

Battery Energy Storage Systems

Operational hazards



Image credit: FireTech-HCT, India

Fire

Explosion

Harmful
chemicals

Toxic gas
emissions

Electric shock

Arc flash

- Heat, noise and EM flash

Movement
and handling
of materials

Specific site considerations

- Arc flash
- Limited operational life, <10 years
- Future proofing and resilience
- Detection and monitoring
- Electrical interfaces and network connections
- Back-up supplies



Fundamentally it is about public safety

- Identification of hazards
- Impact on surrounding communities
- Location of infrastructure in a way that does not put at extreme risk emergency responders
- Safe access and withdrawal from around the facility



Pulse Clean Energy, Hyde, Stockport



50MW

132 kV, <1 sec

Connected to 110,000 homes

1 hour duration

Pulse Clean Energy, Hyde. Gtr. Manchester

Typical 'dimensions'

- 6.25MWh. Many sizes are available
- Lithium Iron Phosphate (LiFePO_4) cells: 3.2V / 587Ah
- IP54 ingress protection rating
- Liquid cooled
- Mass: 36 tonnes
- Format: 20ft 'ISO' container



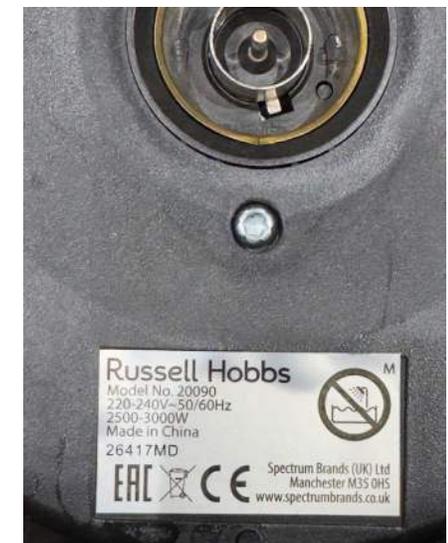
Image credit: © HighJoule Group

Size, capacity, units

- A household consumes 30kWhr of electricity per day ...
- Say: 1.25 kW/hr (1.25 Units)
- Price: 26.5p / unit
- Making a brew ... 1.0l water, 2.5 kW kettle: 114 sec. Say 2 min
- 2 units/hr = 53p x 2/60 = 1.76p
- Say 2p to make a brew!
- Thanks Constantine



Quantity	Dimensions	SI Unit	Comment
Energy	ML^2T^{-2}	Joule (J)	$KE = \frac{1}{2}MV^2$ $KE = mgh$ The capacity for doing work
Work	ML^2T^{-2}	Joule (J)	A measure of the transfer of energy
Force	MLT^{-2}	Newton (N)	Mass.acceleration
Power	ML^2T^{-3}	Watt (W)	$P = \text{Work}/\text{unit time}$ 1 Joule per second Often kW, MW, GW or TW
A unit of electricity	$ML^2T^{-3} \times T$ $= ML^2T^{-2}$	kWhr	A quantity of energy, used for billing the use of Power



Electrical bad boys

- Anything that heats or moves, except 2 slice toasters
- Don't do washing and ironing or charge your BEV
- Anything with a motor, pump or fan
- Sit indoors, Eat toast, Drink tea, play games on the laptop, straighten hair (60W), listen to the radio (15W) or read the paper (5W LED bulb) by a desk lamp

