The Role of Batteries in Energy Storage

John-Joseph Marie
Principal Analyst – Energy Storage
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The role of batteries in energy storage

Where do batteries fit in?

Very Short Duration Storage	Short Duration Storage	Medium Duration Storage	Long Duration Storage
Discharge duration of 1 to 10 mins	Discharge duration of 0.5 to 4 hours	Discharge durations of 4 to 200 hours	Discharge durations of 200+ hours

The role of batteries in energy storage

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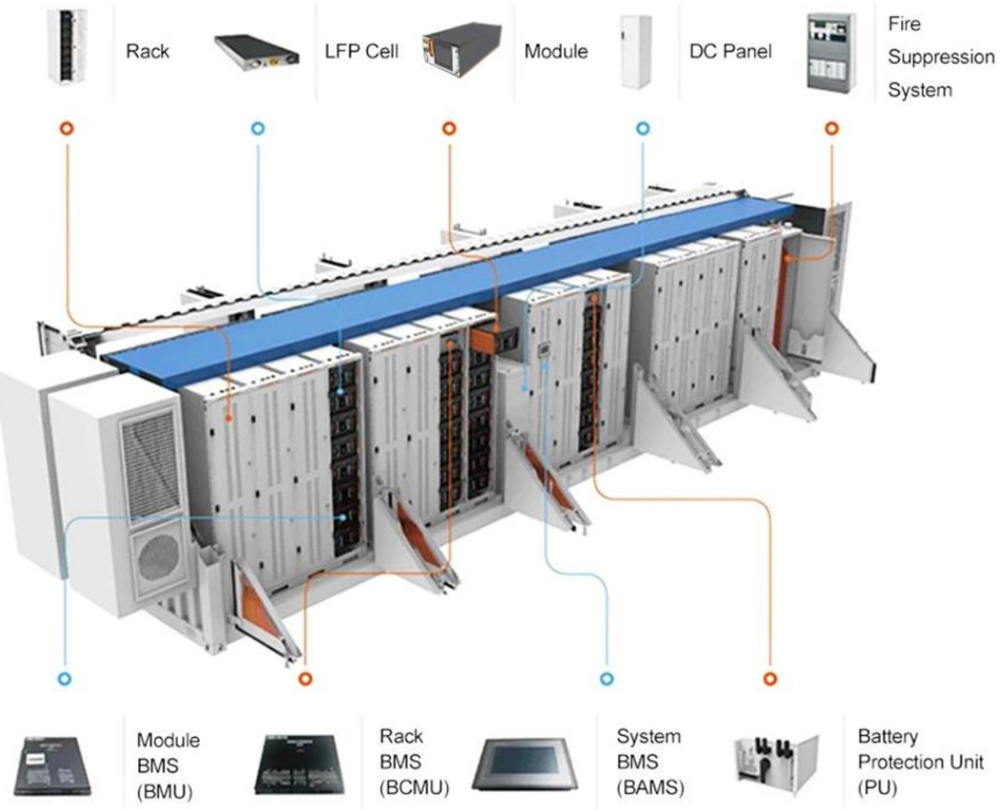
	Battery Energy Storage		

Talk Overview

- How are batteries used as energy storage devices?
- What are the key applications of battery energy storage on the grid?
    - Utility scale
    - Behind-the-meter
    - Co-location
- How will these applications change between now and 2030?
- What technologies are used for battery energy storage?

An overview of battery energy storage systems (BESS)

