OSKAR GRÖNLUND

Guidelines for the fire protection of battery energy storage systems – Swedish experiences

RISE – Research Institute of Sweden

RISE is an independent, state-owned research institute.

We collaborate with industry, academia and the public sector.

More than 3000 employees are engaged in innovations and cross-disciplinary research.

RISE is the 4th largest institute of its kind in Europe, after Fraunhofer (Germany), CEA (France) and TNO (Netherlands).

It is worth noting that CEA focuses a significant proportion of its research on defence.

Battery safety at RISE

- Research
- Testing
- Accident & fire investigations
- Consulting
- Education


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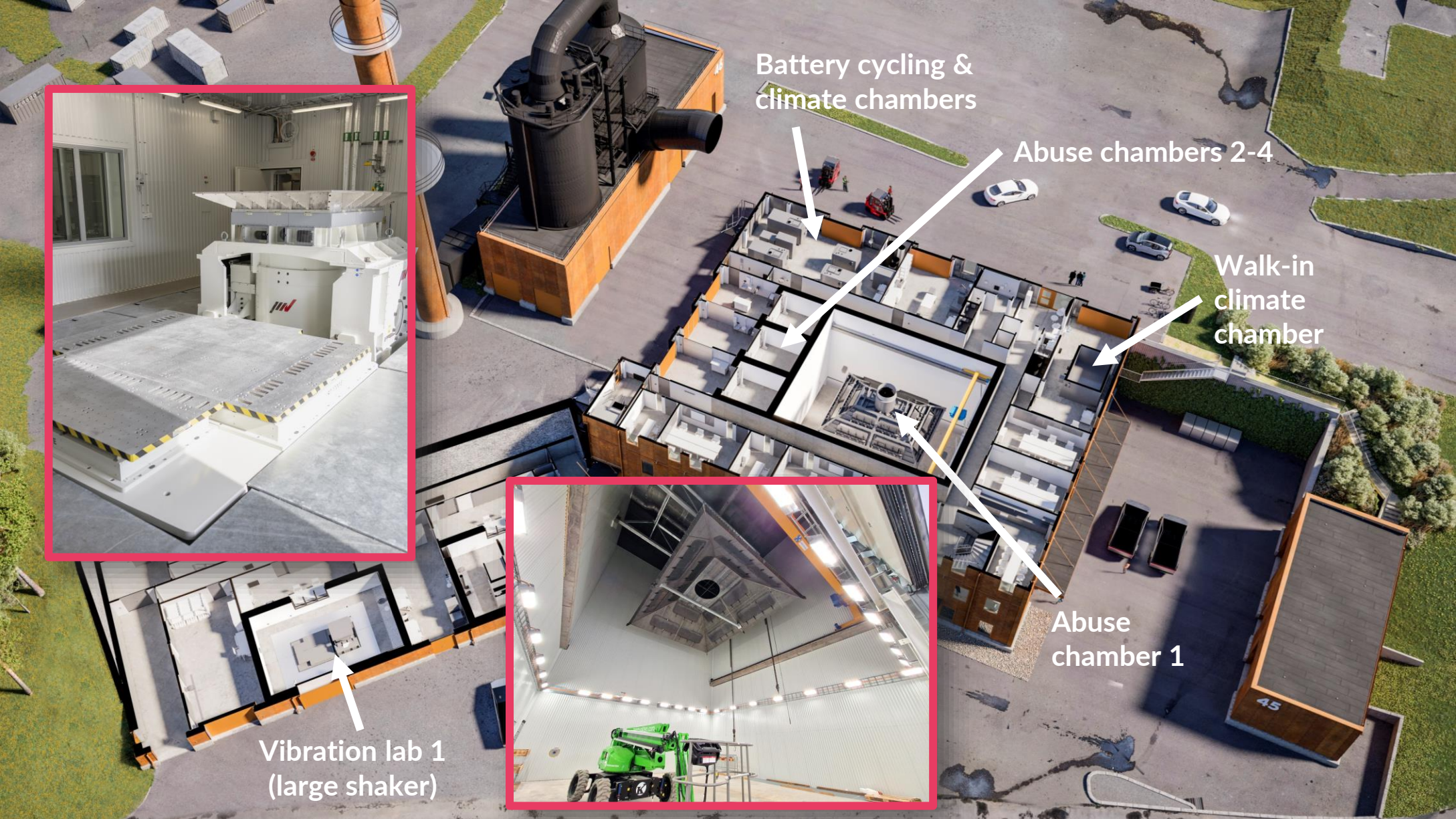
Battery cycling &
climate chambers
Abuse chambers 2-4
Walk-in
climate
chamber
Abuse
chamber 1
Vibration lab 1
(large shaker)

