Lessons Learned from Past Failures Around the World

Session 6: Responding to a Safety Event

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Energy Storage Systems Safety and Reliability Forum
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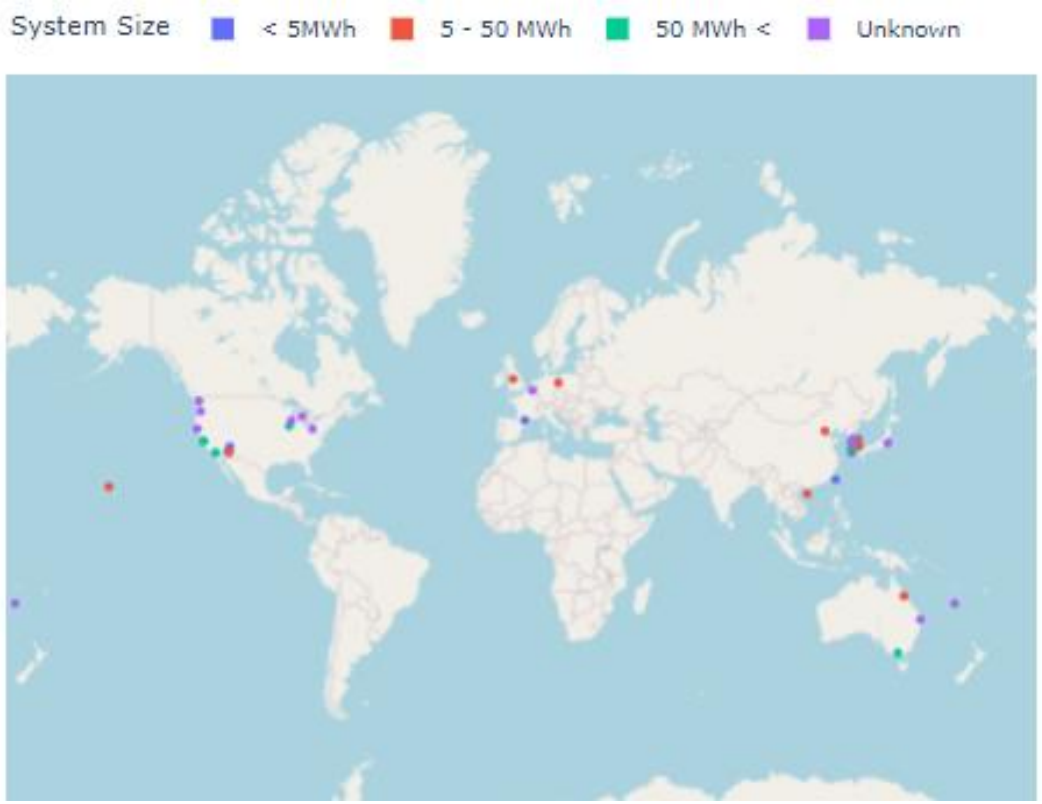
Agenda

- BESS Failure Incident Database
- Overview of recent events from around the world
- Carnegie Road Incident in the UK
- Lessons Learned