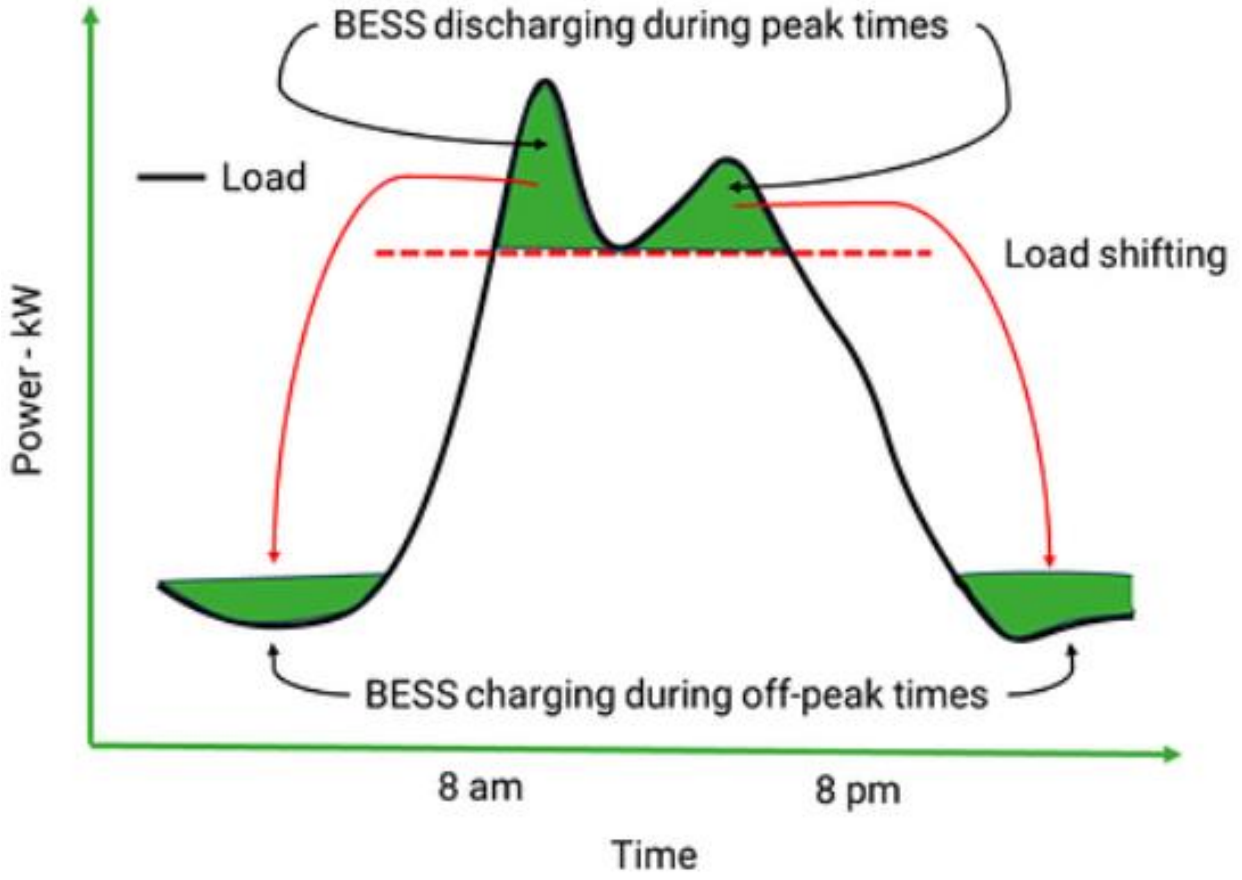
- A battery energy storage system allows electricity from the grid, or from renewable energy sources, to be stored and used later.
- BESS are comprised of:
  - Battery system (battery cells)
  - Battery management system (at the module, rack and system level).
  - Power conversion system
  - Cooling systems
  - Fire suppression systems
- Different battery chemistries may be installed depending on the use.



Applications of BESS – Utility scale

Energy shifting

- **<u>Energy supply applications</u>** for energy storage provide electricity to the grid to help meet demand.
- BESS are **<u>charged during periods of low electricity demand</u>**, or with excess generation from renewables (energy arbitrage).
- This energy is then supplied back to the electricity grid in **<u>periods of peak demand.</u>**



