Emerging Hazards - Lithium Ion Batteries

AFAC 2022

24th August 2022

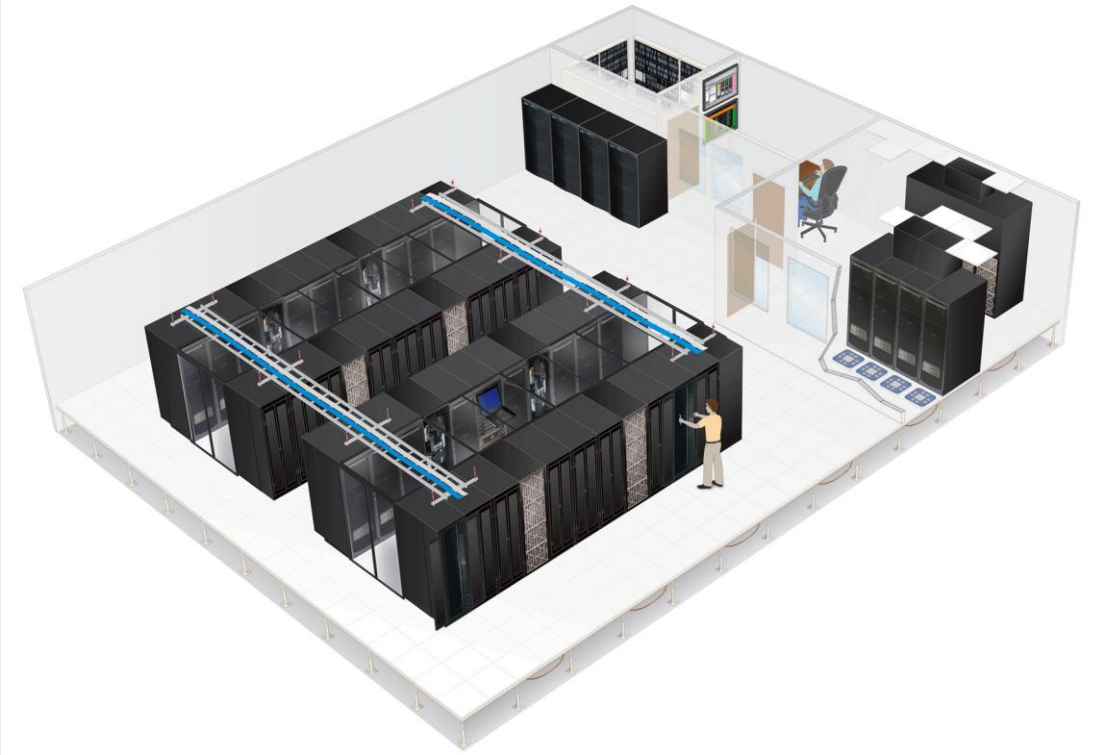
Dr Amer Magrabi & Christopher Koch

Lote Consulting – Fire | Risk | Security

www.loteconsulting.com

LiB Presentation Outline

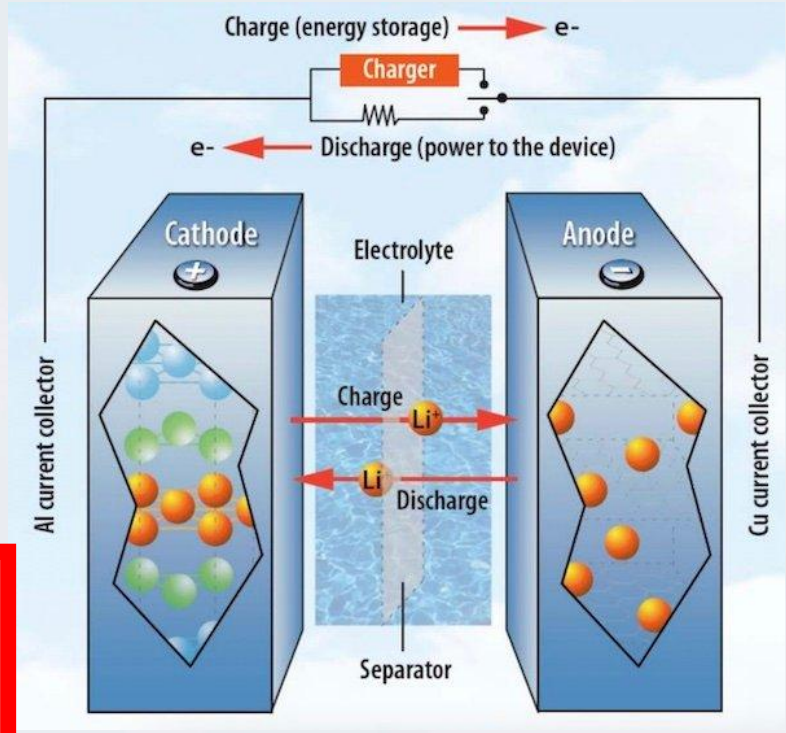
- Part 1 – LiB Background
- Part 2 – BESS Applications
- Part 3 – Codes & Standards
- Part 4 – Fire Strategy for BESS Installations



Part 1 – Lithium Battery Background

Why Lithium Ion Batteries (LiBs)?

- High energy density
- Low self-discharge compared to other batteries
- Low maintenance
- Major uses:
  - Laptops and small electronics
  - Cars
  - Data Centres – Uninterrupted Power Supply (UPS)
  - Battery Energy Storage Systems (BESS)