Recent Energy Storage System Fires: Incident Database



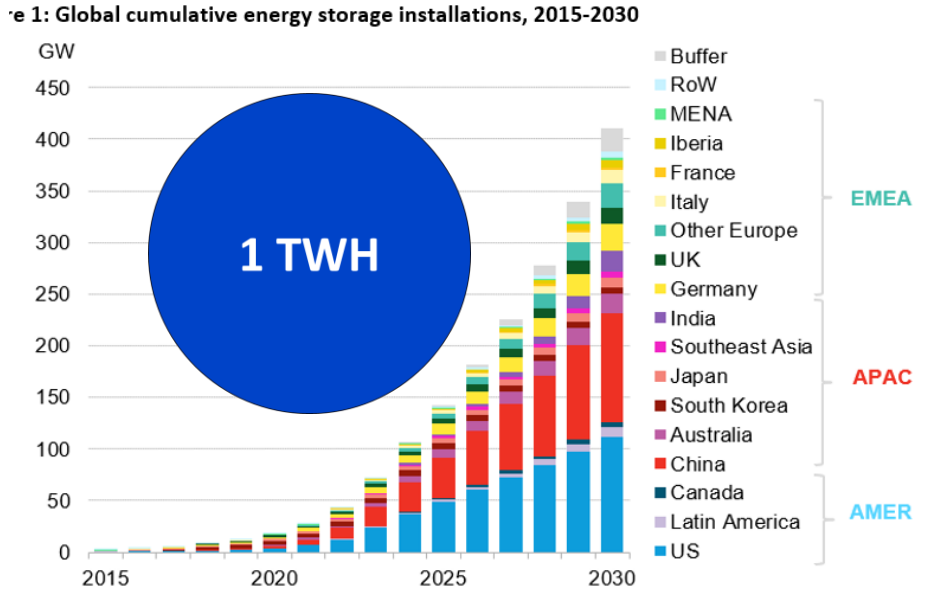
60+ documented incidents

Site of Battery Fire in South Korea
(Source: E2News)

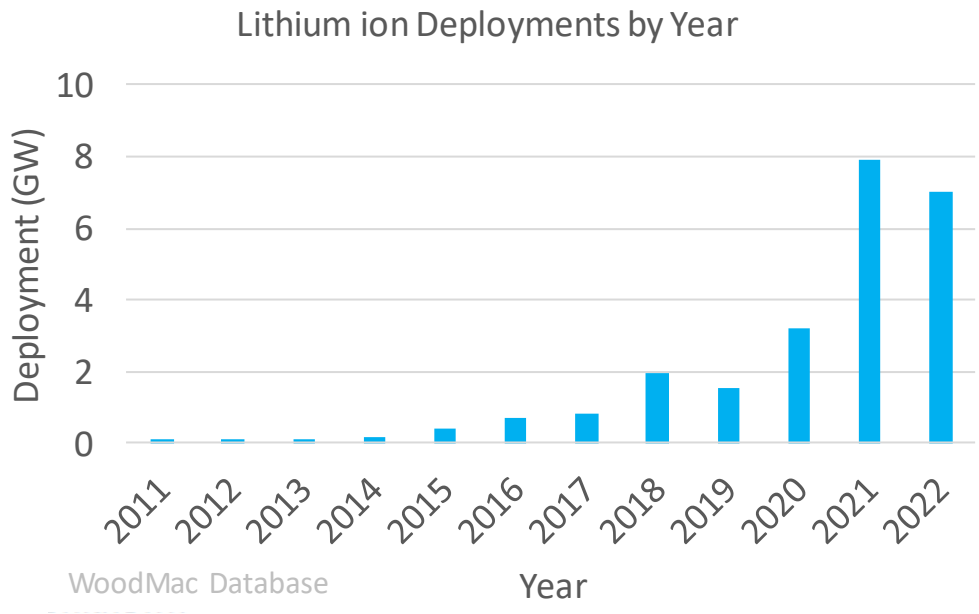
Battery Fire in Moss Landing, CA
(Source: KSBW Action News 8)

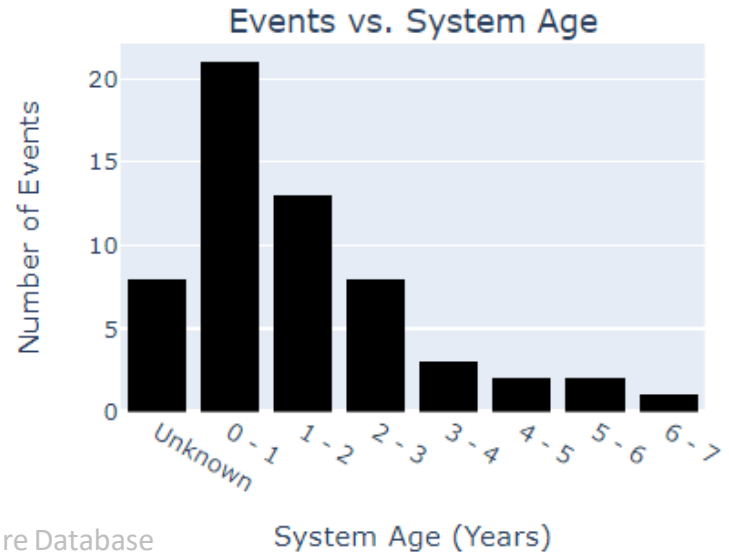
https://storagewiki.epri.com/index.php/BESS_Failure_Event_Database