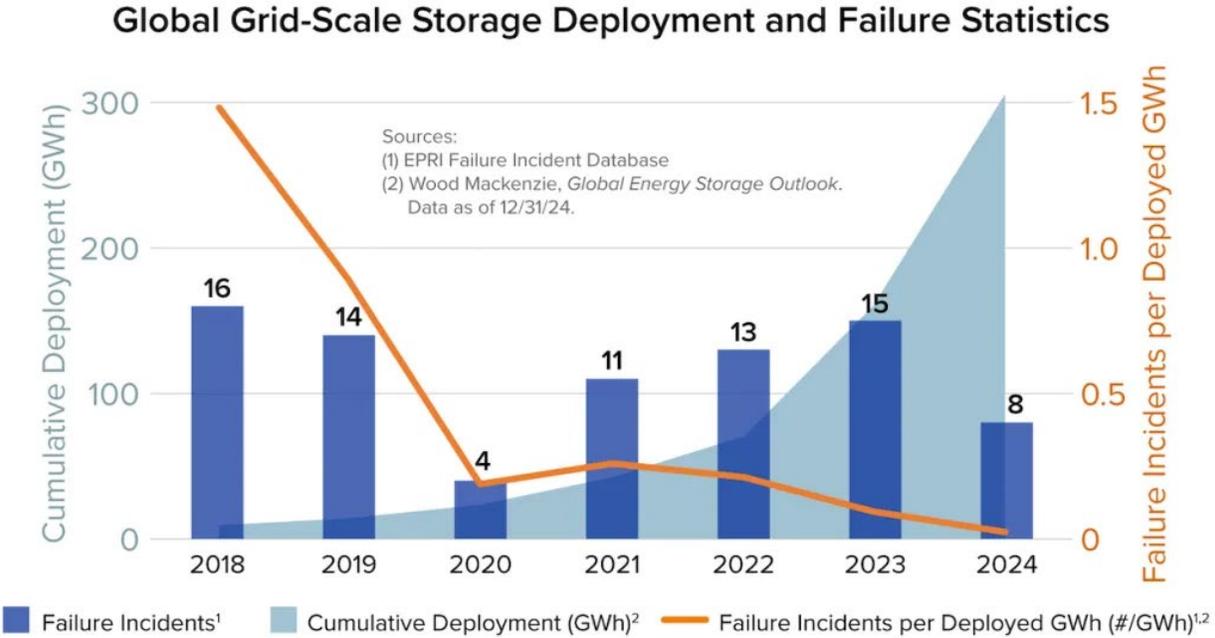
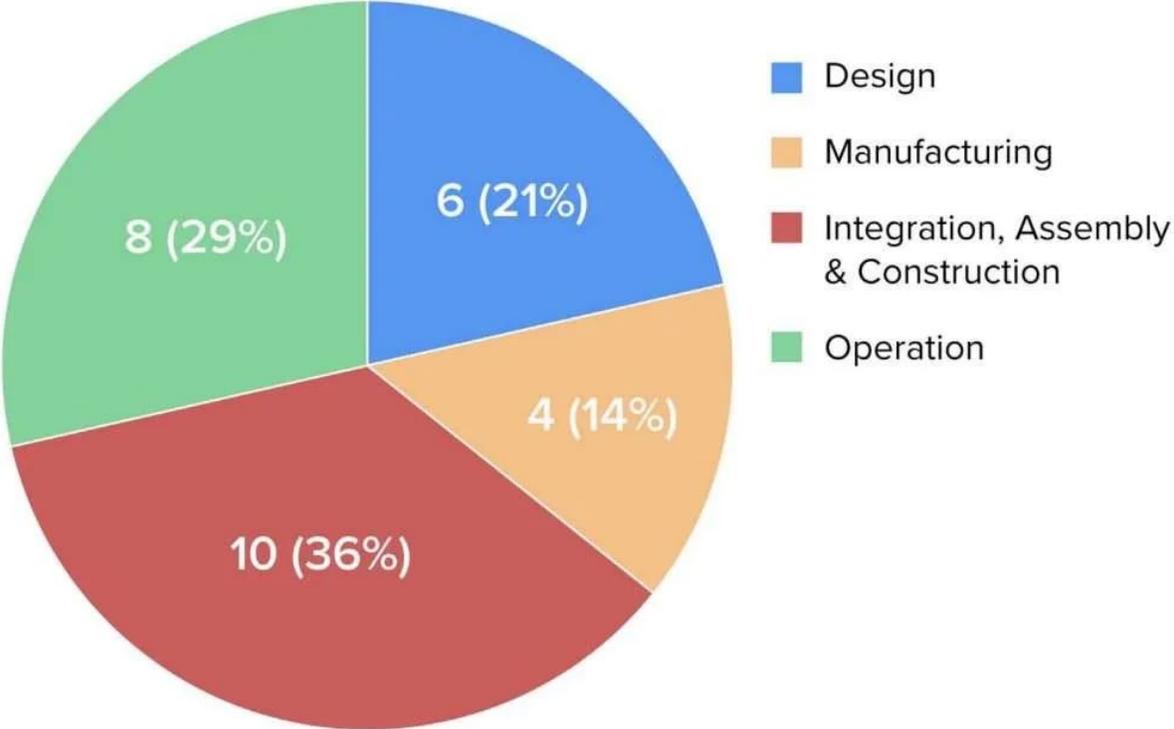
DEVICE	A	W	NOTES
Microwave oven	6.5	1500	Standard microwave oven
Vacuum cleaner	7.0	1600	Pre 2017, 1.6kW. Pre 2014 2kW, >2017 900W
Toaster (4 Slice)	9.0	2000	900W for a 'two-slice' toaster
Portable air conditioner	<9.3	<2000	Typically, 900-2000W. The higher the BTUs / kW, the higher the power
Hair dryer	10.0	2200	Use a towel or buy a Caterham
Washing machine	10.0	2200	Avoid
Dishwasher	10.0	2200	Avoid
Tumble dryer	11.0	2500	Avoid
Air Fryer	<11.0	<2600	Single drawer versions tend to be around 1500W whilst twin drawer versions are closer to 2600W
Kettle	<13.0	<3000	Typically, 2200 – 3000W
Radiator / Fan Heater	<13.0	<3000	Typically, 2000 – 3000W
Iron	13.0	3000	Don't bother
Single oven	13.0	3000	Eat toast
Electric Vehicle (Slow Charge)	<13.0	<3000	Not to be used with an extension lead. Dedicated circuit required and ideally an EV rated socket-outlet. Use your bike
Patio Heater	<13.0	<3000	Typically, 1200-3000W. Sit indoors