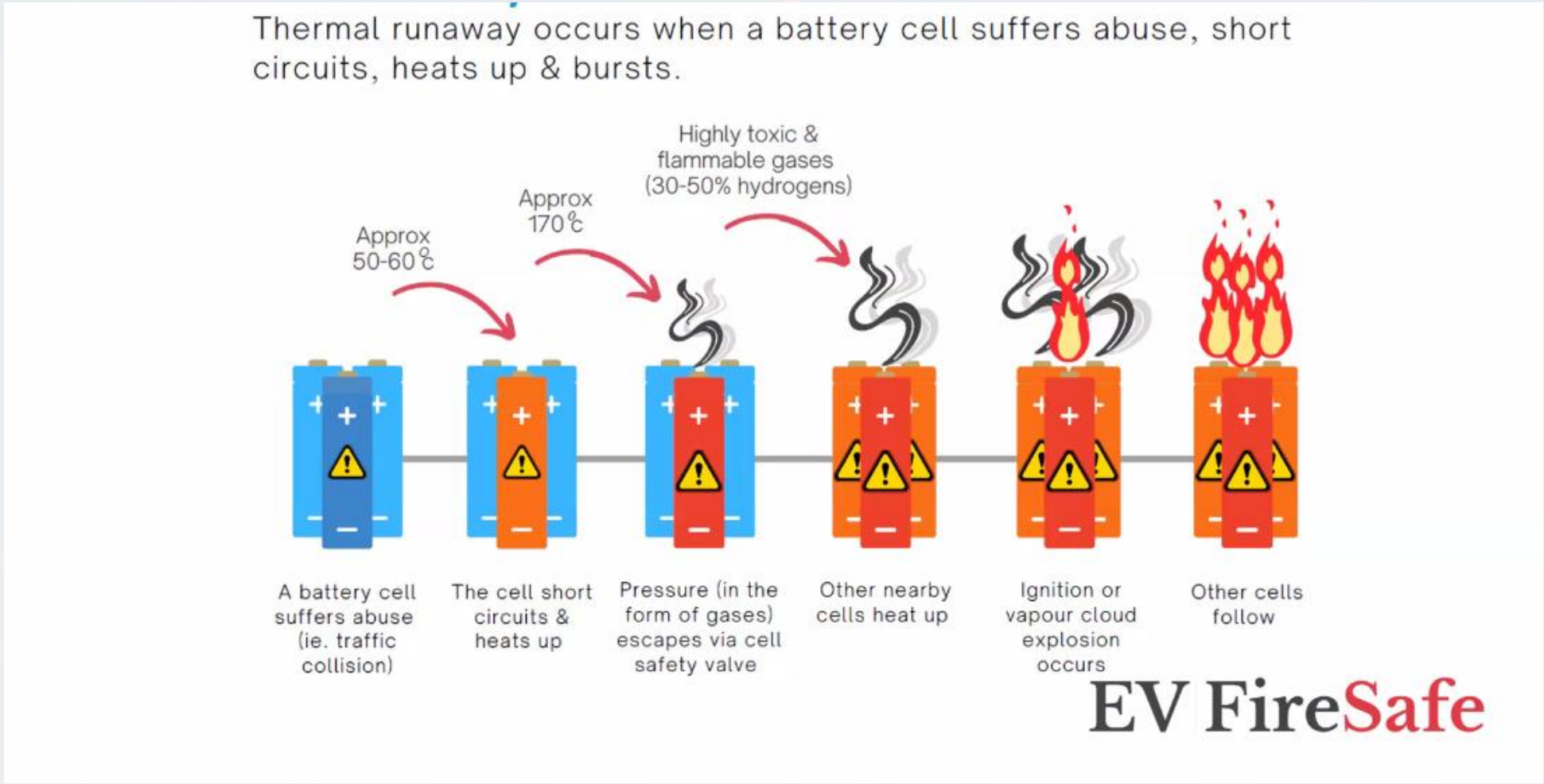


LiB Failure Modes

- LiBs can fail due to a short circuit or overcharge which leads to thermal runaway.
- High temperature leads to the decomposition of elements within the cell via an exothermic reaction.
- Decomposition forms part of a self-sustaining cycle that continues until the battery ruptures.