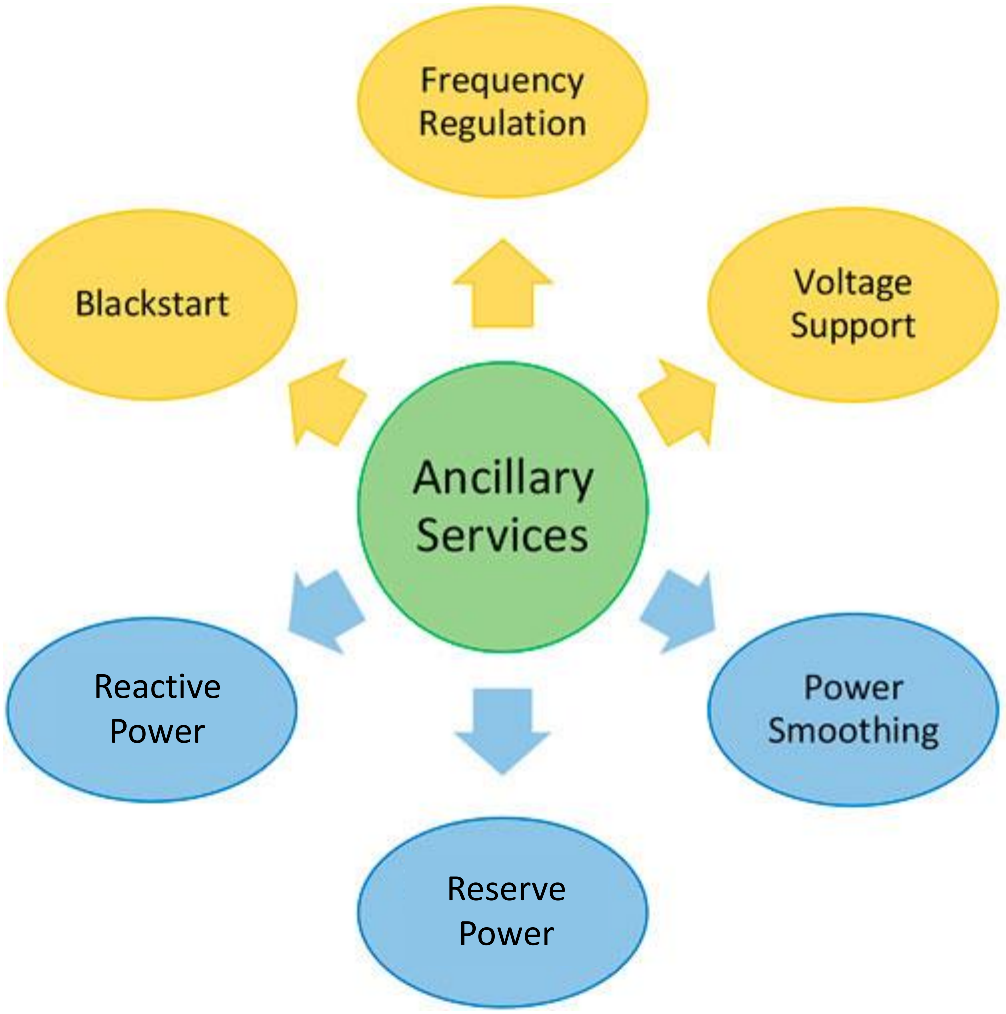
Applications of BESS – Utility scale

Ancillary services

- Refers to a **broad array of services** keeping the electricity grid within its operational frequency requirements and **ensure system stability.**

- Batteries are particularly well suited to frequency regulation applications due to fast response times.

- BESS are being investigated to **provide synthetic inertia** to the grid, as well as providing **black-start capabilities**.