Fundamentally it is about public safety



- Provision of fire water supplies
- Land management of vegetation
- Limitations on fire spread
- Effective E-planning
- Comprehensive E-response plan

BESS Li-ion battery incident data



Li-ion battery incident data: QBE Insurance, 2025

- UK Fire Services attended 921 incidents
- E-scooters: 125. BEV: 118
- E-trucks: 12 (involving 7 FRS)
 - But how many E-trucks are on the road???
- It is unclear whether the data is rising or falling
- Electric Power Research Institute (EPRI) California data
- https://storagewiki.epri.com/index.php/BESS_Failure_Incident_Database
- 105 entries: 3 historically in the UK
 - 2011-2025
 - NB Some incidents could be logged under the construction sector
- A fantastic database, but not if you live in South Korea!!

Incident No. 1: Orsted Ltd. Carnegie Road, Liverpool

- **First debut BESS fire in the UK**
- 15 September, 2020
- 59 hours to extinguish
- Automatic FA system activated
- Significant blast, **debris travelled 6-23 metres**
- The blast blew the (*****) doors off!
- Site remotely managed from Denmark



Orsted Ltd. Carnegie Road, Liverpool



- Note the proximity of a 'Neighbourhood Nursery'
- NOVEC 1230 system fitted to the units, which had activated
- 33kV battery on site
- Excellent Investigation Report again from Merseyside Fire & Rescue
- Causation: (Poor) Frequency Regulation

Incident: Cirencester

- Wippet Lane, **Preston**, near Cirencester
- 1531 Friday 28 March 2025
- Two 20ft ISO containers
- Hybrid solar farm: Owned by **Warrington Borough Council!** >88 acres. 43,000 solar panels
- Fire Crews prevented fire spreading to a third container Stop time 2204
- Roads closed and public movement lockdown