- Liquid electrolyte combusts when exposed to oxygen.

Ref: https://ifpmag.mdmpublishing.com/putting-in-place-fire-protection-measures-for-lithium-ion-battery-energy-storage-systems/

Thermal Runaway



Ref: www.evfiresafe.com

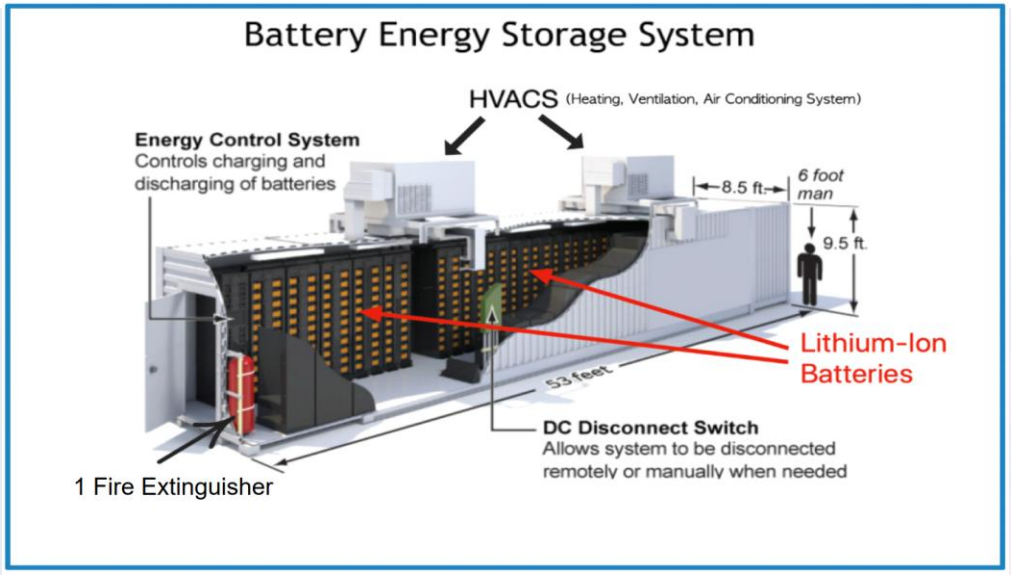
Part 2 – BESS Applications What's Special

