The alternative to BATTERIES

If not a direct replacement to batteries, super-capacitors may offer complementary benefits, finds Steve Banner

Peter Harrop has nothing against electric vehicles. As chairman of technology analyst IDTechEx Research, however, he is highly critical of the batteries that are used to power them (see also pp31-32).

He attacks them on the grounds of cost, weight, the amount of space they take up, their limitations so far as power and energy density are concerned, the possibility of current leakage, their reliability, their maintenance requirements and their limited lifespan. He also alleges that they pose safety hazards in terms of toxicity, flammability and the risk – however remote – that they will trigger an explosion.

"Lithium-ion batteries will dominate the market for at least the next ten years, and probably much longer, yet no lithium-ion cell is inherently safe, and no lithium-ion battery management system can ensure safety in all circumstances," says Harrop. "Tesla says it will have solar bodywork on all its electric vehicles, but as the trend from components-in-a-box to structural electronics and electrics progresses, the batteries are the problem. Even solid state ones swell and shrink in use," he adds. "They would destroy bodywork."

Harrop's criticisms accompany a new report published by IDTechEx entitled 'Battery Elimination in Electronics and Electrical Engineering 2018-2028' (*https://is.gd/lazuma*).

No vehicle power source is inherently safe, of course; harness a horse to a cart and there is always the risk you will be kicked at some stage. Traction battery manufacturers would doubtless dismiss many of Harrop's strictures as either exaggerated or baseless. Nevertheless, they cannot deny his point that reserves of many of the materials used in batteries – cobalt for example – are limited and being depleted.

Harrop observes: "Even the start of a journey towards battery elimination can give valuable wins."

Not everyone agrees. Supplies of lithium carbonate, one of the main sources of lithium used in the manufacture of battery cells, are currently very stable, according to Allan Paterson, chief electrochemist at Johnson Matthey battery systems. He also argues that future legislation will change the market's dependence on raw materials. He says: "You can recover the lithium-based compounds with recycling processes. You'd end up with, ideally – assuming the economics stack up – a closed-loop system where you can 'mine' the fleets of vehicles with batteries. It doesn't all have to come out of the ground."

Being able to exchange an old battery pack for a new one would certainly increase the appeal of electric vehicles to potential buyers, as well as make obvious sense to those EV manufacturers who currently lease battery packs to end users.

Assuming for a moment that batteries are undesirable, IDTechEx's report points to a potential alternative: super-capacitors, sometimes referred to as ultra-capacitors, which it says can last four times as long as batteries.

Thanks to their ability to deliver short, sharp bursts of energy, super-capacitors

can provide a boost that a vehicle might require when it is pulling away from a kerb, for example. So says Will Putter, chief commercial officer at hybrid technology specialist Adgero, whose technology was exhibited in July on a demonstration truck at the LoCity event in London (see box).

"The difficulty with super-capacitors is that while they can absorb a lot of energy quickly and give it back to you quickly, they cannot hold it," says Iveco's technical and alternative fuels director Martin Flach. "In order to replace batteries, they would have to be able to retain a charge for a lot longer."

HELPING HAND

But even if they are not sufficiently developed to replace batteries, they may be able to provide assistance. If a lithium-ion battery pack, for example, is not being asked to provide regular power boosts because super-capacitors are shouldering the burden instead, then the vehicle's range between recharges could increase by around 25%, he contends. "The battery pack's life could be doubled, too," Putter adds.

He is not alone. IDTechEx senior technology analyst Franco Gonzalez suggests that installing super-capacitors to provide peak power may result in being able to shrink the pack's size and reduce its weight.

He continues: "If you run diesel trucks and buses then you could use a super-capacitor rather than a lead-acid battery to start the engine. Remember that a super-capacitor can function at -40°C without any trouble."

Wrightbus product director David Barnett agrees with Putter and Gonzalez that super-capacitors can have a role to play on pure electric vehicles, but views their future role somewhat differently, especially where opportunity charging is concerned.

"The faster and harder you charge a battery, the more long-term damage you do to it," he says. "What you can do instead is use a super-capacitor to take the initial high charge, then feed it into the batteries at a more controlled rate." That's the theory at least. "The problem is that doing so requires a complex control algorithm, and I've yet to see one delivered," says Barnett.

"Super-capacitors are becoming a lot better in terms of energy density, but I don't see them replacing batteries on electric buses," he adds. "It all comes down to the amount of energy that can be stored, and batteries still have the advantage; don't forget that they have to be capable of providing the power to heat or cool a bus if it is going to be truly zero-emission."

And note: "A super-capacitor has 10% of the energy density of a lithium-ion battery," says Gonzalez.

Paterson of Johnson Matthey admits that transport applications do exist. He says: "There are super-capacitor buses that use periodic in-route charging, that go from bus stop to bus stop with either a pantograph or wireless-induction connection. All they need to do is store enough energy to get from one stop to the next. But because super-capacitors aren't very energy-dense, the packs containing them can potentially end up huge. They fill the roof, but they don't have a vast amount of energy."

Ultimately, Paterson remains sceptical about their potential, stating: "There's not an application we've looked at that we couldn't do with batteries."

Super-capacitors are undergoing continued development however, with Estonia's Skeleton Technologies – a leading player in the sector – raising €13 million last September to help it further develop its graphene-based products. Following a €6.2 million investment (including German government funding), it opened a new line at its Dresden factory in March that will scale up to production capacity of four million cells per year by 2019. TE

KERS COMPANION

A 12-tonne Iveco Eurocargo from Fraikin's rental fleet, exhibited at the LoCity event in July, demonstrated the potential of super-capacitors for urban freight transport. It is said to be the world's first rigid truck to utilise motor racing-style kinetic energy recovery system (KERS) regenerative braking technology to provide operators with significant fuel savings while also cutting emissions.

The 200kg KERS system (pictured, p35) has been installed by UK vehicle conversion specialists Alternatech, which worked alongside hybrid technology specialists Adgero and capacitor supplier Skeleton Technologies to get the vehicle on the road.

This energy is stored in a set of super-capacitors and then used to provide acceleration assistance via an electric motor fitted to the prop shaft. This power is channelled to the motor via specialised ECU software developed by Skeleton Technologies (see also main text).

During initial testing, the KERS system was said to offer 32% fuel savings when compared to a standard vehicle of the same type, as well as slashing associated nitrogen oxide emissions by around 50% and carbon dioxide emissions by around 30%.

Mack Murray, president of Adgero, says: "The system is primarily designed for multi-drop urban distribution or refuse collection, as the more the brakes are used, the more power is created. Our initial tests were only based on six stops over a six-kilometre course and they surpassed our expectations. In a genuine urban environment we would expect the savings to be even greater."

The KERS technology, developed by Adgero and Skeleton Technologies, was first installed on an SDC trailer owned by Eddie Stobart last year, and exhibited at the 2016 CV Show, but the new installation is believed to be the system's first fitment to a rigid truck.

Fraikin is making the vehicle available for demonstration within customer fleets across the UK.