http://dx.doi.org/10.1595/205651317X695839 *Johnson Matthey Technol. Rev.*, 2017, **61**, (3), 222–226

JOHNSON MATTHEY
TECHNOLOGY REVIEW

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UK Energy Storage Conference

Research progress, economics and policy considerations in the field of energy storage

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Introduction

The third UK Energy Storage Conference (UKES2016) was held at the Edgbaston campus of the University of Birmingham, UK, from midday on Wednesday 30th November to midday on Friday 2nd December 2016. The aim of the conference, organised by the Energy Storage Research Network on behalf of the UK Research Council funded Energy SuperStore Hub and chaired by Professor Nigel Brandon (Imperial College London), is to provide an inclusive platform for the UK energy storage community to come together and share their work and views.

The conference was well attended, with a total of 280 delegates, 61 from industry and six from government. The rest were from academia, including 89 students. Most of the delegates were from the UK, but 28 were international. A total of 73 posters were on display throughout the conference, stimulating discussions during refreshment breaks.

Judging by the positive feedback received, the conference appears to have been a success. Delegates were enthusiastic and highly engaged in the programme, which involved long sessions running until late afternoon. During the breaks, discussion groups formed, either around the highly topical posters or to discuss possible future collaborations.

The presentations reviewed below consist of a selection of those who volunteered their slides for public access. The three winning posters are also reviewed in this article. For a full listing of the talks presented at UKES2016, please go to the conference website. Where permission has been granted, the slides are available to download. The top three posters were selected by a panel of judges. Digital copies of these and a few others, all volunteered by the presenters, are available on the conference website.

The conference presentations were arranged within the following themes:

- Demonstration Projects
- Policy and Economics of Storage in Energy Systems
- Storage for Transport
- Integration of Storage into Energy Networks
- Hydrogen for Energy Storage
- Flow Batteries
- Thermal, Mechanical and Thermochemical Storage
- Electrochemical Energy Storage
- Advanced Tools and Diagnostics
- Power Management and Control.

Batteries

Dan Rogers (University of Oxford, UK) gave an engineering perspective of grid-scale energy storage in his plenary talk on the second day, explaining his work on power electronics. This field involves using semiconductor devices to control and convert electrical energy. This allows large arrays of cells to be monitored and managed electronically, through carefully constructed algorithms. For large arrays, it is more probable that at least one cell will be significantly weaker than the rest and therefore the construction of simple large arrays becomes challenging. Power electronics can be inserted into the pack to mitigate the influence of the weaker cells and improve overall performance (capacity utilisation and system reliability). Using Markov chain reliability modelling, Rogers was able to show that the reliability of high voltage grid-scale batteries (comprising very large numbers of cells connected in series) can be greatly improved by adding power electronics within the pack (**Figure 1**), even if the power electronics devices themselves are significantly less reliable than the cells.

These themes were discussed further in a keynote delivered by Joel Sylvester, the Chief Technical Officer for Dukosi Ltd, UK, in the Power Management and Control session. Battery management systems improve safety, balance the performance of multiple cells and monitor cell degradation to predict failure early on. Embedding this into cells at the time of manufacture can reduce costs, extend lifetimes and validate warranties. Jorn Reniers (University of Oxford) won a prize for his poster in this theme, entitled 'Offering Multiple Grid Services in Parallel while Minimising Battery Degradation'. The results of a battery pack simulation are presented, showing that the cost benefits of extending the lifetime of the battery through active management outweigh the revenue loss from occasionally missing grid revenue opportunities.

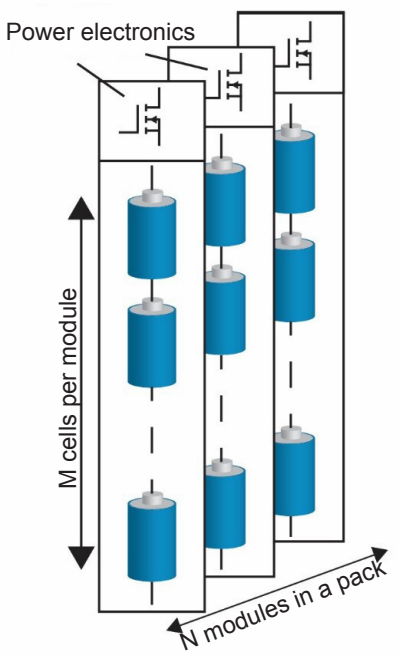

Fig. 1. The cells in a battery pack can be divided up into N modules, with each module of M cells controlled by power electronics (Reproduced with permission)