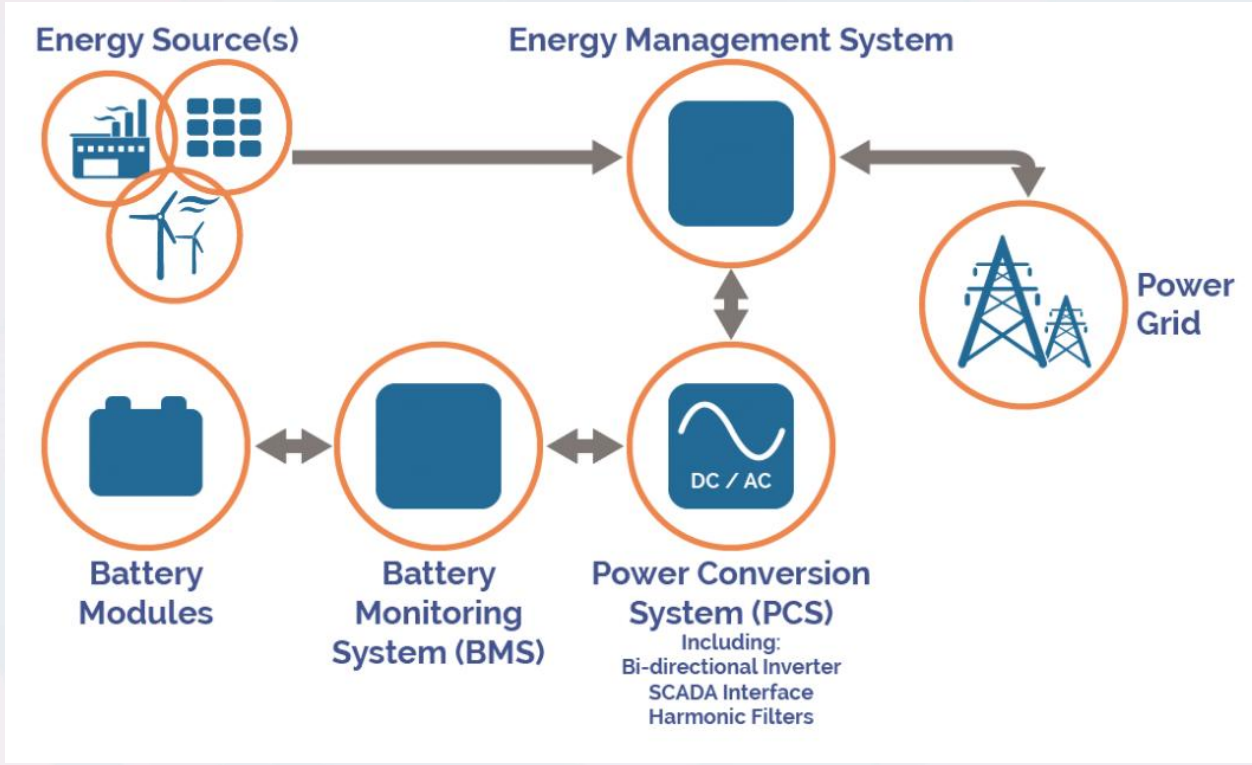
BESS Applications

External Use in a Power-Grid

Internal Use in a Data-Centre

BESS Components





Ref: https://www.innoliaenergy.com/products/energy-storage-systems/

Current State of Play

Ref: https://reneweconomy.com.au/reneweconomy-unveils-big-battery-storage-map-of-australia/

Special Hazards & Thermal Runaway

- LiBs are considered a special hazard due to the BESS and UPS system configuration as it provides both heat and fuel for a fire.
- USP /BESS racks and the battery casing also contain a lot of plastics which fuel the fire.
- LiB fires are generally shielded by the elements around it.
- Re-ignition can occur as the heat from the centre of the battery builds and reaches the ignition point as the inner portions are shielded from cooling water.
- Some possible by-products produced from the release of LiBs include:
  - Phosphoric acid and Hydrofluoric acid when mixed with water;
  - Hydrogen Fluoride gas, etc.
- LiBs are currently considered an unknown hazard as they are a new and emerging technology with less test data than systems that have been around longer.