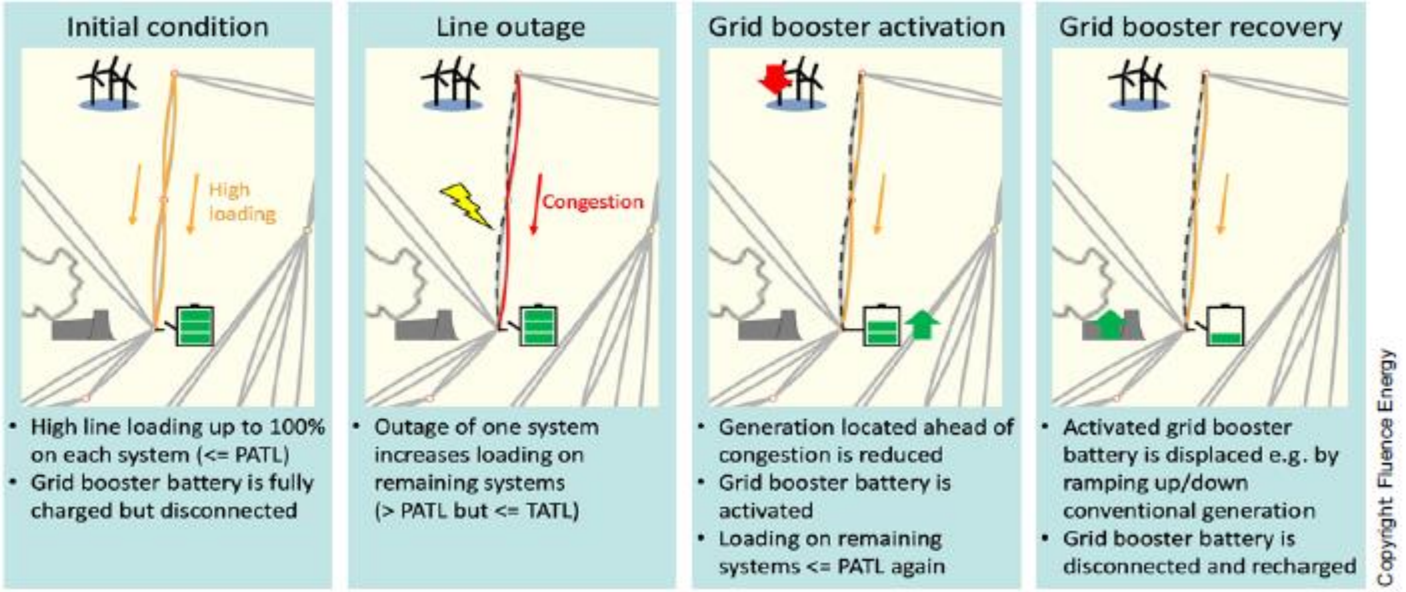
Applications of BESS – Utility scale

Congestion Relief

- Providing **local flexibility** aims to **alleviate and manage grid constraints** on the transmission and distribution networks.

- These are required when the electricity grid is unable to transmit power due to thermal constraints (or others).

- BESS provides an alternative to these solutions by shifting electricity usage from peak to off-peak periods.



Applications of BESS – co-location and BTM

Co-location

- BESS can be co-located with renewable energy generation to help smooth power output and reduce curtailment.

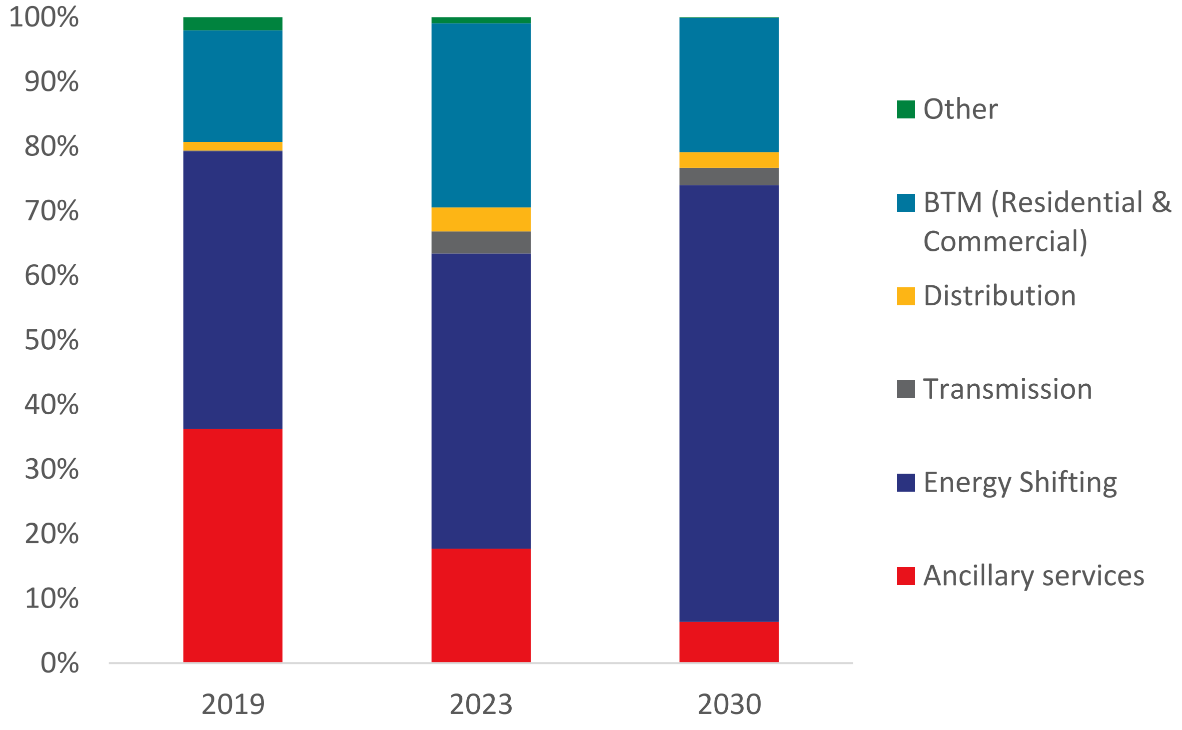
Residential & Commercial

- Improve the resilience of consumers.
- Increase consumption of on-site renewable energy generation.
- Provide grid connection upgrade deferrals.