The session on demonstration projects aimed to showcase a range of automotive and grid scale projects currently being developed. Colin Arnold (AGM Batteries Ltd, UK) introduced two new automotive projects that AGM Batteries Ltd are heavily involved in, 'UK Automotive Battery Supply Chain', funded by the Advanced Propulsion Centre (APC), UK, and 'Sodium-Ion Batteries for Electric Vehicles', funded by Innovate UK. The first requires the development of highly innovative embedded electronics whilst establishing the foundations of a world class UK lithium battery supply chain involving industrialists and academics working together to share insights and expertise. The second project aims to take advantage of exciting sodium-ion chemistry to develop safer and lower cost batteries for electric vehicles and other sectors. During the evening of the first day, the APC hosted a panel session focused on energy storage applications in the automotive industry. Chris May (APC) opened the session with a talk on how the APC is working to identify strategic opportunities for the UK automotive supply chain (**Figure 2**). Mike Woodcock (APC) and Professor David Greenwood (University of Warwick, UK) then went on to explain how the APC is bringing together the academic and industrial communities to capitalise upon these opportunities.

Xiaohong Li (University of Exeter, UK) delivered one of the keynote addresses in the flow batteries session on a redox flow battery (RFB) system which does not use membranes. In most commercially available RFBs, the ion exchange membrane comprises about a third of the production cost, so removing the need for this membrane will offer opportunities to make RFB technology economically viable for grid-scale applications (**Figure 3**). Her technique is to develop a zinc-nickel RFB which uses a single electrolyte, eliminating the need to separate two electrolytes with

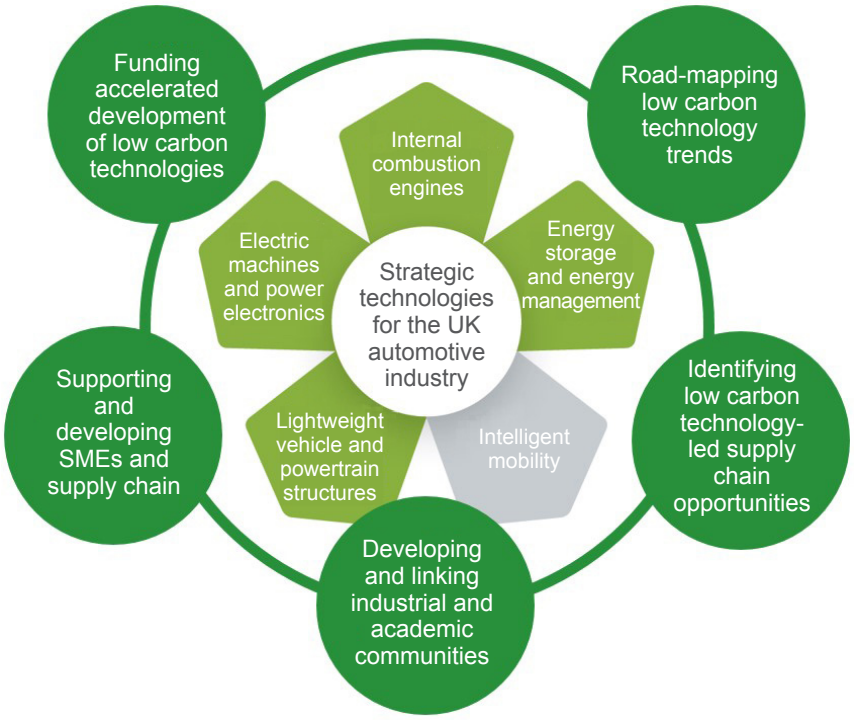

Fig. 2. The 'hub and spoke' model of the APC's strategy for helping the UK automotive industry capitalise on low carbon technologies (Reproduced with permission)

