions

Reference: [7]

Ventilation Decision Pathway



Fire System Requirements

Test	Fire Detection	NFPA 69	Suppression or Extinguishing agent	Battery Management System (BMS)	Thermal Management System (TMS)	Thermal Runaway Propagation (TRPP)
CSA/ANSI C800	On and active during test	-	Off or unpowered	On in the container of fire origin only for data recording and to determine loss of communication	-	Off
UL 9540A	-	Not required to be active in any of the containers	-	-	Not required to be active in any container	Off in fire affected container. Can be active in target container if UL 9540 compliant

- Not addressed by the standard

Ambient Test Conditions

- Tests largely driven by engineering judgment.
- Results are dependent on how the testing apparatus is arranged.
- Example – SOC drastically changes the composition of the off gas produced.
- What ambient temperature is utilized?
- What humidity?
- Should wind be considered?

Test	Temperature	Humidity	Wind
CSA/ANSI C800	10°C - 40°C	<90%	<6 mph (~9.5 km/h)
UL 9540A	>0°C	<90%	<12 mph (~19 km/h)

Part 4 – Relevance of Large-Scale Fire Testing

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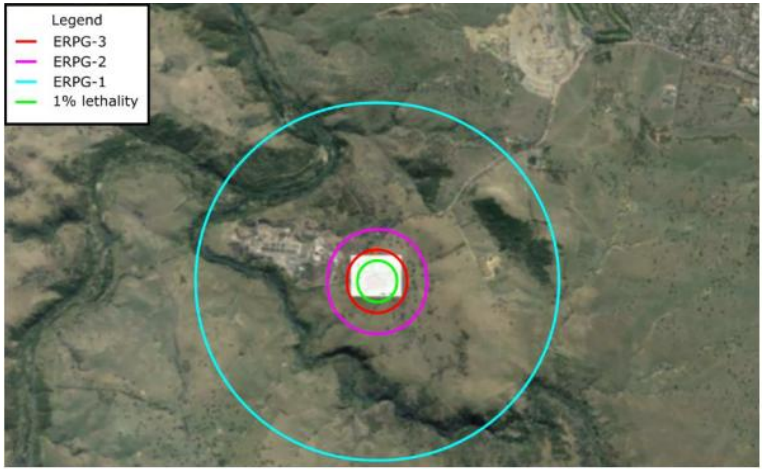
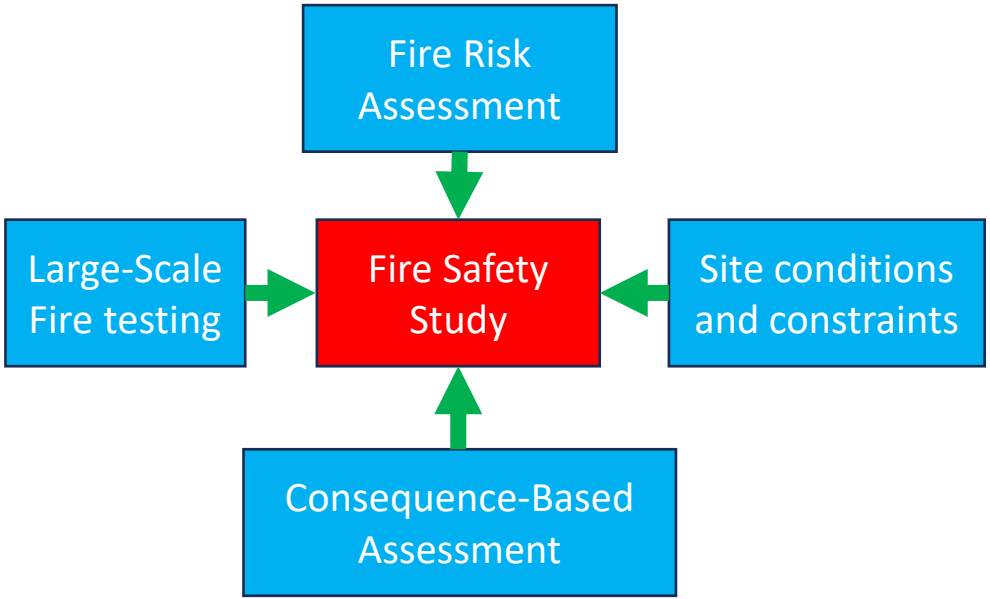
Importance of Large-Scale Fire Tests

- Large-scale fire tests are a critical part of understanding fire behavior
- Validation of modelling results
- Critical in undertaking consequence assessments.
- QLD, VIC and NSW fire brigades expect to see data.
- Becoming standard in industry
- NFPA 855:2026 requires that:
  - Tests are undertaken or witnessed by an Approved Testing Authority.
  - Test reports are accompanied by supplementary report by Fire Engineer.



Summary



- Conventional fire have decades of fire test data
- Lithium-ion batteries evolving risk
- Large-scale fire tests required to understand fire behavior
- Fire Safety study requires consideration of:
  - Fire Risk Assessment
  - Large Scale Fire Testing
  - Consequence Based Assessment
  - Site conditions and constraints
- Engineering Judgement required when undertaking large-scale fire tests

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Thank you

- Christopher Koch
- Lote Consulting – Fire | Security
- www.loteconsulting.com

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