Appendix A

Battery Energy Storage Systems (BESS) Fires in the UK:
A Comprehensive Review of Risk, Regulation and Planning Implications

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1. Introduction

The UK's transition to renewable energy has accelerated in recent years, driven by commitments to decarbonise the grid and meet net-zero targets. A key enabler of this transition is the deployment of Battery Energy Storage Systems (BESS), which provide the capacity to store energy generated by intermittent renewable sources like wind and solar. This capacity is essential to stabilising the grid, enhancing energy security, and enabling the flexible trading of electricity.

However, alongside their rapid deployment, a number of high-profile BESS fire incidents have raised serious questions about safety, regulation, and planning oversight. This review explores four recent fire incidents at UK BESS sites, synthesises current understanding of lithium-ion battery failure mechanisms based on recent technical work by Prof. Peter Dobson and colleagues, evaluates current best practices informed by the National Fire Chiefs Council (NFCC), and assesses the future risk of incidents based on government deployment targets. It concludes with a call for critical reforms in how these technologies are planned, approved, and regulated.

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2. Review of The Four Recent UK BESS Fires

Liverpool, Merseyside – September 2020

This 20 MW / 10 MWh BESS facility, owned by Ørsted, had been operational for approximately 1.5 years before a thermal runaway event occurred within a battery container. The cause was traced to cell failure leading to uncontrolled heat generation, combustion of the electrolyte, and container rupture. Emergency services employed sustained water cooling over an 11hour operation to prevent fire spread beyond the affected container. The fire was ultimately contained after two days. This incident marked one of the first major BESS fires in the UK and highlighted gaps in emergency response planning and container compartmentalisation.

Cirencester, Gloucestershire – March 2025

A fire broke out at a 10 MW lithium-ion BESS facility integrated into a hybrid solar farm owned by Warrington Borough Council. The system had been in operation for roughly 2.5 years. Although the precise cause remains under investigation, the incident raised significant concern given the proximity of adjacent containers and the potential for escalation. Firefighters succeeded in preventing the spread of the fire, though details of the suppression methods used are limited. The event renewed scrutiny of container spacing, BMS capabilities, and the adequacy of local fire response protocols.

Rothienorman, Aberdeenshire – February 2025

This 49.9 MW facility, developed by One Planet Developments, experienced a fire while either under commissioning or shortly after becoming operational. Although details remain sparse, it prompted significant public concern and has been cited in parliamentary debates about the adequacy of current regulatory and planning systems. The incident was contained by the Scottish Fire and Rescue Service within hours, but the lack of transparency over the cause and environmental impact has reinforced calls for enhanced industry oversight and fire safety planning.

East Tilbury, Essex – February 2025

At the time of the incident, this 300 MW / 600 MWh BESS facility, owned by Statera Energy, was still under construction. A fire initiated by a single battery cell fault was effectively contained to a single container through the use of a water curtain system, supported by effective on-site infrastructure including adequate container spacing and a robust fire water supply. Fire crews controlled the fire within 24 hours, and the site was returned to management the next day. This incident demonstrates the importance of proactive site design and integrated fire response measures.

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3. Technical Causes of Lithium-ion BESS Fires: Summary of Findings by Prof. Peter Dobson

According to Prof. Peter Dobson's February 2025 briefing note, lithium-ion batteries are chemically and thermally unstable under certain failure conditions. The dominant cause of failure is **thermal runaway**, triggered by internal short circuits that arise from the formation of **lithium dendrites**. These dendrites bridge electrodes within a battery cell, leading to localized hotspots, ignition of volatile organic electrolytes, and self-sustaining combustion that can propagate from cell to cell, module to module.

Thermal runaway is uniquely dangerous due to the following:

- **Oxygen-independence**: Fires can persist even without external oxygen, rendering conventional suppression techniques ineffective.
- **Toxic and corrosive emissions**: Combustion releases fluorinated compounds and metal particulates that contaminate air, soil, and water.
- **Explosion risk**: In confined spaces, vapor cloud ignition can lead to container explosions.

- **Reignition potential**: Fires can reignite hours or days after apparent suppression.
- **Firewater contamination**: Millions of litres of water used for cooling can become toxic runoff, threatening ecosystems.

Although newer lithium ferro-phosphate (LFP) chemistries are marketed as safer, they still experience thermal runaway and may produce higher concentrations of hazardous compounds. Importantly, there are no statutory UK standards for container design, suppression systems, or battery chemistries used in BESS.

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4. Best Practice for Managing Fire Risk: NFCC Guidance

The National Fire Chiefs Council (NFCC) has published guidance to help Fire and Rescue Services manage the risks posed by grid-scale BESS installations. Key recommendations include:

- **Physical spacing** between containers to prevent thermal propagation
- **Thermal detection systems** and gas monitoring for early identification of faults
- **Use of water curtains** and deluge systems to cool adjacent containers
- **Passive ventilation** or explosion vents to reduce blast risks
- **Dedicated access routes** for fire appliances and personnel
- **Provision of detailed site plans** and battery specifications to emergency responders
- **Environmental safeguards** to capture and treat toxic firewater runoff

Despite this, NFCC guidance is **non-binding**, and adherence varies widely across projects. Prof. Dobson notes that many facilities lack basic fire barriers, use second-life batteries of unknown provenance, or operate without fire-approved battery management systems. There is no legal obligation to follow NFCC guidance, leaving critical risk controls unenforced.