Image credit: © Entica AG

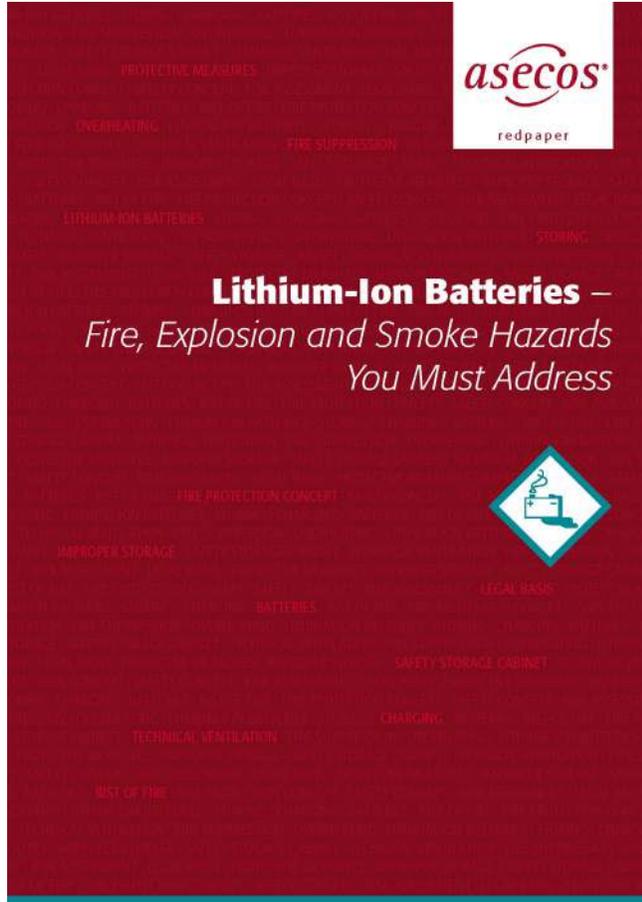
	Small devices	E-micromobility	PLG, BEV Cars	PSV, Construction site vehicles	BESS	Waste management
Typical battery mass	Nokia BL5C 22g iPhone 180g est. Dell Lat. 500g	Typically 5kg	Tesla ~500-700kg M-B ~ 900+kg	Volvo / CAT 2000+kg	5kW - >100MW already for Li-ion systems Up to 36 Tonnes	Completely unknown! ? tonnes
BMS	OK	Questionable	Excellent	Excellent	Excellent	None
'Fiddle factor'	OK. No swapping-out of IT / mobile phone batteries now!!	Dangerous	V Low. Cost, complexity and value of the product	V Low. Cost, complexity and value of the product	Low. Value of the project and its place in the infrastructure	Inherent in the process?
Advice and ERG	Essentially NONE	Questionable to Dangerous	Excellent CTIF/NFPA	Excellent CTIF/NFPA	Excellent	?
FFA	Submerge / AVD extinguishers	Copious water	Run	Run faster	Evacuate?	Evacuate and escape
RISK	LOW	HIGH	V LOW	LOW	? LOW	V HIGH

Battery energy storage systems & Superchargers

- Tesla products, such as: Powerwall, Powerpack, Megapack.
- Supercharger roadside charging facilities.
- **Risks: Very low.** High Li-ion battery mass. Essentially sealed units. May be linked to PV panels. Under constant observation & surveillance.
- **Action: EXCELLENT** manufacturer's emergency response guides.
- **FFA:** Let it burn? Water to cool?

