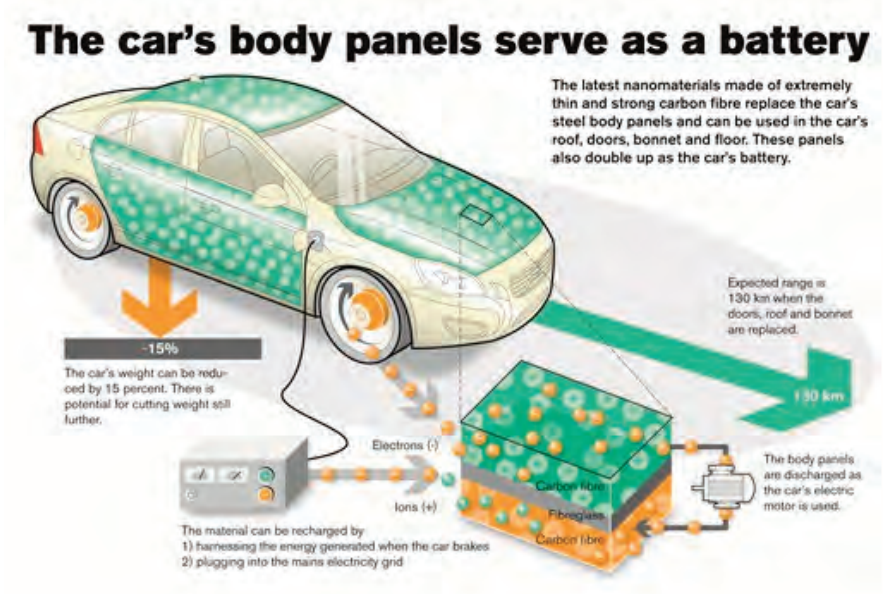
Volvo's game changing STORAGE technology

By **Toby Procter**

Volvo Car Corporation has just released findings from a project investigating what could one day prove as big an energy storage innovation as lithium-ion, and as innovative in materials terms as wearable printed electronics.

The 42-month, €3.37m (US$4.65m) STORAGE ('Composite structural power storage for hybrid vehicles') project, funded from 2010 to 2013 under the 'Transport' Theme of the EU's Seventh Framework Programme (FP7), featured Volvo Car as the only automotive OEM among project leader Imperial College's corporate and academic partners including Sweden's Swerea Sicomp AB, ETC Battery and FuelCells, and Chalmers University of Technology (Swedish Hybrid Centre); the Bundesanstalt für Materialforschung und-prüfung BAM, (Germany); Inasco (Greece); Cytec Industries (UK), and Nanocyl (Belgium).

The teams collaborated to produce prototype lightweight carbon fibre/polymer resin composites that could combine the structural functions of panels such as the engine plenum cover, hood panel, wheel well or roof with energy storage in the form of capacitors, batteries, supercapacitors and hybrid capacitors.



Volvo nano battery project

As the project got underway, Imperial College London's project coordinator, Dr Emile Greenhalgh, who works in the Engineering Faculty's Aeronautics Department and Composite Centre, said, "We think the car of the future could be drawing power from its roof, its bonnet or even the door, thanks to our new composite material. Even the satnav could be powered by its own casing."

The team initially planned the material to replace a Volvo's steel wheel well with composites that could combine structural functions with energy storage and provide a 15% weight saving, but eventually tested a radio-controlled XC60 model car, a full size Volvo S80 plenum cover, and the same vehicle's trunk lid. The radio-controlled XC60 model used the multifunctional supercapacitor material developed by the project; the plenum cover incorporated commercial Li-ion batteries, since the structural batteries developed in the project STORAGE still lacked the energy density needed to substitute for a car's primary battery. The S80's trunk lid incorporated structural supercapacitor materials developed by ICL and Cytec.

Further applications of the polymer-carbon fibre composite sandwich could integrate energy storage in the casing of products such as satnav units, offering additional vehicle mass reduction potential. Dr Greenhalgh explained: "You might have a mobile phone that is as thin as a credit card because it no longer needs a bulky battery or a laptop that can draw energy from its casing so it can run for a longer time without recharging." The

Volvo Battery StorAGE – trunk lid

very considerable weight of the wiring harnesses might also be reduced if, say, light clusters were powered from the adjacent trunk/hood panels.