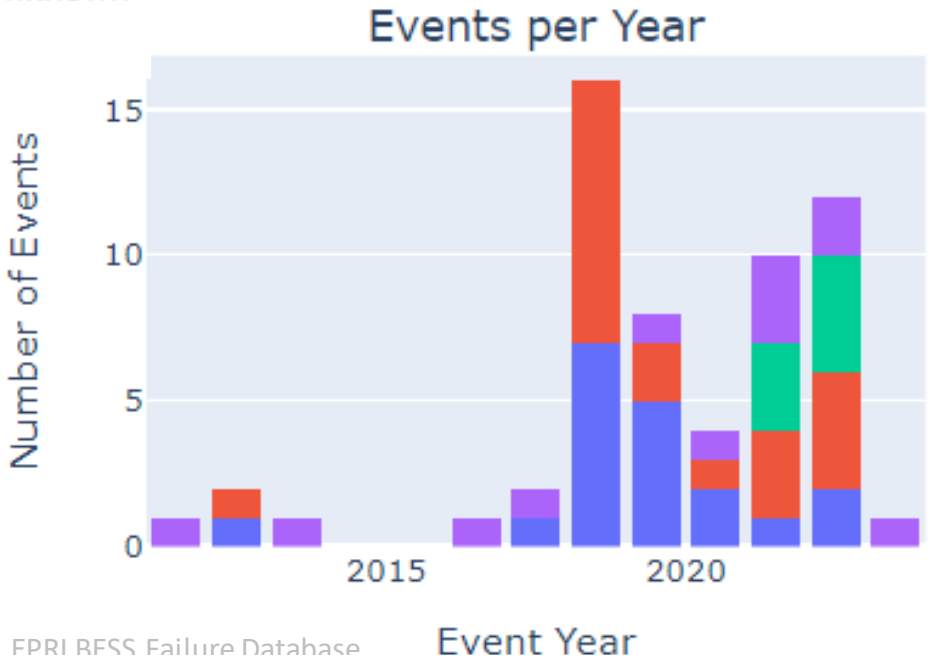
Failure Incident Statistics



Source: BNEF 2H 2022 Global Energy Storage Outlook (excludes pumped hydro)







Incident highlight | Victoria Big Battery – July 30th 2021

- 300MW / 450MWh system used for grid stability
- **Event details** – During construction and commissioning, one unit experienced a failure and was fully consumed by fire. The fire spread to and adjacent unit as well.
- **Key lessons –** Even a fairly well-controlled failure can result in a large fire. Environmental impacts were monitored.
- RCA reports have been published

Event generally followed a pre-defined failure progression

Incident highlight | Vistra Moss Landing – Sept 4th 2021

- 300MW / 1200MWh – building based system in repurposed power plant
- **Event details** – failure was reported that included water damage, electrical shorting, scorched racks and melted wires
- **Key lessons** – Safety systems can become points of failure. QC/QA of construction operations is essential.
- RCA was released

Clear RCA with public statement to industry is very encouraging

Incident highlight | Fluence Dorman – April 18th 2022

- 10MW / 40MWh system in a building
- **Event details** - Unknown cause and final RCA. Thermal runaway was noted and the propagation of that failure through the system was observed. Water sprinklers activated automatically and slowed failure progression.
- **Key lessons** – Long failure duration with large amounts of water used to suppress and maintain safety of system during failure. First Responders observed from a safe distance and managed the outcome without further incident.

Event was managed safely by well-trained fire service and utility staff

Incident highlight | Elkhorn BESS - Sep 20th, 2022

- 183 MW / 730 MWh system
- Commissioned April 2022, consists of 256 Tesla Megapacks
- One unit caught fire, no propagation to adjacent units
- Site evaluation through FPaM ph 1
  - Fire or over-temp alarm de-energizes system, notification to on-site personnel
  - Remote Incident Command center with HMI and camera feeds
  - Coordination with local FD