Part 3 – Codes & Standards

Current State of Play

- Project Scale often triggers an EIS where LiBs are identified as a fire hazard with off-site impacts that need to be addressed at the Planning Phase
- Recent Australian fire incidents involving BESS installations:
  - Geelong, VIC - 30 July 2021
  - Bohle Plains, QLD – 7 April 2021
  - Brisbane, QLD – 17 March 2020

Ref: https://storagewiki.epri.com/index.php/BESS_Failure_Event_Database

Codes and Standards

- AS 1940:2017
- NCC 2022
- AS 5139:2019
- AS 2118.1:2017
- NFPA 855
- FM Global

National Construction Code (NCC) 2022 - 1

- NCC introduced the term ‘battery system’ as part of the 2019 release.
- NCC defines a ‘battery system’ as:

  “One or more chemical cells connected in series, parallel or a combination of the two for the purpose of electrical energy storage.”
- NCC introduced a requirement for battery systems with a voltage greater than 12 volts or greater than 200 kWh storage capacity to be fire separated.
- The fire separation must be equivalent to that of the building classification but not less than 120/120/120 FRL.

National Construction Code (NCC) 2022 - 2

C3D13 Separation of equipment

[2019: C2.12]

(1) Equipment other than that described in (2) and (3) must be separated from the remainder of the building with construction complying with (4), if that equipment comprises—

(a) lift motors and lift control panels; or

(b) emergency generators used to sustain emergency equipment operating in the emergency mode; or

(c) central smoke control plant; or

(d) *boilers*; or

(e) a *battery system* installed in the building that has a total voltage of 12 volts or more and a storage capacity of 200 kWh or more.

(2) Equipment need not be separated in accordance with (1) if the equipment comprises—

(a) smoke control exhaust fans located in the air stream which are constructed for high temperature operation in accordance with Specification 21; or

(b) stair pressurising equipment installed in compliance with the relevant provisions of AS 1668.1; or

(c) a lift installation without a machine-room; or

(d) equipment otherwise adequately separated from the remainder of the building.

(3) Separation of on-site fire pumps must comply with the requirements of AS 2419.1.

(4) Separating construction must have—

(a) except as provided by (b)—

(i) an FRL as *required* by Specification 5, but not less than 120/120/120; and

(ii) any doorway protected with a *self-closing* fire door having an FRL of not less than –/120/30; or

(b) when separating a lift *shaft* and lift motor room, an FRL not less than 120/–/–.

National Construction Code (NCC) 2022 - 3

- LiBs are also indirectly called up in the NCC under Clause E1D17 and E2D21 'Provisions for Special Hazards'
- This clause requires consideration to additional measures not strictly specified by the BCA to be considered where a hazard presents a special problem for fire fighting.

E1D17 Provision for special hazards

[2019: E1.10]

Suitable additional provision must be made if special problems of fighting fire could arise because of—

(a) the nature or quantity of materials stored, displayed or used in a building or on the allotment; or

(b) the location of the building in relation to a water supply for fire-fighting purposes.

E2D21 Provision for special hazards

[2019: E2.3]