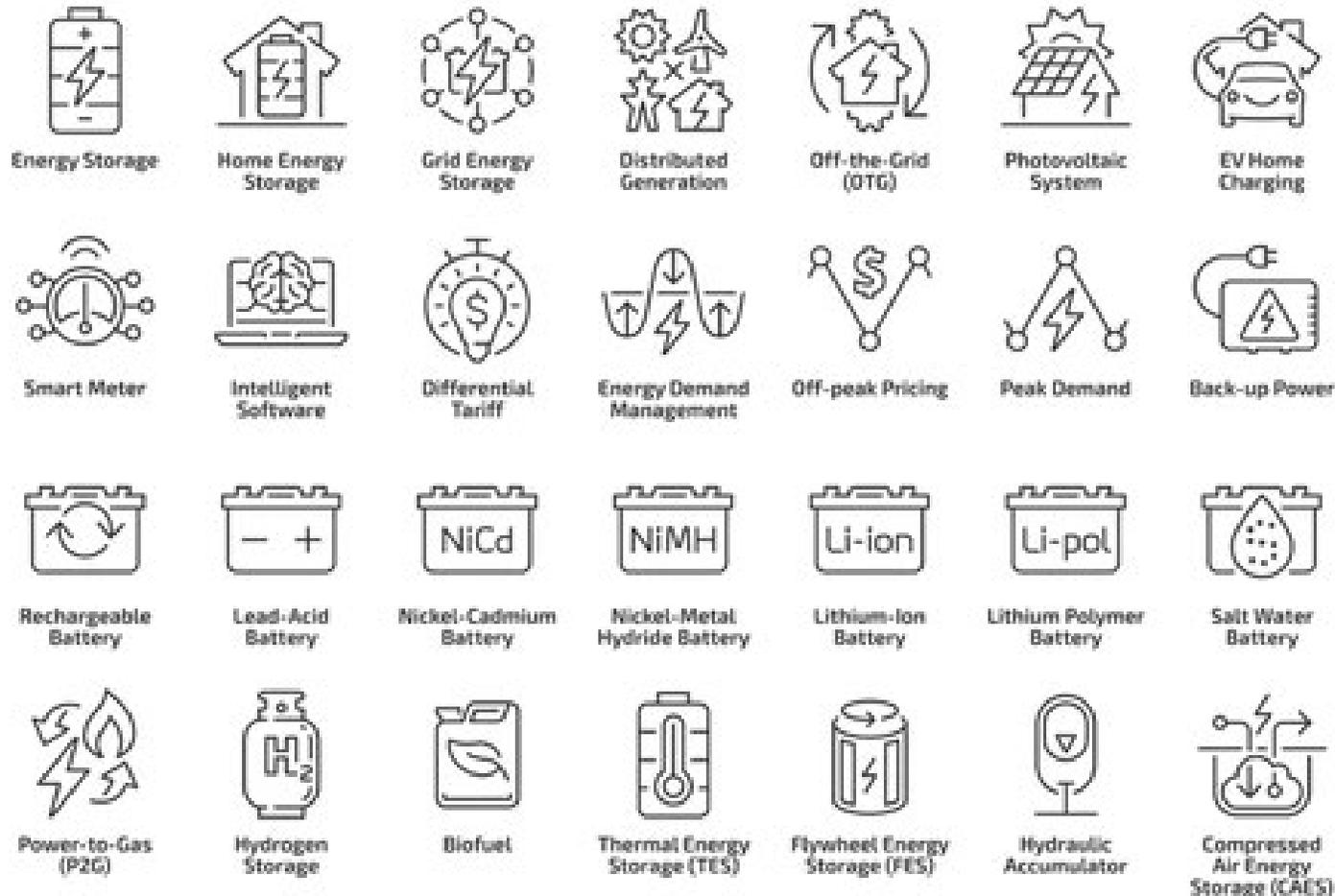


Two new documents



And you thought this was going to be easy ...

Image credit: © shutterstock.com



28
ICONS

ENERGY
STORAGE

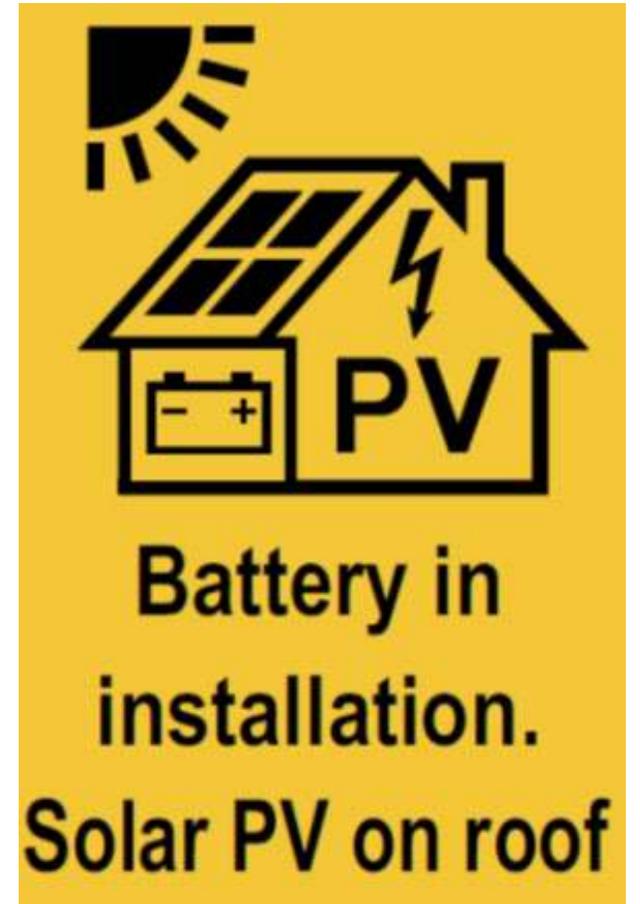
BATTERY

Vector • EPS 10
Editable Stroke

New icons



NOTE Adapted from IEC 60417-6400 and ISO 7000-0242.



Significant Guidance from PAS 63100

6.5.5 Batteries shall not be installed in any of the following locations:

- a) rooms in which persons are intended to sleep
- b) routes used as a means of escape that are not defined as protected escape routes, including landings, staircases and corridors
- c) corridors, shafts, stairs or lobbies of protected escape routes
- d) firefighting lobbies, shafts or staircases
- e) storage cupboards, enclosures or spaces opening into rooms in which persons are intended to sleep
- f) outdoors (ground-mounted or wall-mounted in a suitable enclosure) within 1 m of:
 - 1) escape routes;
 - 2) doors;
 - 3) windows; or
 - 4) ventilation ports.
- g) voids, roof spaces or lofts
- h) within 2m of stored flammable materials and fuel storage tanks or cylinders; and
- i) cellars or basements that have no access to the outside of the building

A Tesla Powerwall installation



- Compliant or not?