No reported injuries, no propagation. Cause still unknown

Incident highlight | South Korea - Dec 8th, 2022

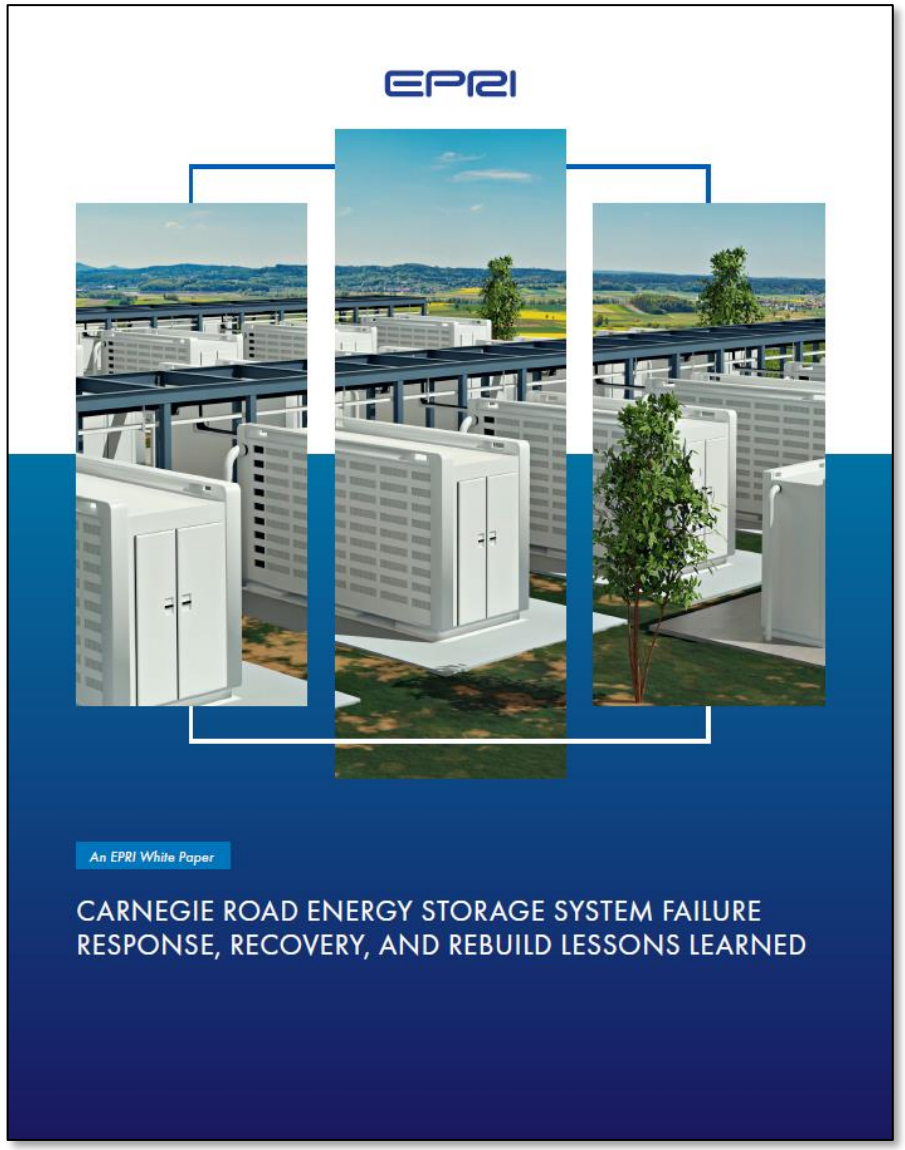
- 2.5 MW / 9.1 MWh
- Samsung SDI modules.
- Building installation, system age is 5.5 years

- “It is necessary to establish a permanent monitoring system in preparation for aging batteries, and to consider placing them in separate buildings to prevent damage from spreading like this time in the event of a fire."

System destroyed. Relatively old system. 39 total incidents in S. Korea

Carnegie Road Failure

- Report covers response, recovery and rebuild lessons learned
- It is **NOT** a detailed Root Cause Analysis
- Industry education and development of best practices
- Public white paper