Funding

FORMAS

Diarienummer: 2022-02015

Project partners

RI. SE Research Institutes of Sweden

VATTENFALL

Polarium

Reference group

Utkiken.net

RI. SE

RÄDDNINGS TJÄNSTEN Södra Älvsborgs Räddningstjänstförbund

RÄDDNINGSTJÄNSTEN STORGÖTEBORG

RÄDDNINGSTJÄNSTEN LULEÅ HJÄLPER RÄDDAR SLÄCKER

Storstockholms brandförsvar

Brandskyddsföreningen

RÄDDNINGSTJÄNSTEN SYD

Short project – 1 y
Literature study (incidents, lessons learnt, guidelines (both land and maritime), laws, regulations and standards)
VF/POL current fire protection, fire protection matrix
Workshops (>100 participants)
National guidelines (lowest level and best practise)

Aim of project
To produce guidance regarding the fire safety of BESS.

Upcoming regulation in Swedish building codes

- Systems larger than 20kWh should be placed in a separate fire cell.
- Fire lock between BESS and escape routes that serves other parts of a building
- Possibility of smoke evacuation for spaces larger than 10m2 and systems larger than 20kWh

Owner responsibility (Sweden)

The person who owns or has the right to use a property or premises is the *owner*. *T*he *owner* is responsible for ensuring that the fixed electrical installations are safe. All *owners* of electrical installations are:

- Obliged to ensure that the facility is safe,
- Responsible for maintenance and repairs of the installation,
- Obliged to check that the person performing electrical installation work at the property/premises is listed in the Swedish Electrical Safety Authority's register of electrical installation companies.
- Obliged to make sure that the installation is correctly documented regarding routines according to ELSÄK-FS 2022:3

What information do we need to provide guidance?

- Probability
- Consequence
- Cost/benefit of protective measures
- Industry and rescue organizations perspective

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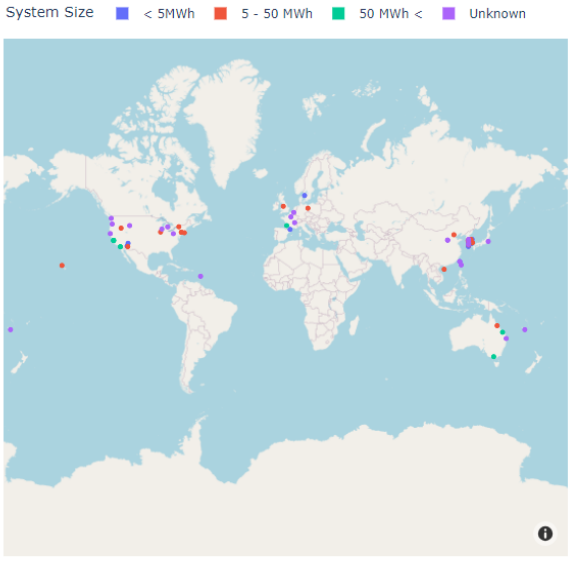
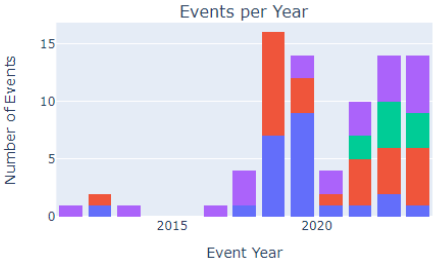
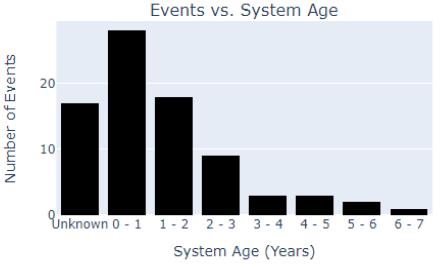
Statistics and data

- Statistics and data of the number of incidents is deficient or hard to access or not reported.
- EPRI database tracks utility and C&I storages, 68 incidents (now 86) public sources. Does not include home owners
- CPUC: approx. 2% of grid connected BESS will be affected by errors the first 2 years. Not necessarily fire.