Photo credit: © Dan Pyett FRMC

So, what's next?

- FSMS, Fire Risk strategy, FRAs
- Review, identify, prioritise, plan
- Back-to-basics approach with the introduction of new site hazards: matching fire extinguishers to hazards etc
- What else can be so easily compromised?
- E.g. BEV charging for visitors?
- Wallboards / posters
- ALL 3 top level objectives stand: Life safety, property protection and business continuity
- Evacuation priorities are NOW
- Active and passive protection
- Compartmentation and FIRE DOORS

Li-ion power series A1 or A2 size posters

3: BATTERY ENERGY STORAGE SYSTEMS



Battery energy storage systems (BESS) comprise groups of battery packs, designed to provide energy from intermittent renewable solar or wind energy sources to be stored and then released to consumers when they need power most. Systems are constructed from arrays of interconnected battery packs within racking to create a high-power energy storage matrix. BESS may also be used as Uninterruptible Power Supply (UPS) systems to protect against power disruptions in supply to sensitive locations such as data centres or hospitals. Computer controlled battery management systems (BMS) are key risk controls which manage the flow of energy around the BESS systems to ensure that Li-ion battery cells remain within their safe operating range for voltage, current, and temperature. National Grid integrated commercial BESS systems, using lithium-ion batteries, may be found on industrial and commercial facilities. Flammable electrolytes, combined with the high intrinsic energy within lithium-ion battery cells, can present fire and explosion risks from single point failures.



TOP EVENTS	HAZARDS	BESS ARRAYS
<p>It is likely that some form of fire or explosion could occur in a BESS system. This could be caused by a fault in the battery cells, a fault in the battery pack, or a fault in the battery management system. This could be caused by a fault in the battery cells, a fault in the battery pack, or a fault in the battery management system. This could be caused by a fault in the battery cells, a fault in the battery pack, or a fault in the battery management system.</p>		

THERMAL RUNAWAY	RISK CONTROL 5 continued	EVENT TREE ANALYSIS
<p>All BESS units should be protected from fire and explosion. This should be achieved by the use of fire and explosion protection measures. This should be achieved by the use of fire and explosion protection measures. This should be achieved by the use of fire and explosion protection measures.</p>	<p>Risk Control 5 continued</p>	

RISK CONTROLS	HAZARDS	HAZARDS	HAZARDS	HAZARDS	HAZARDS
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FURTHER INFORMATION
<p>For more information on BESS safety, visit the BESS Safety Centre website: www.bess-safety.com</p>



4: EMERGENCY POWER GENERATION



Fire, safety and health considerations

As an adjunct to, or predecessor of, Battery Energy Storage Systems (BESS), large industrial, commercial, infrastructure and healthcare facilities have historically relied on site-based emergency power generation (EPG) systems to quickly and securely regain and stabilise power to essential systems and services on site. Now, this EPG function could be undertaken, in part, by BESS which operate at National Grid power network distribution levels. BESS do not fundamentally generate power but merely distribute it readily through existing transmission lines. While BESS may stabilise supplies in widespread power disruption, a 'Private Generator' on-site, backed-up by local UPS to bridge the time gap between loss of power and the generator(s) delivering load, is still a safe and functional alternative. These UPS may now run on Li-ion batteries. EPG still need to use on-site power transformers, switchgear and distribution cables (as a BESS would need to use as well) but local battery back-ups do offer resilience to EPG systems as well. To address systems reliability, redundancy and resilience multiple generators are often installed and safety engineering techniques are used to assess risks and establish control measures.

TOP EVENTS	HAZARDS	V12 11 kv DIESEL GENERATOR SET
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DEFINITIONS: RELIABLE, REDUNDANT, RESILIENT, SURVIVABLE	STORED ENERGY SYSTEMS	FAULT TREE ANALYSIS
<p>Reliable: the probability that a system will perform its intended function under stated conditions for a specified period of time.</p> <p>Redundant: an engineering term – a component which is not strictly necessary, but which is included to provide backup in the event of a failure.</p> <p>Resilient: the ability to withstand or recover quickly from difficult conditions.</p> <p>Survivable: the ability to continue to function in the face of an adverse event.</p>	<p>Stored Energy Systems</p>	

RISK CONTROLS	HAZARDS	HAZARDS	HAZARDS	HAZARDS	HAZARDS
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FURTHER INFORMATION
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D4FS: The TWO (philosophical) equations for life!

