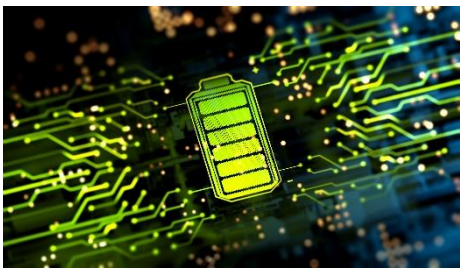
Rapid Technology Assessment: Novel Batteries

Batteries store chemical energy and convert it into electrical energy. Demand for batteries is rapidly increasing. They are used in a huge range of applications from consumer electronics to aerospace and electricity networks. There are many technologies in development that could lead to performance, safety, and sustainability improvements.

Introduction

- **Demand for batteries is projected to increase 20% year on year up to 2030**, primarily driven by electric vehicle sales and restrictions on non-electric vehicles. The Faraday Institution estimates a successful UK industry in 2040 could support ~270,000 jobs in electric vehicle (170k) and battery manufacturing (65k), and battery supply chains (35k).
- **Lithium-ion (Li-ion) batteries are expected to dominate the rechargeable battery market for the next decade** due to their high energy density, long cycle life and decreasing costs.
- **However, there is likely no single technology that will suit all future use cases** in transportation, aerospace, and in decarbonised electricity grids. Emerging technologies are expected to outperform Li-ion batteries in specific applications with benefits including enhanced performance, sustainability, and safety. **Emerging technologies are at a range of readiness levels** and most require further research or face challenges to commercialise at scale.



UK Position

- **The UK has a strong research base** and produces impactful research but fewer publications or patents than leading nations. Globally, across different emerging battery technologies the UK ranks:
- **2nd-6th** for research impact.
- **2nd-6th** for investment.
- **6th-8th** for research publications and patents.

Recent Developments

- **Current Li-ion battery technologies are thought to be nearing their theoretical performance limits**. Advanced cathode or anode materials (e.g. niobium, silicon) will be needed to further reduce costs, reliance on critical minerals, and improve performance.
- **Research into solid-state batteries (SSBs) is an area of increasing industry focus.** SSBs could provide significant increases in battery performance (e.g. significantly extending EV range), longevity, and safety. Challenges remain in developing cost-effective SSBs and scaling manufacturing. Early commercialisation could occur in the late 2020s, with wider adoption in the 2030s.
- **There are a range of emerging battery technologies at different stages of development**, with varied characteristics that lend them to different applications, e.g. redox flow for long-term storage, and Li-sulfur where low battery weight is critical (e.g. aerospace). The UK has notable research and industry activity in Na-ion batteries, which may offer cost and safety benefits in a range of applications.

Opportunities

- **Battery demand in the UK is expected to increase significantly.** There is an opportunity to meet this demand by scaling domestic manufacturing, along with supply and processing of key materials such as lithium. Some emerging battery technologies could be well suited to application in **a decarbonised grid.**
- **Sustainability.** Battery manufacturing is energy intensive. Localising manufacturing in countries using a high proportion of low carbon electricity could increase battery sustainability. Capability for recycling, reuse and repurposing of batteries also offers sustainability benefits and will become increasingly important as the volume of EV batteries reaching end of life increases.
- **Transport and aerospace.** Heavy goods vehicles, aviation, and maritime are expected to be difficult sub-sectors of transportation to decarbonise and electrify, presenting opportunities for emerging battery technologies. Future battery technologies could also be suited to satellite and other space and high altitude applications.

Challenges & Risks

- **Many emerging battery technologies require further research and development** before they are viable in real-world applications. Technologies will need to demonstrate scalability and cost competitiveness with established technologies.
- **Securing supply of critical minerals as demand increases.** Many emerging battery technologies, but not all, will require similar critical minerals as Li-ion batteries.
- **Skills.** Increased domestic capacity for manufacturing and recycling, reuse, or repurposing will require an increase in the number of skilled technicians.
- **Repurpose, reuse and recycling.** Methods for recycling batteries can be crude and energy intensive. Reusing or repurposing batteries that no longer meet the performance requirements for their first use also requires new or improved processes, and faces challenges such as unstandardised battery designs. However, innovative solutions are emerging.

*This is a summary of a report completed in October 2022. There may have been developments and additional data since then that are not captured in this summary. Patent and research publication data was sourced from **Dimensions Analytics**. Investment data from **PitchBook Data, Inc**. Search terms available on request. With thanks to the following for their contribution and expert review: BEIS, HSE, FCDO, NPL, DfT, DSTL, IPO, the Royal Society of Chemistry, the Faraday Institution, the Faraday Battery Challenge at UKRI delivered by Innovate UK, Prof. Sir Peter Bruce, Prof. Dan Brett, Prof. Kang Li, Dr Amor Abdelkader, Prof. Zulfiqar Kahn, Haydn Francis, and Prof. Mauro Pasta.*