Don't, however, expect to see the next model-year Volvo hybrids 'wearing' their energy storage. The prototype composite laminates have not been made in a moisture-free environment, hence cannot accept the voltage required to achieve the energy density provided by a conventional car battery, although Dr. Greenhalgh says, "Longer term, in ten years or so, we envisage reaching 20Whr/kg, which is akin to a state-of-the-art supercapacitor. With our current work, I can't see us getting to this energy level just with supercaps, but utilising pseudo capacitance, or improving the maturity of structural battery work such as at Sicomp, we could get there." 20Whr/kg compares well with the project's current near-1Wh/kg, but it is still, in percentage terms, "several decades" – but maybe only five years or so in time – away from sufficient power density.

The project has also investigated the potential of growing carbon nanotubes on the surface of the composite's carbon fibres, to make it more energy-dense and to also improve its mechanical properties. Even now, however, the STORAGE composite trunk lid has the potential to replace the S80's standard 12V battery, while the STORAGE composite plenum cover could also replace both the S80's anti-roll bar and the start-stop battery, providing a 50% weight gain, and freeing the battery's space besides reducing the thermal load in the engine. Such advantages are expected to outweigh the additional investment in the materials and manufacturing of the plenum.

The strength of the composite was not optimised in lab-scale assembly, though the chemistry for wetting the fibres will be improved and the means of bringing the lab-based manufacture piloted at Imperial to industrial scale have been tackled by project partner Cytec.

Because the STORAGE composite behaves more like a capacitor or supercapacitor than a battery, it may be particularly suitable for substituting for conventional start-stop batteries. It can be recharged like any hybrid or plug-in hybrid EV's battery, or via brake energy regeneration.

It may show potential for further energy density, but Per-Ivar Sellegren, Innovation Project Manager at Volvo Car Corporation, already says, "If we use the doors, roof and engine hood for a battery concept as in the demonstrator plenum cover, we have enough power and energy to run an EV for 130km. This is in the same range as a conventional Li-ion battery pack. If we use the supercapacitor STORAGE concept, it is more suitable for a hybrid car for acceleration and to store braking power.

"The concept is excellent and works, but needs better performance than today's status to be put in a major part of a car."

What will it cost?

On cost forecasts versus Li-ion cell battery packs, Sellegren told *Automotive World*, "Because you are integrating two components in one, and as a whole are saving weight and additional material, indications show at least no higher cost. Even if carbon fibre is expensive at the moment, you save costs on battery trays, body steel, cooling fans, better performance and so on."

Besides the need for carbon fibre composite panels to provide structural integrity, the STORAGE composite also has to counter the fear of electrical fires that has dogged EVs since the notorious conflagrations that have engulfed Fisker Karmas and Tesla's Model S. On electrical safety, Per-Ivar Sellegren says, "The battery is divided into segments, and is disconnected in a crash or if failure is detected.

"The decentralised segments have large cooling areas, no hot liquid or leaking substances. Our demand for the project is that crash cycle performance must be at least as good as for a regular vehicle." Dr Greenhalgh adds, "We've done some crashworthiness studies, and from what we've seen to date, they are very benign in a penetrative impact event."

So, if further development work on power and energy density and on cost-competitive scaled-up manufacture fulfils the STORAGE project's early promise, we could expect to see the first implantation in select components lightweighting start-stop systems without a serious cost penalty – except to the incumbent battery suppliers. Thereafter, OEMs could increasingly substitute Li-ion derivatives for composite structural power storage to extend EVs' range and significantly reduce their weight in the cause of range extension and/or performance. Who knows, structural energy storage composites may even wind up competing for panel area with next-generation PV technologies capable of feeding power to them.

Imperial College will eventually seek to license the supercap technology IP it has secured to date in conjunction with the STORAGE project, and Sweden's SWEREA Sicomp AB has patents on fibre battery technology to exploit.

What's fascinating about the development of this potentially game-changing technology is its combination of several functions in one material, and its dependence on inter-disciplinary research: factors which also entail that it would be highly disruptive of the current automotive supply chain in relation not only to energy storage but also to the pressed steel heritage that has for so long determined the economics of automotive production.