• Designing for fire safety.

• $N \geq M + 1$ and ...

• $S \leq N - 1$. Or $S \neq N - 1$

• Always argue for more! Go large, have at least one more than you thought you needed!

• Never compromise on survivability. Never go less than N – 1.

• It is time to look at fire protection in much more detail ...

Fire Doors: Fundamental fire protection

- In buildings and infrastructure:
 - Fire doors ‘seal’ compartments and prevent ‘smoke’ spread. Check them frequently.
 - In any circumstances, an open fire door is useless.
 - **In domestic accommodation**, never re-charge batteries unattended, at night, or on an MOE, and close doors.

INSPECTION OF FIRE DOORS

INTRODUCTION

Passive fire protection comprises fire doors, dampers, fire stopping around pipework, cables and services, fire resistant glass, smoke curtains etc. This is a form of fire safety provision that remains dormant, or inert, during normal conditions but becomes active in a fire situation. It is an integral component of ensuring the protection or compartmentation within a building and is designed to contain fire or smoke that spread to buildings and escape. We walk past and through fire doors every day without a second thought, but fire doors play a vital role in life safety, property protection and business continuity and are a fundamental defence against fire.

KEY PHASES AND ROLES

Design and Construction phase: CDM focused. NB: CDM applies through to the PM phase.

Occupation phase: The Occupier is responsible for fire safety management. Hospitals, NHS, Schools, Local Authority, Universities, the governing body.

Facilities management phase: FM Company, in cooperation with the building occupier and operator.

Fire doors should be inspected by Competent Persons with appropriate KATE: Knowledge, approach, training and experience.

KEY RISK FACTORS

- Sleeping risk and type of occupancy
- Specific purpose of the building
- Presence of occupants
- Height of the top storey above the ground
- Depth of the lowest basement level below ground

PURPOSE OF FIRE DOORS

Fire doors are specialist doors within a building or structure that are specifically designed, manufactured, installed and maintained to provide life safety to occupants and users within a building. We walk past and through them every day without a second thought, but fire doors play a vital role in the defence against fire. They provide a vital aspect of passive fire protection to prevent the passage of fire, smoke and products of combustion including toxic gases.

Fire doors have many vital safety features and are essential to the survival of people in a building that is on fire. Two of the most important functions fire doors are to form an impermeable barrier to stop the spread of fire and restrict fire and smoke, when open, to provide people with an easy means of access and passage around the building and also a secure means of escape. To these ends, it is fundamental that the door 'works' properly as the designer intended it to.

A fire door that is wide open or wedged open is useless at preventing the passage of fire and smoke and compromises the complementary aspects of passive fire protection within the building. One open door at the wrong moment can put at risk the whole building.

CRITICAL FACTORS IN THE PROVISION OF FIRE DOORS

For everyone's safety it is vital that fire doors are:

- Properly specified, designed, produced, manufactured and competently installed.
- Certified to required standards and that their use is managed.
- Inspected for proper functionality and condition, especially after wear and tear.
- Maintained on a PMN schedule. (Planned preventative maintenance).
- Replaced or repaired if conditions warrant or standards are breached.

COMPONENTS OF FIRE DOORS

Fire doors comprise various components designed to protect against the spread of fire and smoke. The frame with the components of a fire door. All components on fire doors i.e. door furniture must comply with British Standard Certification which is issued by the British Standard Institute. The components include:

The door leaf: Typically made from timber or metal and fitted with a fire-resistant core.

The frame: Designed to provide an airtight seal around the door, helping to prevent the spread of smoke. Ideally, it should be made from the same material as the door and beaded together.

Seals: Intumescent strips, which expand when heated, and cold smoke seals should be fitted to the door frame or door edge to resist the passage of smoke and flames. Different types and sizes of seals activate at temperatures above human survival levels, so it is crucial to fit the correct seals to the right door.

Glazing and heat transfer grilles: The glazing in a fire door is designed to resist the spread of fire and heat while still allowing light to pass through. Glazing and heat transfer grilles are installed only in a factory-controlled environment by trained individuals, using appropriate components such as fire-rated glass and intumescent beading. Intumescent glass usage can result in radiant heat transfer through the glass, potentially starting a fire on the other side of the door.