Many thanks to EPRI and Ørsted teams

https://www.epri.com/research/products/000000003002026396

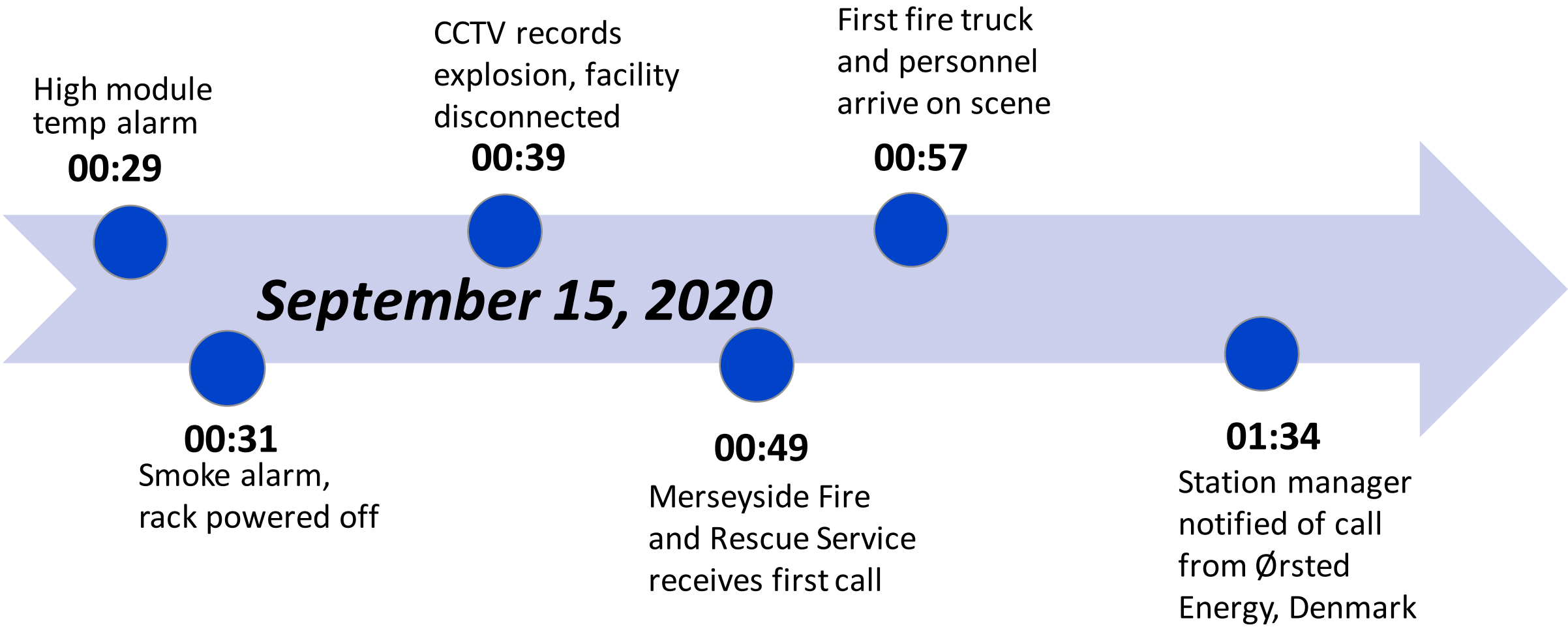
Carnegie Road Failure

- Commissioned in May 2019
  - 20 MW, 11.25 MWh
- Suppliers: NEC, LG Chem
- Procured and operated by Ørsted
- Firm Frequency Response Service

- Explosion and fire on September 15, 2020
- Fire consumed one container

https://www.epri.com/research/products/000000003002026396

What happened?