Additional smoke hazard management measures may be necessary due to the—

(a) special characteristics of the building; or

(b) special function or use of the building; or

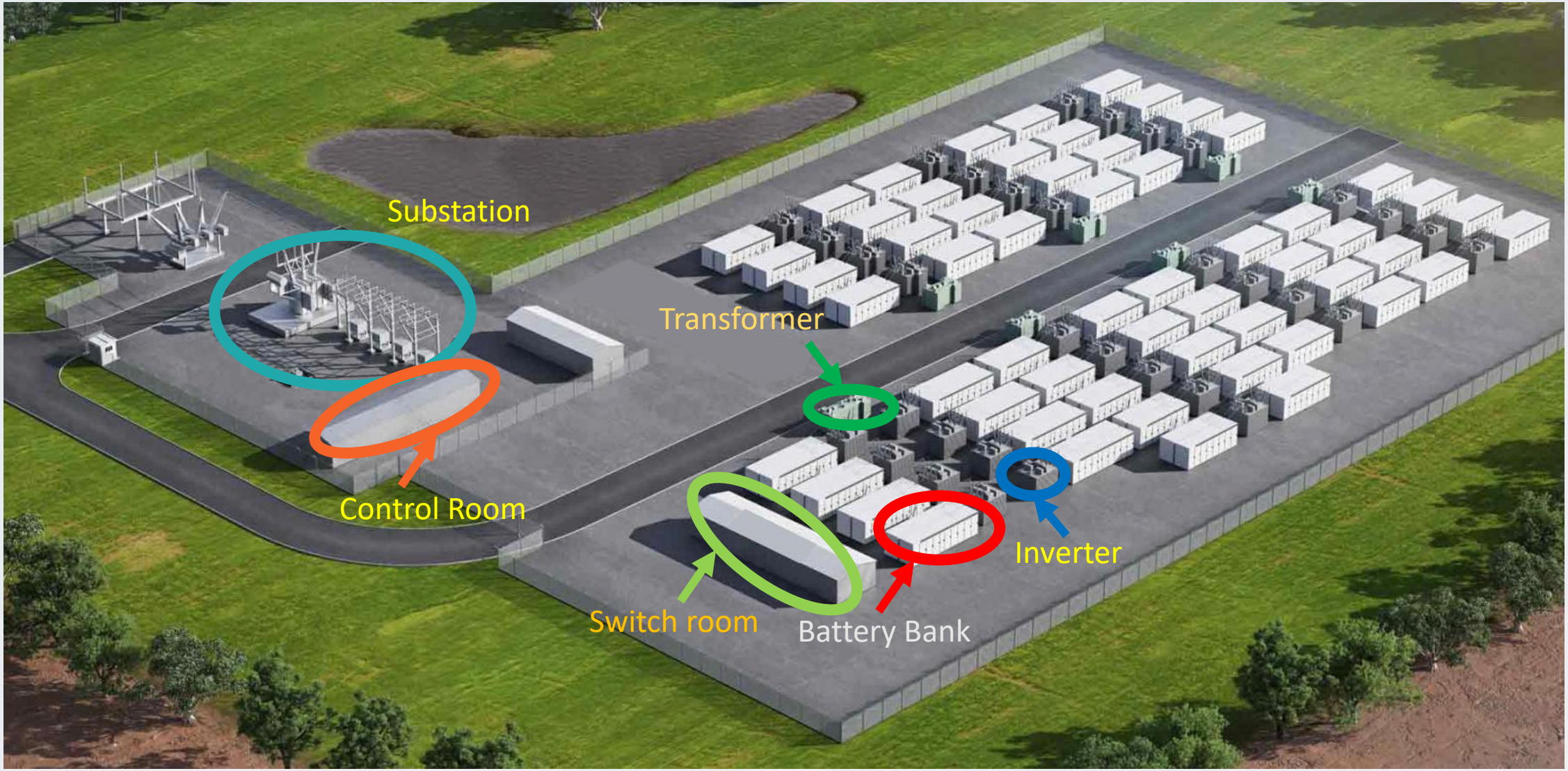
(c) special type or quantity of materials stored, displayed or used in a building; or

(d) special mix of classifications within a building or *fire compartment*,

which are not addressed in E2D4 to E2D20.