Ref: CPUC:s report ”Energy Storage Procuremnet Study”, appendix F

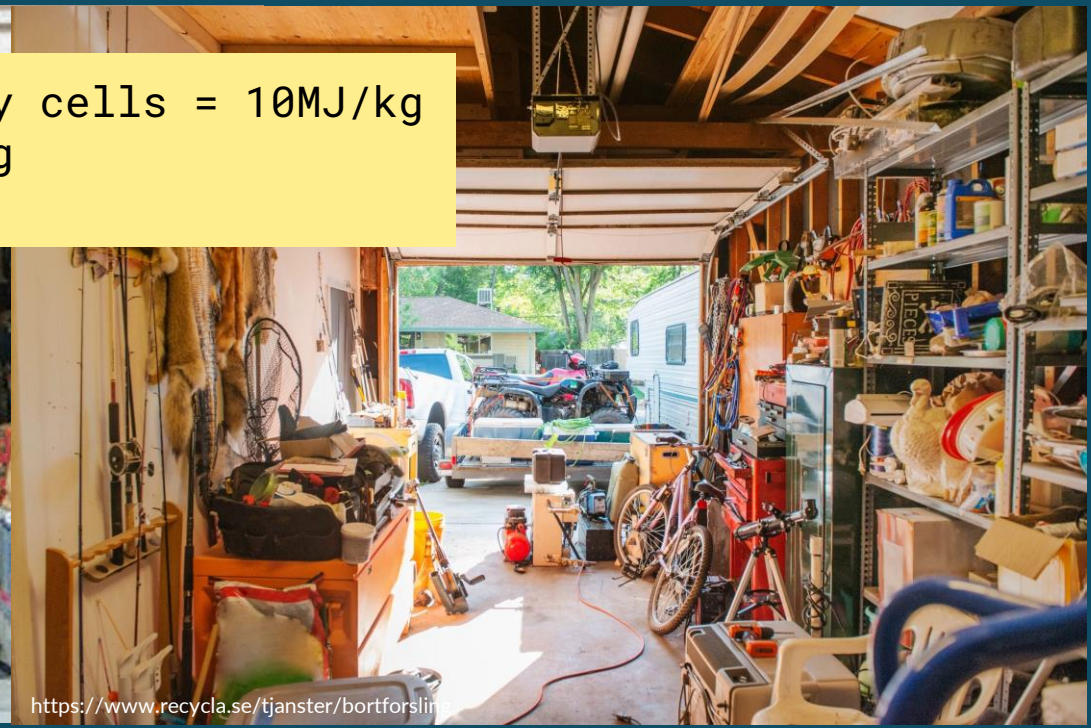






https://storagewiki.epri.com/index.php/BESS_Failure_Event_Database

Fire load?



Li-ion battery cells = 10MJ/kg
Tyre = 27MJ/kg
Car = 23MJ/kg

4.8 kWh module = 35 kg =120 MJ (RISE project *Lion Fire II, 2021*)
One tyre weighs between 7 – 15 kg = 190 – 400 MJ (Ingason, 2010)
Vehicle (small SUV) = 5GJ

Should we be worried about a small battery when we accept the fire load from tyres or even a car

Explosion risk and hard to extinguish

https://www.cbc.ca/news/canada/montreal/electric-car-catches-fire-and-explodes-in-%C3%AEle-bizard-garage-1.5227665(Mathieu Daniel Wagner/Radio-Canada)

Worst-case scenario:

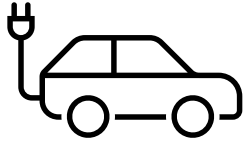
100% SOC, all cells enter thermal runaway, no ignition of gases and no ventilation

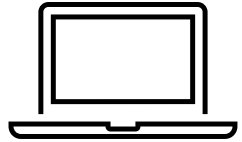
2 L/Ah ≈ 0.6 L/Wh,
LEL ~ 6%

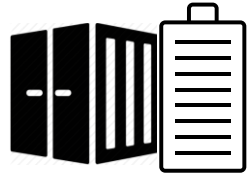
Product	EV (V2G/V2H)	Laptop	Energy storage (small)
Capacity	80 000 Wh	50 Wh	14 000 Wh
Largest room size with explosive atmosphere (ceiling height 2.5 m)	320 (m^2)	0.2 (m^2)	56 (m^2)

Explosion risk!

https://www.cbc.ca/news/canada/montreal/electric-car-catches-fire-and-explodes-in-%C3%AEle-bizard-garage-1.5227665(Mathieu Daniel Wagner/Radio-Canada)