Applications of BESS in the UK – Breakdown of use cases

- BESS are used for multiple applications at once (also known as revenue stacking).
- Initial uses of BESS were focused on ancillary services (requires 0.5 to 1 hour BESS).
- As ancillary service markets become saturated, new revenue opportunities have emerged such as energy shifting (requires 2hours+ BESS).
- This will lead to an **<u>increase in the average discharge duration of installed BESS</u>**, increasing from **<u>~1.5 hours to +2.5 hours</u>** towards 2030.

Breakdown of applications for UK energy storage installations between 2019 and 2030.



Data from BNEF, 2023.

UK BESS Demand and Technologies

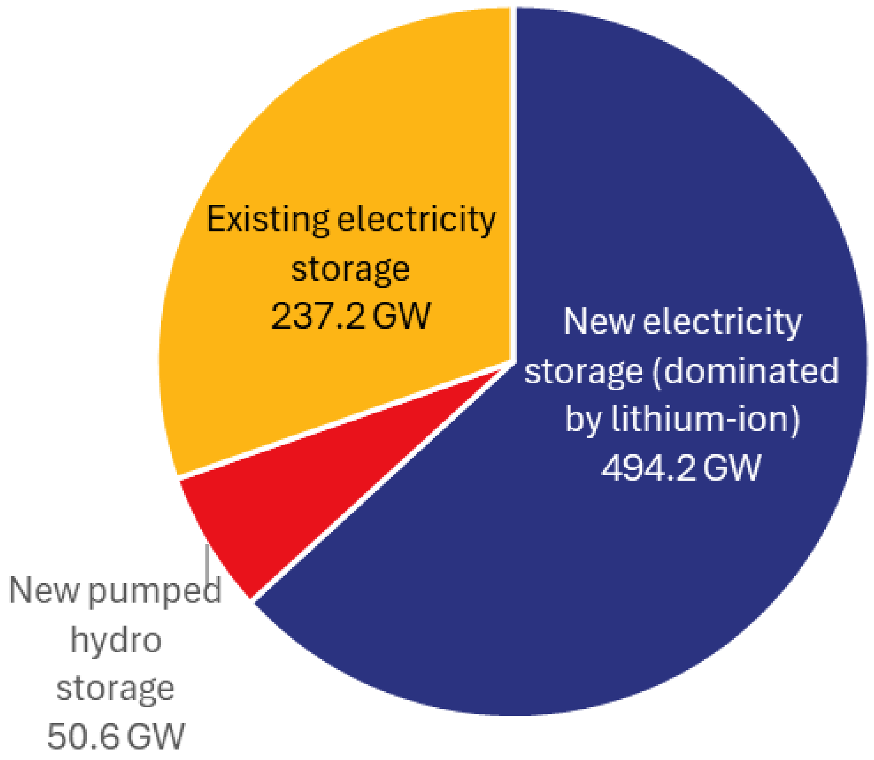
Current technologies: Lithium-ion

- UK BESS capacity sits at:
    - In 2024, 3.5GW / 5GWh.
    - By 2030, ~30 GW / 60GWh.
    - By 2050, ~50GW / 100 GWh.

- **In 2030, lithium-ion BESS will be the most widely installed energy storage technology globally**.

- Lithium-ion batteries are in high demand as:
    - **Lithium-ion can be deployed quicker than other storage technologies**
    - **Lithium-ion batteries are higher performing than other battery chemistries**
    - **Lithium-ion batteries have benefitted from rapid technological innovation.**

Global energy storage capacity landscape in 2030.



Data from CNESA, BNEF, and IEA.