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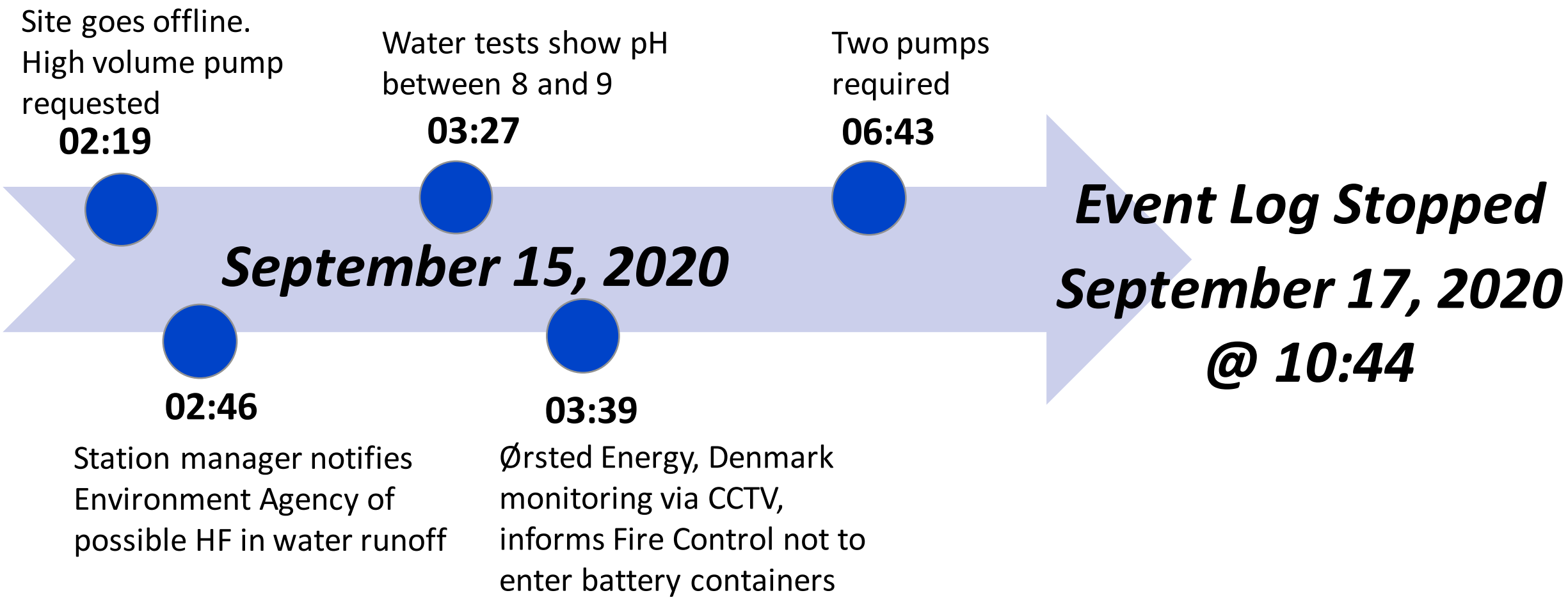
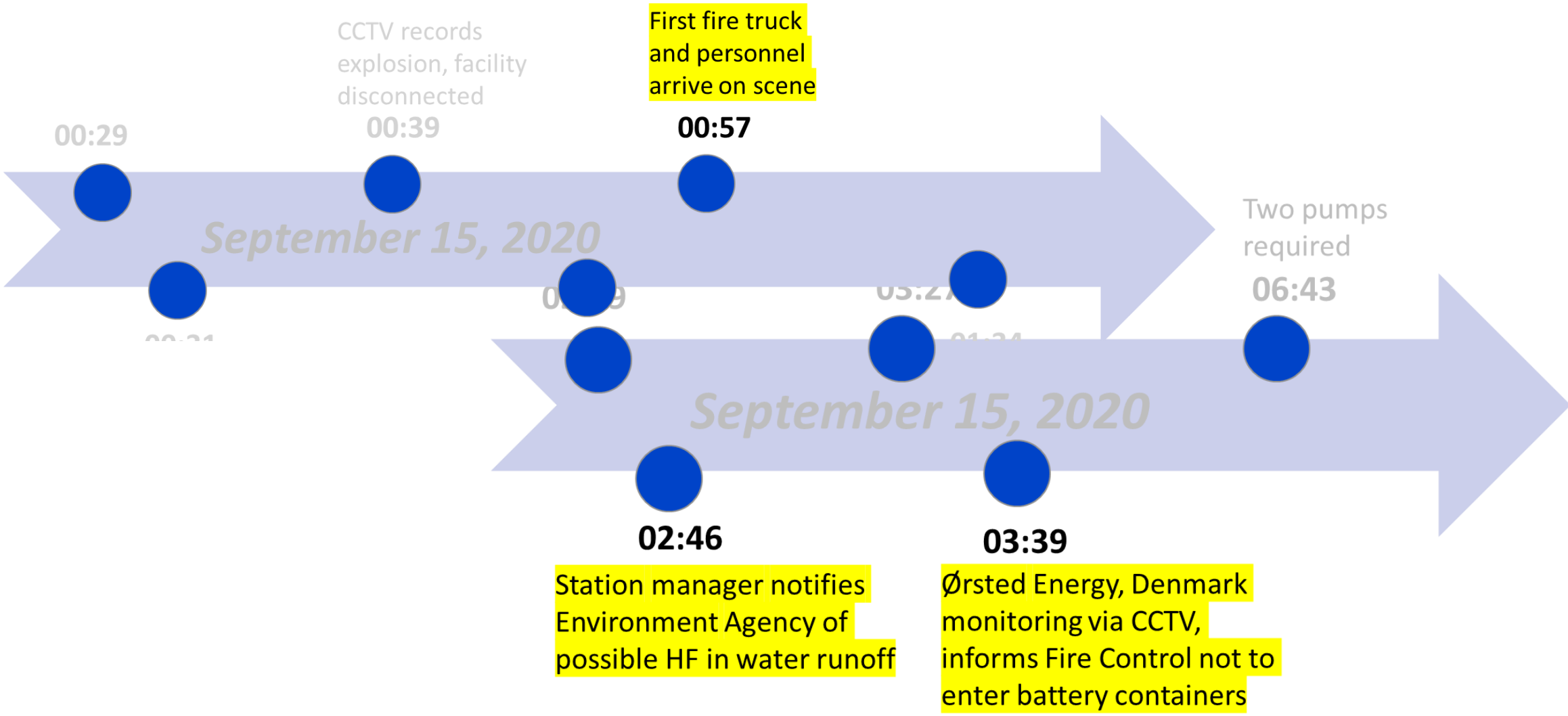