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5. Risk Assessment: Fire Incidence per MW-Year

To assess risk systematically, we calculate the fire incident rate per installed MW-year, which allows us to normalise the risk across varying scales of BESS deployment. This method provides a comparative benchmark for assessing the relative safety of energy storage deployment over time and helps quantify the likelihood of future incidents as capacity scales up.

- **Cumulative Total of UK BESS Fires** : 4 recorded incidents 2020-2025
- **Current Operational Capacity**: 2,600 MW
- **Average Operational Period Considered**: 3 years (approximate window over which fires occurred)
- **Total Exposure**: 2,600 MW x 3 years = 7,800 MW-years

This results in an incident rate of:

4 fires / 7,800 MW-years = 0.000513 fires per MW-year, or approximately **1 fire per 1,950 MW-years**

Projecting Future Risk:

The UK Government's stated 2030 Clean Power Action Plan BESS delivery targets are:

- **Target Capacity by 2030**: 27,000 MW
- **Target Capacity by 2035**: 29,000 MW
- Assuming a consistent average operational period:
  - 2030 projection: 27,000 MW x 1 year = 27,000 MW-years
  - 2035 cumulative (5-year extension): 29,000 MW x 5 years = 145,000 MW-years

Using the observed rate:

- **By 2030**: 27,000 x 0.000513 = ~13.85 fires per year
- **Cumulative by 2035**: 145,000 x 0.000513 = ~74.4 additional fires

This equates to a **cumulative total of nearly 90 BESS fires** in the UK by 2035 if current patterns persist. While this extrapolation is based on limited data, it illustrates a crucial trend: as BESS capacity increases, so too does the absolute number of potential incidents—even if relative risk remains constant.

It is important to acknowledge that while BESS technology is rapidly evolving, **there is currently no fail-safe method to eliminate the risk of thermal runaway**. All known fire suppression, detection, and monitoring systems—such as Battery Management Systems (BMS), thermal sensors, gas detectors, and water curtain suppression—can reduce but not eliminate this hazard. These systems are also subject to hardware failure, miscalibration, and limited reaction time during rapidly developing events.

This was tragically demonstrated in the **Moss Landing BESS fire in California**, which occurred despite the facility being equipped with all the latest state-of-the-art detection and suppression systems. The site, operated by Vistra Corp., was designed with comprehensive fire protection features including water-based deluge systems, gas detectors, and automatic alarm escalation protocols. However, these technologies did not prevent a series of overheating and venting events that led to substantial damage and operational shutdowns. Moss Landing highlights the limitations of even the most advanced systems when faced with unpredictable battery behaviour and complex cascading failures.

These findings reinforce the argument that risk calculations such as the fire-per-MW-year metric must play a central role in **planning decisions**. They should be used to:

- Establish baseline thresholds for acceptable risk in local authority assessments
- Inform the level of required fire mitigation and site access infrastructure
- Justify the involvement of Fire and Rescue Services as statutory consultees
- Require worst-case scenario planning, including evacuation protocols and water runoff containment

Planning frameworks must evolve from assuming ideal operation to recognising that thermal runaway is a known, foreseeable, and potentially catastrophic failure mode. Policy must be based on empirical evidence, probabilistic risk, and engineering realism—not theoretical performance models.

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6. Implications for Planning Policy and Planning Decision Making

The growing deployment of BESS technologies is not being matched by an equivalent evolution in planning policies or safety oversight. To date, planning decisions by Local Councils and the Planning Inspectorate have often accepted the assumption that BESS facilities will "operate as intended" and do not address failure scenarios. This position is **wholly illogical and dangerous**, given the inherent instability of lithium-ion chemistries and the documented history of fires and explosions.

Fire and Rescue Services currently have **no statutory role** in the planning consultation process for BESS applications. This omission is indefensible. Local fire authorities must be:

- **Made statutory consultees** for all BESS-related planning decisions
- **Given authority to delay or block approvals** where insufficient fire mitigation is demonstrated
- **Empowered to review site design**, battery specifications, and emergency access plans prior to consent

No planning permission for large-scale lithium-ion BESS installations should be granted unless and until the relevant Fire and Rescue Service has signed off on the proposed safety measures.

Furthermore, the Government must:

- **Introduce mandatory design standards**, including minimum spacing, suppression systems, and BMS protocols
- **Apply COMAH regulations** to large-scale BESS sites
- **Require Hazardous Substances Consents** where applicable

Without these changes, local communities, emergency responders, and the environment remain at unacceptable risk.

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7. Conclusion

Battery storage is an essential technology for the clean energy transition, but it is not without significant hazards. The UK's experience with BESS fires, though limited in number, offers urgent lessons in design, regulation, and planning. The risks are well understood. However, the technical challenges involved in ensuring Fire Safety remain unresolved. What is also lacking is regulatory clarity and policy leadership.

The pathway to 2035 must include not only many hundreds of gigawatt-hours of storage, but gigawatt-hours of safe, intelligently managed, and properly regulated storage. Anything less threatens to undermine public trust and compromise the long-term sustainability of the UK's energy infrastructure.

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