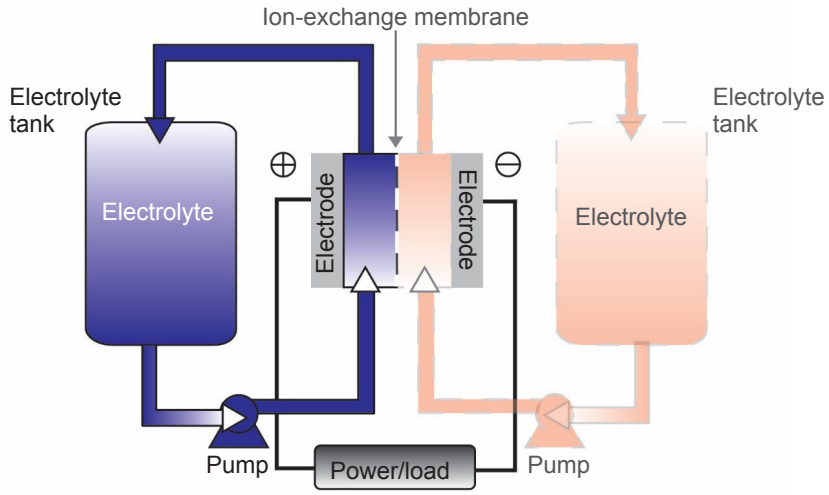

Fig. 3. A conventional RFB has two electrolytes, separated by an ion-exchange membrane and requiring duplicate storage and flow mechanisms. A membrane-free system uses a single electrolyte for reactions at both electrodes, eliminating a large proportion of the components (indicated by the faded out sections) (Reproduced with permission)

a membrane. This will also improve performance and greatly simplify device manufacture and operation.

In the session on electrochemistry, Professor Maria-Magda Titirici presented her work on anodes for sodium-ion batteries at Queen Mary University of London, UK. Sodium is cheaper and more abundant than lithium and is therefore an attractive option for making large scale batteries. The research challenge is to find a suitable anode material and Professor Titirici is researching carbon derived from biomaterials to explore the link between microstructure and performance. One of her PhD students, Pelin Yilmaz, won a prize for her poster, 'Biomass-Derived Low Cost Negative Electrodes in Na-Ion Batteries'.

Energy Storage

The policy session included a joint talk from Catherine Bale (University of Leeds, UK) and Andrew Pimm (University of Edinburgh, UK), describing the objectives

and progress of the Consortium for Modelling and Analysis of Decentralised Energy Storage (C-MADEnS). Two case studies were presented, one examining the public perception of domestic energy storage and the other exploring the potential for peak demand reduction using Tesla Powerwall installed in 100 homes in the city of Leeds. The first study is still underway, but the second study found that it was possible to reduce peak demand by more than 50%.

Graham Oakes, the Founder and CEO of Upside Energy Ltd, UK, gave a keynote address in the storage integration session, entitled 'Stimulating Storage Research through Open Innovation'. Upside Energy considers the many uninterrupted power supply batteries around the UK as a distributed storage asset and has developed online control systems to enable these devices to connect to the grid, providing automated demand side flexibility services (**Figure 4**). Upside Energy was funded by the Innovate UK programme and is an excellent showcase for the benefits of innovation-level funding, demonstrating one way in which the deployment of storage can be encouraged.

A keynote address on the role of storing hydrogen underground was delivered by Professor Bent Sørensen (Roskilde University, Denmark). There are two facilities in operation in Denmark which use underground storage of natural gas: one using a salt cavern and the other using an aquifer store. They could both be converted to hydrogen stores at a low cost and do not require high pressures or low temperatures to store hydrogen in a condensed form. In both cases, hydrogen would be produced using electrolysis, powered by excess renewable energy. The talk discusses the options for similar installations to be established around the world, mainly in China and the USA. He concluded that renewable energy generation integrated with underground hydrogen storage is the least expensive way to supply 100% of the world's electrical energy demands.

