THE ROYAL SOCIETY

Electrochemical energy storage

A summary of a Royal Society workshop held on 10 January 2017

Background

As society transitions to renewable and often variable power sources, energy storage is playing an increasingly important role.

A workshop was organised by the Royal Society to identify opportunities for the UK's world class research base to play a leading role in the field of electrochemical energy storage, from breakthroughs in fundamental research, through their translation into new or improved technologies, with further consideration given to their mass commercialisation for both static and mobile applications.

Discussion

Batteries, a major electrochemical energy storage technology, are needed with improved energy density, safety, cycle and calendar life as well as being engineered to permit faster charging and discharging. These requirements translate into challenges in the following areas

- **New materials**: advances in the materials used for electrodes and electrolytes are required, including higher capacity cathodes, higher power cathodes as well as materials advances that enable greater safety such as solid electrolytes.
- **Safety**: it is essential to keep the risk of combustion to a minimum for the safety of customers and also to enable safe transport of batteries before and after use.
- **Interfaces**: improved understanding of the complex interfaces between the solid electrode and electrolyte is needed. This is important to address longer lifetime, reduce degradation, improve temperature stability and advance safety.
- **New liquid electrolytes and additives**: are required to reduce the volatility and flammability of existing liquid electrolytes.
- **Smarter electrode design**: to improve energy and power density.
- **Sodium batteries**: potential to reduce cost from a more abundant material.
- **Solid-state batteries**: in the longer term, solid-state batteries offer a potentially significant step forward in safety along with increased gravimetric and volumetric energy density.

Given the typical lead-times for the development of any new technologies and the scale of research effort in battery science required to drive new battery development, it is reasonable to assume that for at least the next several years there will be no transformative technology coming to the market that will outperform Li-ion battery technology.

The workshop identified gaps in the energy storage market that the UK could play a role in:

- **Recyclability**. This is currently not a design criterion and there is little industry activity targeting the issue. Overall there are no real incentives to recycle batteries. Expertise in recycling is low worldwide, so this could create an opportunity for the UK to become a world leader in understanding which materials can be effectively recycled and developing methodologies for the recycling process. Trade-offs may be necessary between developing non-recyclable powerful batteries and less powerful recyclable batteries. Recycling could also

bring new opportunities to the fore as highly recyclable but shorter life batteries may be easier to create than long life.

- **Standards**. There is a gap in safety certifications on the battery market; the UK could pioneer this.

The UK holds significant strength in research capability across a range of science and engineering disciplines that could be harnessed to accelerate the pace of battery research, but this drops off in commercialisation where countries like Japan and Korea have the lead. A small number of companies in the UK are involved in electrochemical energy storage, but there are no large cell manufacturers or materials supplier. The Industrial Strategy could provide an opportunity to address this problem.

The UK is particularly well placed in small and medium sized enterprises focussed on technologies beyond current lithium ion research. This includes both sodium ion, lithium sulphur and silicon based batteries. These fields, and correspondingly these organisations, rely on a wide range of expertise coming together across disciplines.

The current market for lithium batteries has been driven by portable personal devices, but a significant shift is being seen as electric vehicles come on line in mass. Keeping the electric vehicle industry in the UK will help both safeguard and create jobs as well as stimulating exports.

Current electric vehicle markets show significant clustering of the value chain. Battery manufacturing plants should ideally be built next to their corresponding car factory. This would help ensure quality and reduce the risks and transport costs associated with shipping. For the full life cycle to take place in the UK, research, cell formation, packaging and second life manufacturing facilities need to exist. The critical missing element in the UK so far is the lack of cell and packaging manufacturing.

Delegates suggested that as part of the UK energy storage industry strategy a joint venture involving a leading battery company should be explored as an inward investment to the UK. While being immediately able to produce batteries based on licensed technologies, the plant could also prepare for the production of upcoming technologies. This joint venture could be directly involved in the development process of new technologies and build strong collaboration with UK academia.