Storing up success for the future

It's all about creating the right environment – for developing battery technology that is. At one pioneering project Unitemp has supplied Espec environmental chambers to ensure that testing of these new chemistries is safe and reliable

Mark Amor-Segan

Future generations will probably look back on this era with astonishment at the transformation in energy generation and use. The move away from fossil fuels to more sustainable options is well and truly underway and the technology to efficiently harvest energy from renewable sources is maturing nicely. However, for the transformation to become complete the way we store energy needs to become more efficient.

The problem with solar and wind, the main sources of renewable energy, is that they are not good at keeping to a schedule – the wind doesn't blow and the sun shine (particularly at this time of year), just because the nation is sitting down to watch Coronation Street with a cup of tea. Tidal is more reliable but is still relatively speaking in its infancy. The key therefore becomes on storing the energy generated so it can be used when needed.

Despite the advances in chemistries, particularly with Li-ion, the battery is therefore the focus of much attention. And it is not just in power generation. With everything from planes, trains and automobiles down to the billions of smart devices that are being developed, battery life can be a gating factor.

The UK Government has recognised this and identified it as one of the key areas where Britain could gain world leadership by backing the industry now, at a time when battery technology and manufacturing are still evolving. It is not just about the battery technology though, equally important is competitive manufacturing techniques.

Greg Clark, Business and Energy Secretary, said: "Battery technology is one of the most game-changing forms of energy innovation and it is one of the cornerstones of our ambition, through the Industrial Strategy and the Faraday Challenge, to ensure that the UK leads the world, and reaps the economic benefits, in the global transition to a low carbon economy."

Clark was speaking at the end of November 2017 at an event to announce the venue for a £80 million National Battery Manufacturing Development Facility (NBMDF). This new national facility will be built in the Coventry and Warwickshire area by WMG (Warwick Manufacturing Group), the Coventry and Warwickshire LEP and Coventry City Council. It will allow companies based in Britain to come together with researchers to build and maintain a world leading position in manufacturing technologies for batteries and their components in electric vehicles.

It is no surprise that the WMG bid won the day. Part of the High Value Manufacturing Catapult , WMG has been one of the pioneering organisations in the quest to combine the best of academia and industry, as successive Governments' commit to accelerate technology sectors with most potential.

Battery technology is clearly one of those sectors and WMG can boast a facility that is unique in the UK. It includes pilot-scale production equipment in a climate controlled environment that protects the electrolyte from moisture and consequently becoming acidic.

This Battery Materials Pilot Line dovetails with other WMG facilities, such as the battery characterisation laboratory, a module and pack manufacturing pilot line and established electric / hybrid drives test facility. In this environment, new battery chemistries can be developed from concept to final product, and post-test facilities help researchers understand the changes that occur in materials as a battery ages from use or testing.

Mark Amor-Segan is Principal Research Engineer at the WMG's Energy Innovation Centre at Warwick University. He claims that the lesson has to be learned from the story of Lithium Ion batteries, developed at Oxford University three decades ago. The technology was taken as far as it could in that academic environment and was licenced to Sony in Japan. Now all LI-ion batteries are imported.

"We do not want that to happen again," said Amor-Segan. "The idea is that the manufacturing facility we've got here is a pilot scale facility, so it allows companies in the UK which are still generating huge amounts of innovation, new chemistries, new technologies, who don't want the same story to happen again. So they can perfect their manufacturing techniques here on representative manufacturing equipment and then go to Asia or America to the big cell manufacturing plants with all our know-how locked down."

The Energy Innovation Centre is one of the UK's, if not Europe's, largest battery research centres. Under its umbrella there are 15 different laboratories doing everything from experimental chemistry

Espec Chambers in place at Warwick Universities' Energy Innovation Centre

development, particle engineering, recipe making of new chemistries for cells through to cell manufacturing. In the UK it's the only centre that manufactures large format lithium ion batteries. It has recently expanded to three manufacturing lines and the additional funds from NBMDF will allow further capability and capacity to be added.