Pau Farres-Antunez (University of Cambridge, UK) gave a talk on pumped thermal energy storage (PTES), a high energy density thermomechanical form of energy storage having no dependence on nearby geographical features. If liquid reservoirs are used instead of solid, then each tank of liquid can be stored at low pressure and maintain a single temperature, rather than the gradient necessary for solid thermal reservoirs. The design of these enables a greater separation between the hot and cold stores, limiting the opportunities for thermal transfer after the charge has been completed, which is a source of loss in thermal storage systems. The research at Cambridge is exploring ways to improve the efficiency of these systems. Haobai Xue, a PhD student working in the same research group as Pau, presented a winning poster in this theme, comparing compressed air energy storage (CAES) systems with PTES and showing that while the system efficiency for CAES systems tend to be higher than for PTES, PTES achieves a much higher energy density.

Professor Phil Taylor, Director of the new Centre for Energy Systems Integration at Newcastle University, UK, closed the conference on 2nd December with a plenary talk on the broader perspective of how energy storage fits into future energy systems. His talk examined how the apparently disjointed aspects of

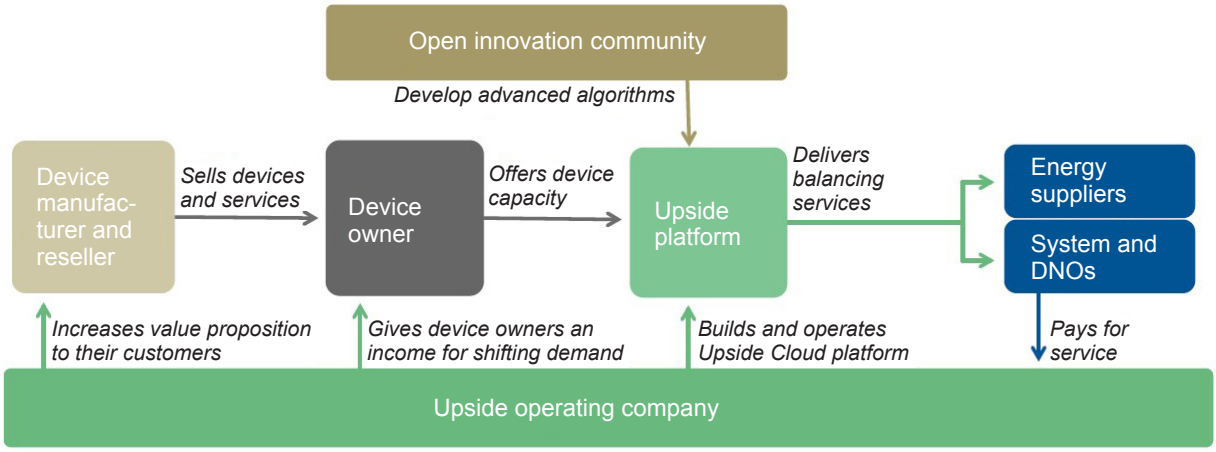

Fig. 4. Schematic showing the Upside operation platform and all stakeholders (Reproduced with permission)

energy storage addressed during the conference could be joined up through integration of the technology into an advanced test bed (**Figure 5**). The new facilities at Newcastle University are part of the Engineering and Physical Sciences Research Council (EPSRC) £30 million programme funding research equipment at several universities around the UK and enable energy storage devices to be integrated into a reconfigurable grid. This will allow testing of many aspects, such as the performance of the devices, ways in which they could be combined to provide multiple grid services or new system operating paradigms to extract the maximum value from the integrated assets.

Conclusions

The conference succeeded in its aim to bring the UK research community together to discuss a wide range of topics in the field of energy storage, spanning economics and policy considerations, through to advanced diagnostics materials and devices. The presentations, both oral and poster, were of a high standard and served to report research progress in these diverse fields, stimulating discussion between people with expertise in diverse research areas, to identify and address the key research challenges for the further deployment of energy storage.

Fig. 5. The Newcastle University energy storage testbed (Reproduced with permission)

The Reviewer

Jacqueline Edge holds two BSc degrees from the University of Cape Town, South Africa, in Zoology and Computer Science. After a career in online banking development, she returned to academia to study Nanotechnology at University College London (UCL), UK, followed by a PhD in Hydrogen Storage. She now manages the Energy Storage Research Network at Imperial College London, facilitating research collaborations through the running of conferences such as the UK Energy Storage Conference.