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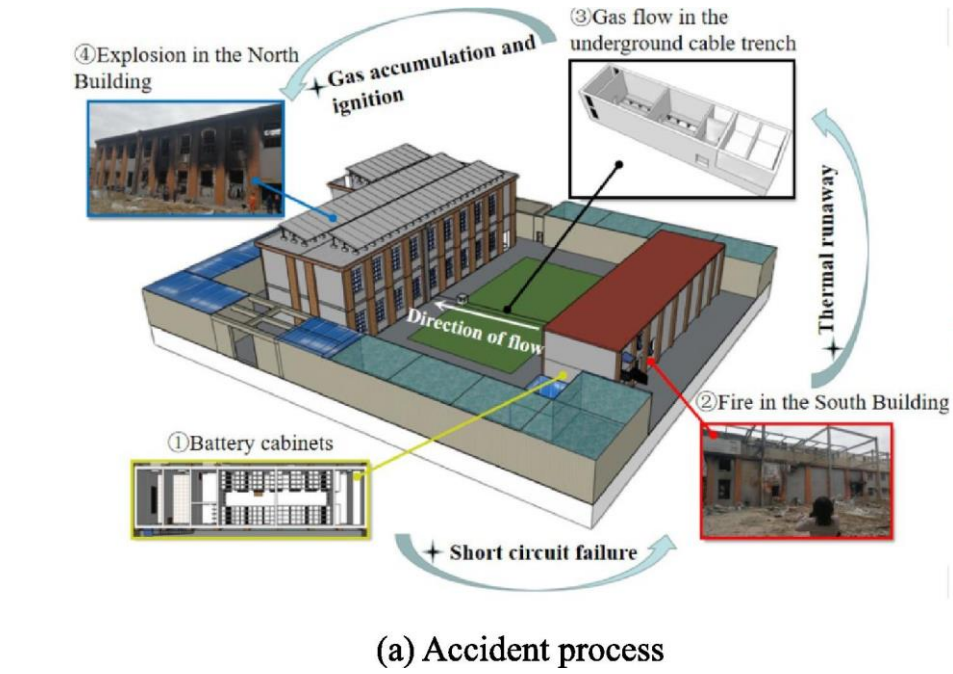
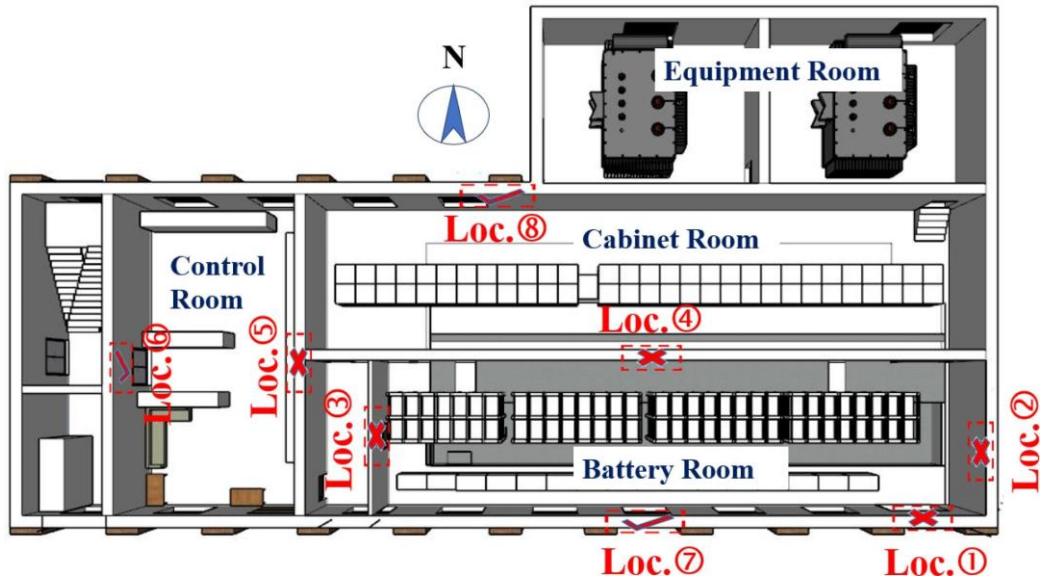
Dahongmen – Beijing China

Two firefighters and one employee lost their lives.



(a) Accident process



These very serious type of incidents are rare. Limitations in data!

Two workshops were held

- Live workshop with approx. 25 participants from the industry, fire brigade, insurance and Fire protection consultants.