Lesson Learned



Clear and continued engagement and training necessary

Investigation

- First incident in the UK
- During Covid-19 pandemic
- ESIC Reference Hazard Mitigation Analysis used for root cause work
- Cell defect potential cause

Long investigation timeline, no definitive root cause determined

Incident Recovery, Repair, and Rebuild

- Limited telemetry
- ‘No entry’ strategy
- Extensive damage, including melted metals and plastics
- Contractual issues affected redesign and rebuild

Challenging to de-energize and remove system

Where were the gaps?

- System design
  - Rebuild included deflagration venting, explosion control, water suppression, gas detection
- Training and coordination
  - HMA / RCA
  - First responders
- Lack of industry maturity
  - Codes and standards
  - New processes for recovery and rebuilt

Industry still needs to mature

Take-aways from Recent ESS Fires

Prevention

- Maintaining strict operational limits via **robust Battery Management Systems** (BMS) can inhibit thermal runaway
- **Thermal runaway may be inevitable** at a cell level due to cell defects, aging
- Propagation depends on many factors, such as chemistry, cell packaging, thermal resistance of the module
- **Monitoring** of voltage, current, temperature, and gases may provide failure pre-conditions

Mitigation

- Clean agent fire suppression (alone) is often incapable of stopping propagating thermal runaway
- Cascading thermal runaway generates large amounts of heat –**water suppression** requires large volumes
- Explosive off-gases can build quickly – **ventilation is essential** to avoid deflagration
- Coordination, planning, and communications **before, during, and post event** can save lives and equipment

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QUALITY ASSURANCE & VENDOR COORDINATION

SUBSYSTEM INTEGRATION

DATA ACQUISITION & TRENDING

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HAZARD IDENTIFICATION & TRADEOFF STUDIES

PROJECT SITING & RESOURCE PLANNING

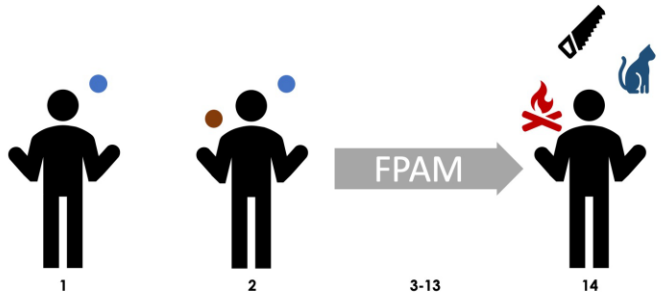
SYSTEM ENVELOPE

RESPONSE PROCEDURES & INFORMATION SHARING

EPRI Research Addressing Gaps

Project Lifecycle Safety Toolkit

- Emergency Response Plan Guide
- Considerations for Air Plume Modeling
- White Papers
  - Battery Thermal Runaway vs. Fire Ignition
  - General Guide to BESS Safety
- Residential Storage Safety Guide
  - https://interactive.epri.com/ress-guide/p/1



VR Training for Incident Response

Reach out to collaborate on Phase 3

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