UK BESS Demand and Technologies

Current technologies: Lithium-ion

- The BESS landscape is dominated by lithium-ion (specifically, LFP batteries).
- **In 2030, lithium-ion BESS will be the most widely installed energy storage technology globally**.
- Lithium-ion batteries are in high demand as:
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Next-generation battery chemistries

- Sodium-ion batteries:
    - Could cost 20-30% less than lithium-ion
    - Will compete with lithium-ion in short duration storage applications.
- Redox flow batteries:
    - Vanadium-flow already in use. Many other chemistries under development.
    - Targeting longer discharge duration applications (~4-8 hours).
- Metal-air batteries:
    - Theoretically very cheap to produce, but low power density and efficiency.
    - Targeting 100 hours discharge durations (Form Energy, US based company).

Concluding Remarks

BESS are well suited to short duration energy storage

- Lithium-ion (in the form of BESS) are the fastest growing energy storage technology today.
- BESS will be used for energy shifting applications on the grid but are also important for ensuring grid stability through ancillary services.
- The average discharge duration of BESS will increase towards 2030 as larger BESS are installed.

Lithium-ion is the technology of choice for BESS towards 2030

- Lithium-ion technology is the driver behind the demand for energy storage globally.
- Lithium-ion batteries are characterised by high power densities and high round-trip efficiencies.
- The cost of lithium-ion cells has fallen dramatically over the past decade, ensuring their use beyond electric vehicles.

New battery technologies are aimed at medium duration storage

- Next generation battery technologies are aiming to reduce the costs of BESS.
- Sodium-ion has the most potential to compete with the lithium-ion batteries of today.
- Redox-flow batteries and metal-air batteries are aiming for medium duration storage.

Thank you

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Next-generation battery technologies for energy storage

Sodium-ion batteries

- Cons: Lower energy density, but overall similar performance for lower cost.
- Pros: Could cost 20-30% less than lithium-ion (at the cell level).
- Will be used for similar applications to lithium-ion.
- Has the most potential to compete with lithium-ion for market share.
- Sodium-ion BESS were installed in China in 2024.

Redox-flow batteries

- Cons: Very low energy density and lower efficiency.
- Pros: No self-discharge, can decouple power output and energy storage volume.
- Targeting longer discharge duration applications than lithium-ion (~4-8 hours).
- Vanadium-flow batteries are already in commercial use.
- However, many other chemistries are under development in a bid to reduce costs.

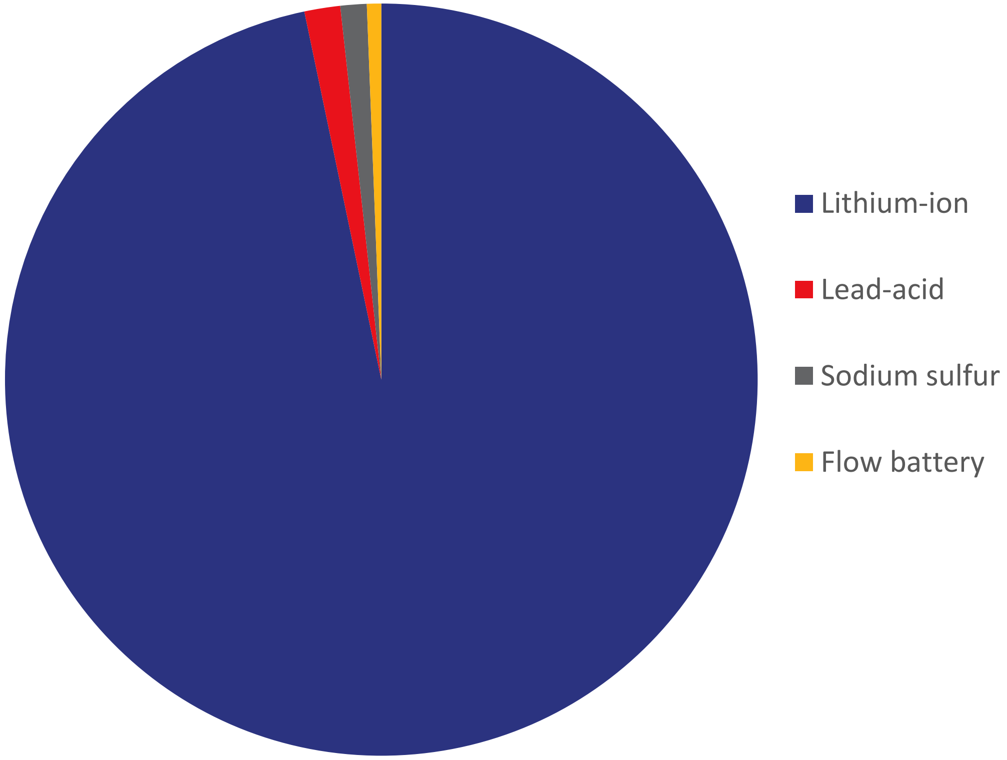
Metal-air batteries

- Cons: Very low energy, power density and efficiency.
- Pros: Theoretically very cheap to produce.
- Targeting 100 hours discharge durations at a tenth of the cost of lithium-ion.
- Most advanced company in this space is US Form Energy.