- Digital workshop with 100 participants, the participants were asked to prioritize safety measures

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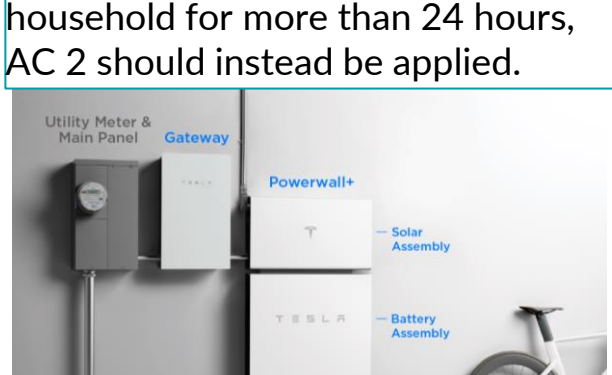
Application Categories (AC)

AC 1 - BESS for Single-family homes

AC 1 targets private users in single-family homes and the guidelines are proposed based on the general needs and application of private customers (limited resources and knowledge regarding maintenance and service). BESS with capacity to supply the average power demands of a household for more than 24 hours, AC 2 should instead be applied.



https://www.tesla.com/support/energy/powerwall/learn/system-design

AC 2 - BESS for multi-dwelling blocks or businesses

AC 2 targets groups of individuals, companies, associations, or other property owners/users (not for commercial purposes). The guidance is based on the BESS size that generally meets the needs and applications of these actors.

https://www.riksbyggen.se/hallbarhet/forvalta/foretag/lagra-solenergi/

AC 3 - BESS for Large scale commercial applications and mobile BESS

AC 3 targets businesses, municipalities, and other actors who utilises BESS for commercial use, or provides mobile BESS for other actors.

https://energyplaza.vattenfall.se/blogg/sveriges-storsta-batterilager-tas-i-drift-i-uppsala

https://group.vattenfall.com/se/nyheter-och-press/pressmeddelanden/2021/stort-batterilager-i-ovik-laddar-elbilarna-i-sommar

General for all application categories

-Placement so that a fire in the battery system does not affect the rest of the buildings escape routes

-System is tested for thermal propagation, for example IEC 62619 or UL 9540A

-Emergency shut down of outgoing electricity. Incoming electricity for critical safety systems shall not be shut down

Two levels of protection

- Minimum protection level

Includes protection measures that are proved effective to reduce the risk of human causalities.

- Best practice

Includes measures that may be effective in certain situations but might not be cost efficient. Can be effective in reducing the risk of property damages.

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Minimum level

- Warning signs
- Placement (avoid placement in buildings with sleeping individuals)
- Possibility of smoke evacuation
- Minimize the risk of mechanical impact

Best practice

- Communicating smoke detectors
- Explosion preventive ventilation

AC 1 – Single-family homes

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Minimum level

- Warning signs
- Placement (avoid placement in/or in connection with shared escape routes)
- Fire cell/safety distance to other buildings if outdoors
- Emergency action card with information about the system for the fire brigade
- Local smoke detectors
- Possibility of smoke evacuation & pressure relief (doors or windows to the outside)
- Separate explosion preventive ventilation
- Lower risk of mechanical impact
- Risk assessment

Best practice

- Comprehensive fire alarm system
- Extinguishing water collection
- Spark free ventilation fan
- Operating device for activation of smoke evacuation from a safe distance
- Pressure relief (deflagration panels)

AC 2 – Multi-dwelling blocks or businesses

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Minimum level

- Warning signs
- Placement (avoid placement in/or in connection with shared escape routes)
- Fire cell/safety distance to other buildings if outdoors
- Emergency response card with information about the system for the fire brigade
- Local smoke detectors
- Possibility of smoke evacuation
- Separate explosion preventive ventilation
- Lower risk of mechanical impact
- Risk assessment

RISK ANALYSIS

Best practice

- Comprehensive fire alarm system
- Extinguishing water collection
- Spark free ventilation fan
- Operating device for activation of smoke evacuation from a safe distance
- Pressure relief (deflagration panels, windows, doors)
- Connection for fire hose to sprinkler pipe

AC 3 – Large scale commercial applications and mobile BESS

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What should be included in the risk analysis as a minimum?

- Explosion risk
- Distance to buildings
- Distance to critical infrastructure, pedestrian paths or other crowded areas
- Thermal propagation and internal safety distances within the system (between modules or racks)
- Distance between units (BESS parks)
- External factors such as climate, and risk of mechanical impact (for example collision or falling objects such as ice from wind turbines)
- Response time for the fire brigade
- Extinguishing water and nearby water protection area

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Further research needed: Incident data, effect of suppression & ventilation systems

LinkedIn ”Batteries at RISE”

Thank you for listening!

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