Hardware: Fire-rated handles, hinges, and other door furniture.

Signage: "Fire Door Keep Shut" sign, preferably screwed in place.

RATINGS OF FIRE DOORS

The rating of a door is represented by FD and then a number (30, 60, 120, or 240). This number represents the minimum amount of fire (minutes) that a door maintains its structural integrity for in the event of a fire. When the rating number is followed by E, the door is smoke rated. Fire doors with a rating in excess of FD60 are rarely used on escape routes or to protect people that may be found where the penetration of property is important e.g. data storage areas where documents cannot be removed in the event of fire or in security sensitive environments. Some of these doors have the appearance of timber but may be constructed with a mineral core.

5-STEP SIMPLE FIRE DOOR CHECK

Physically check for the correct certification.

Average around the door are between 2mm and 4mm and seals are intact and undamaged.

Are hinges in good condition and that 3 hinges are fitted.

Does the door close properly? Is the wall clear in good condition?

If hold-open is fitted, does it work properly?

PRACTICAL FIRE DOOR INSPECTION

Fundamentals of inspection of fire doors comprise the following questions:

1. Has the door the correct fire rating for its location and purpose etc?
2. Is the door fitted properly, without the gap of door edge gaps that can put at risk the integrity of the compartmentation in the building?
3. Is the fire door in excellent serviceable and functional condition and not damaged in any way that would impair its performance in the event of a fire?
4. Is the door fitted with the correct intumescent hardware and closes, and that these things are located correctly and function correctly?
5. Does the fire door have the correct intumescent strips fitted?
6. Is the door properly identified on both the door safety labels and fire signage and in the building's asset register?

Where appropriate, has the door been installed with the correct type of fire glazing and that it is fitted correctly? Because of their importance in protecting lives, it is imperative that fire doors receive regular inspections. The frequency of inspections is likely to depend on many factors, including the age and condition of the door. It had been expected that a minimum quarterly inspection schedule may be applied when the new Fire Safety Bill 2021 is implemented, as a recommendation from Phase One of the Grenfell Tower Inquiry. The Fire Door Inspection Scheme (FDIS) recently highlighted that three-quarters of all fire doors inspected in 2019 were condemned as unfit for purpose.

CERTIFICATED OR NOMINAL FIRE DOORS?

Certificated Fire Doors may be marked with Certification statements from organisations such as BSI, BMA or Eureka. Marks may include labels, coloured plugs or fixed metal plates and data should be recorded. The door will have been rigorously tested by a testhouse to a relevant British Standard. Certificated doors will be recorded into a frame of the same standard and will carry Certified hardware and fire safety signs. However, in some circumstances, such as typically in domestic or historic premises, the door will have been installed without certification standards were available. In these cases, the door may be described as a Nominal Fire Door. Additionally, it may have been upgraded to above this, a Certificated fire door or have been flush-panelled, stained or painted.

FOR FURTHER ADVICE ON THE GOVERNMENT CONTACT: **KNOW YOUR FIRE EXIT, KNOW YOUR MEANS OF ESCAPE**

FIRE RISK MANAGEMENT GROUP

FURTHER INFORMATION

For further information regarding fire risk management strategies contact your Fire Safety Manager, fire or safety department or Director of Safety.

www.fra.gov.uk www.iosh.co.uk www.fire.gov.uk www.britainonfire.co.uk www.britainonfire.co.uk www.fra.gov.uk www.fra.gov.uk www.fra.gov.uk www.fra.gov.uk www.fra.gov.uk



Latest International interest

- Austroads Research Report AP-R746-25
- Incident Response for Low and Zero Emission VEHICLES

Incident Response for Low and Zero
Emission Vehicles

Standards for safe working

- BSI PAS 43:2018 – TC
- **Safe working of vehicle breakdown, recovery and removal operations. Management system specification**
- UK Dept Transport guidance
- [Recovery operators: working with electric vehicles - GOV.UK](#)
- To ID an electric vehicle
- [Enter the registration number of the vehicle - Check if a vehicle is taxed and has an MOT - GOV.UK](#)
- [Vehicle Tax and MOT status results - Check if a vehicle is taxed and has an MOT - GOV.UK](#)

EV conversions: 1970 Mercedes-Benz SL



Images credit: Channel 10 News Melbourne



EV FireSafe: Thermal Runaway
<https://www.youtube.com/watch?v=52mfE2w9t1c>