Why is lithium-ion so good?

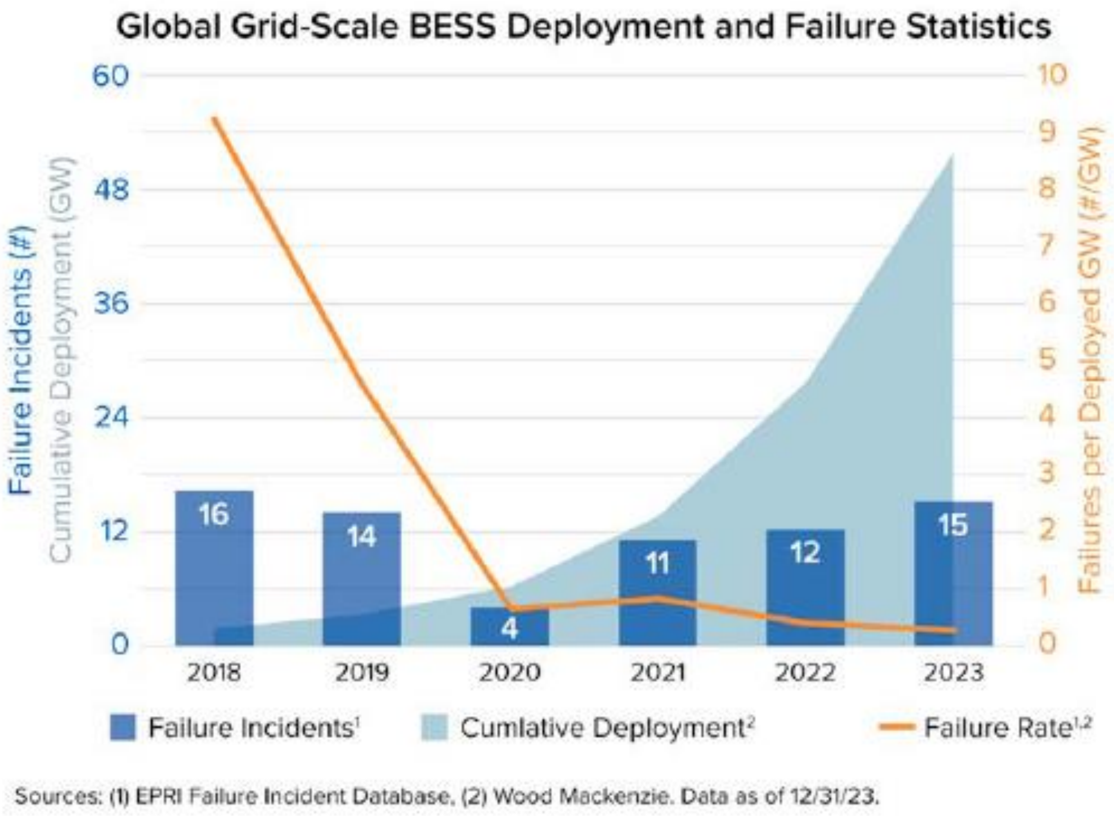
- Many legacy battery chemistries have been used in energy storage systems.
- However, the BESS landscape is dominated by lithium-ion (specifically, LFP batteries).
- There are three key reasons for this:
  1. **BESS are modular** and can be **deployed more quickly** than other storage technologies.
  2. **Lithium-ion batteries are higher performing** than other chemistries in key areas, notably **power density** and **efficiency**.
  3. Lithium-ion batteries have benefitted from **rapid technological innovation**.

Breakdown of battery chemistries installed in energy storage applications in 2022.