Part 4 – Case Study BESS Site

Case Study

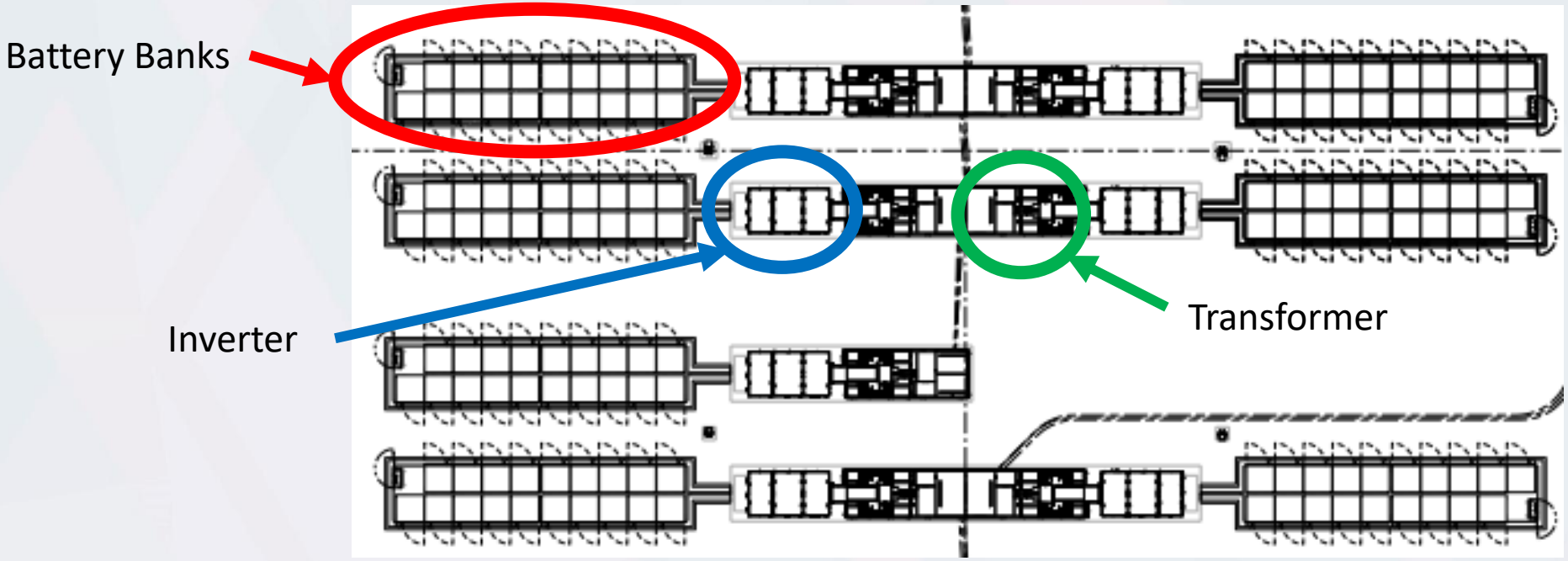

Substation
Control Room
Transformer
Switch room
Battery Bank
Inverter

Fire Strategy Development

1. Holistic approach site wide and building specific design
   - Fire, explosion overpressure, deflagration
   - Battery specification
   - NCC Clause C3D4, C3D5 - Separation of Equipment, E1D2-Fire Hydrants, E1D4-Smoke Detection, Special Hazard Clauses - E1D17-Fire Suppression and E2D21-Smoke Management
   - Design drivers other than compliance including business continuity
   - Risk assessment workshop with project stakeholders
2. Off site impacts on the surrounding area
   - Plume modelling
   - Fire water retention and potential environmental impact
3. Fire Services
   - Built in fire suppression / detection
   - External fire suppression
   - Fire brigade intervention

Site Layout & Equipment Spacing

- Site layout and battery spacing is a major factor to consider during design
- Fire spread and explosion impacts on surrounding equipment is likely during thermal runaway



Matters to Ponder

- Emerging hazards not adequately covered by existing standards
- Beware of NCC Special Hazard Provisions E1D17 , E2D21 and Fire Brigade Intervention
- A risk based fire performance engineering is recommended
- Holistic approach considering site wide and individual building matters
- Objectives other than compliance e.g. Business continuity
- Relevant project stakeholders
  - Registered Fire Safety Engineer
  - Fire Protection Designer
  - Hydraulics & Storm Water Engineer
  - Electrical Engineer
  - Building Certifier
  - Regulatory Authorities – Fire Brigades, Safe Work, Planning, etc
  - Local Consent Authorities – Council
  - Insurers

Thank You.

- Dr Amer Magrabi & Christopher Koch
- Lote Consulting – Fire I Risk I Security
  - Ph: 1300 761 744
  - www.loteconsulting.com
  - info@loteconsulting.com