"The focus of our research is aimed at three different things," said Amor-Segan. "Generally it's performance, cost, safety - those are the three areas. You can't have them all, basically, it's the classic engineering compromise."

Much of the focus in industry remains on Li-ion batteries. Although they have a long track record in such things as laptops and phones, they are starting to be used in transport and bigger storage applications. But for the new chemistries WMG is working on to go from laboratory to large scale manufacturing takes eight to ten years, so for all that the transition to these larger applications is slow and incremental, the Li-ion battery is going to be around for at least another decade.

Not that chemistry is the only factor – good old-fashioned engineering can make a big difference too. The Centre did an experimental project with a Tesla battery pack that weighs about 300kg and is essentially one of these new applications using stacked laptop batteries. In fact these batteries form a structural part of the car. Amor-Segan commented: "Out of that 300 kg of battery there's only 40 kg or 50 kg of active chemistry actually pushing the car forward. The rest essentially is dead weight. You've got some battery cells that are put into modules, the modules are then put into packs. So you've got a Russian doll effect. There's a lot of weight in this pack which does nothing to push the vehicle forward, it's purely higher packaging, safety systems, contactors, bus bars, sensors, factory management systems and so on. So you can make this car go a lot further without touching the chemistry if better materials, engineering making this a light-weight pack, et cetera."

The team changed the module design, the spacing and the cooling to make the system 80% more energy dense than before. "We've almost doubled the capacity of that pack,"

Espec Platinous chamber, with Level 6 EUCAR safety Features

continued Amor-Segan. "So I'd like to say it's not all about chemistry and recipe making. Good material science, light weighting technologies, dense power electronic systems, better safety devices will get you an awful lot of the way to where you need to be."

Recipe making is an important aspect however and not enough is known at the moment to know how new recipes behave. Amor-Segan said: "Our aim here over the next five years is to be able to start to get enough knowledge of how these chemistries work so that we can predict the behaviour, build one, do a little bit of testing to find out whether we've got it right or not. At the moment we make a recipe, we've got no idea what the outcome is, so we then have to test it to death to find out what it does or doesn't do."

What it may do is explode. A battery is essentially a metal can and when pressure builds from within as a result of a chemical reaction then it can become like a hand grenade. Unsurprisingly there are standards, set by the European Council for Automotive R&D (EUCAR), which stipulate the type of testing chamber that batteries are tested in. This scale ranges from zero at the benign end, to seven, which is for units that are likely to explode with considerable force. One down from that at level six are chambers that happily tolerate fire, gas venting and what's called 'energetic release of materials'.

Finding the right chambers was important. First and foremost tests needed to be reliable and safe but other factors also came into the equation; the amount of available test space for the given footprint, energy efficiency, and the ability to meet Eucar at level 6 as a standard rather than as an add-on.

Being a publicly funded body the university needs to put all projects out to tender, and Unitemp has consistently come out on top and initially supplied 12 Espec units to the site, with a second batch of 9, delivered during the last quarter of 2018. Amor-Segan said: "It's the quality, it's because the level 6 requirement are an integral part of the product specification, and also the amount of test space compared to the floor area that the chambers take up is very good."

Because the way they're designed with ventilation air coming out of the top rather than at the back there is a lot of flexibility in where they can be positioned. They can be pushed up against a wall or virtually side by side. "In terms of the amount of test chamber space you can get into a given laboratory, then they're very good. And our experience of using them is that they're very, very reliable," added Amor-Segan.

Energy efficiency has become another interesting factor and the newer Espec cell cyclers are regeneratives - they put energy back into the Grid. "I don't need any air conditioning because there's no losses in here," commented Amor-Segan: "They cycle the same batteries in and out and all energy goes in and out of the Grid, it doesn't go in and out of the room. So I can save several hundred thousand pounds on the air conditioning to back new technology."

Amor-Segan concluded: "I think the final part of the puzzle is the support and after-sales service. Our experience with some of the other manufacturers has not been good, whereas with the Espec chambers it's been very good. We're running 24/7, we've got a multimillion pound programme of activity, we need the chambers to be reliable but also if anything happens we need them to be fixed quickly."

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