Safety improvements of BESS

- **Safety** is a priority for batteries in energy storage applications.
- Safety concerns are prominent due to the rapid increase in demand for lithium-ion batteries, which has experienced several high-profile incidents in recent years.
- However, **global failure rates of BESS dropped 97% between 2018 and 2023.**
- This is thanks to **lessons learned** from previous incidents have been incorporated into **system designs and safety protocols**



Source: EPRI - Insights from EPRI's Battery Energy Storage Systems (BESS) Failure Incident Database (2024).

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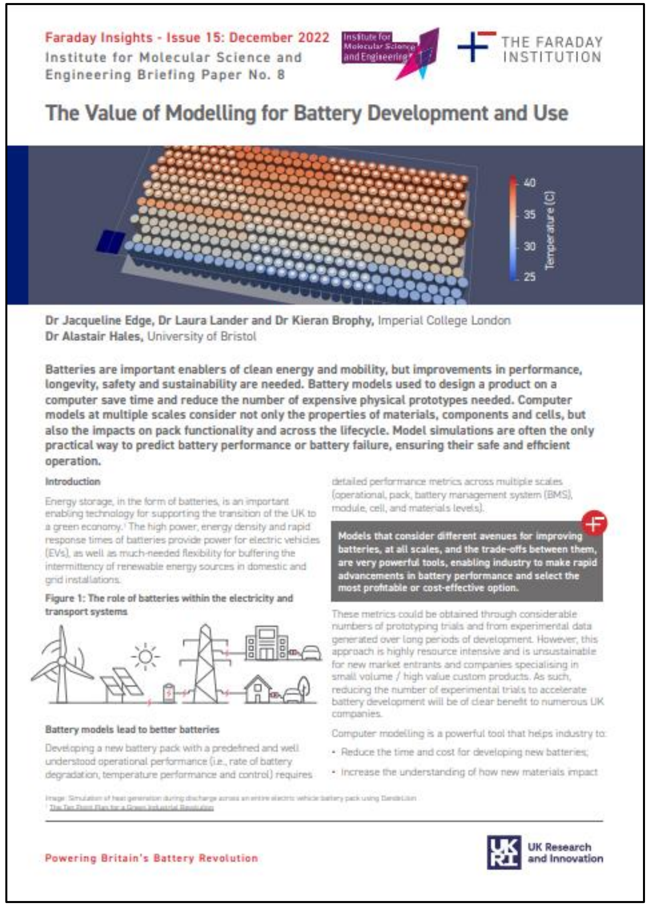

Faraday Insights - Issue 15: December 2022

Institute for Molecular Science and Engineering Briefing Paper No. 8

The Value of Modelling for Battery Development and Use

Dr Jacqueline Edge, Dr Laura Lander and Dr Kieran Brophy, Imperial College London
Dr Alastair Hales, University of Bristol

Batteries are important enablers of clean energy and mobility, but improvements in performance, longevity, safety and sustainability are needed. Battery models used to design a product on a computer save time and reduce the number of expensive physical prototypes needed. Computer models at multiple scales consider not only the properties of materials, components and cells, but also the impacts on pack functionality and across the lifecycle. Model simulations are often the only practical way to predict battery performance or battery failure, ensuring their safe and efficient operation.

Powering Britain's Battery Revolution

Faraday Insights - Issue 20: July 2024

Developing a UK lithium-ion battery recycling industry

Jonathan Leong, Business Intelligence Manager, Faraday Institution

Establishing a battery recycling industry in the UK will enhance the security of the supply chain for the raw materials needed for EV battery production, while also ensuring the sustainable treatment and management of used materials. At present, recycling is a labour-intensive process, with costs heavily dependent on factors such as battery chemistry, commodity prices and recovery efficiency. Developing and implementing advanced recycling technologies and processes should increase efficiency, reduce costs and help foster a circular domestic battery economy.

Powering Britain's Battery Revolution

Faraday Insights - Issue 17: July 2023

Improving the Safety of Lithium-ion Battery Cells

Paul Christensen, Wojciech Mrozik, Newcastle University
Julia Weaving, University College London

Lithium-ion battery cells in electric vehicles are already safe and failure incidents are very rare. But with increasing use across automotive, stationary storage, aerospace and other sectors, there is a need to make them even safer. Whilst lithium-ion cell fires are extremely infrequent, they can occur under conditions of mechanical, thermal or electrical stress or abuse. Building safer and more reliable lithium-ion battery packs, as well as improving the design and optimisation of safety systems, will help to decrease the risks associated with rising lithium-ion battery usage.

Powering Britain's Battery Revolution

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