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Battery Breakthrough?

A Texas company says it can make a new ultracapacitor power system to replace the electrochemical batteries in everything from cars to laptops.

By Tyler Hamilton

A secretive Texas startup developing what some are calling a "game changing" energy-storage technology broke its silence this week. It announced that it has reached two production milestones and is on track to ship systems this year for use in electric vehicles.

The ZENN car will be the first commercial application of EEStor's new energy storage system. The company is expecting delivery of the systems later this year.
Credit: ZENN Cars

EEStor's ambitious goal, according to patent documents, is to "replace the electrochemical battery" in almost every application, from hybrid-electric and pure-electric vehicles to laptop computers to utility-scale electricity storage.

The company boldly claims that its system, a kind of battery-ultracapacitor hybrid based on barium-titanate powders, will dramatically outperform the best lithium-ion batteries on the market in terms of energy density, price, charge time, and safety. Pound for pound, it will also pack 10 times the punch of lead-acid batteries at half the cost and without the need for toxic materials or chemicals, according to the company.

The implications are enormous and, for many, unbelievable. Such a breakthrough has the potential to radically transform a transportation sector already flirting with an electric renaissance, improve the performance of intermittent energy sources such as wind and sun, and increase the efficiency and stability of power grids--all while fulfilling an oil-addicted America's quest for energy security.

The breakthrough could also pose a threat to next-generation lithium-ion makers such as Watertown, MA-based A123Systems, which is working on a plug-in hybrid storage system for General Motors, and Reno, NV-based Altair Nanotechnologies, a supplier to all-electric vehicle maker Phoenix Motorcars.

"I get a little skeptical when somebody thinks they've got a silver bullet for every application, because that's just not consistent with reality," says Andrew Burke, an expert on energy systems for transportation at University of California at Davis.

That said, Burke hopes to be proved wrong. "If [the] technology turns out to be better than I think, that doesn't make me sad: it makes me happy."

Richard Weir, EEStor's cofounder and chief executive, says he would prefer to keep a low profile and let the results of his company's innovation speak for themselves. "We're well on our way to doing everything we said," Weir told Technology Review in a rare interview. He has also worked as an electrical engineer at computing giant IBM and at Michigan-based automotive-systems leader TRW.

Much like capacitors, ultracapacitors store energy in an electrical field between two closely spaced conductors, or plates. When voltage is applied, an electric charge builds up on each plate.

Ultracapacitors have many advantages over traditional electrochemical batteries. Unlike batteries, "ultracaps" can completely absorb and release a charge at high rates and in a virtually endless cycle with little degradation.

Where they're weak, however, is with energy storage. Compared with lithium-ion batteries, high-end ultracapacitors on the market today store 25 times less energy per pound.

This is why ultracapacitors, with their ability to release quick jolts of electricity and to absorb this energy just as fast, are ideal today as a complement to batteries or fuel cells in electric-drive vehicles. The power burst that ultracaps provide can assist with stop-start acceleration, and the energy is more efficiently recaptured through regenerative braking--an area in which ultracap maker Maxwell Technologies has seen significant results.

On the other hand, EEStor's system--called an Electrical Energy Storage Unit, or EESU--is based on an ultracapacitor architecture that appears to escape the traditional limitations of such devices. The company has developed a ceramic ultracapacitor with a barium-titanate dielectric, or insulator, that can achieve an exceptionally high specific energy--that is, the amount of energy in a given unit of mass.

For example, the company's system claims a specific energy of about 280 watt hours per kilogram, compared with around 120 watt hours per kilogram for lithium-ion and 32 watt hours per kilogram for lead-acid gel batteries. This leads to new possibilities for electric vehicles and other applications, including for the military.

"It's really tuned to the electronics we attach to it," explains Weir. "We can go all the way down from pacemakers to locomotives and direct-energy weapons."

The trick is to modify the composition of the barium-titanate powders to allow for a thousandfold increase in ultracapacitor voltage--in the range of 1,200 to 3,500 volts, and possibly much higher.

EEStor claims that, using an automated production line and existing power electronics, it will initially build a 15-kilowatt-hour energy-storage system for a small electric car weighing less than 100 pounds, and with a 200-mile driving range. The vehicle, the company says, will be able to recharge in less than 10 minutes.

The company announced this week that this year it plans to begin shipping such a product to Toronto-based ZENN Motor, a maker of low-speed electric vehicles that has an exclusive license to use the EESU for small- and medium-size electric vehicles.

By some estimates, it would only require $9 worth of electricity for an EESU-powered vehicle to travel 500 miles, versus $60 worth of gasoline for a combustion-engine car.

"My understanding is that the leap from powder to product isn't the big leap," says Ian Clifford, CEO of ZENN, which is also an early investor in EEStor. "We're the first application, and that's thrilling for us. We took the initial risk because we believed in what they are doing. And energy storage is the game changer."

The key challenge, however, is to ensure that the barium-titanate powders can be made on a production line without compromising purity and stability. "Purification gives you better production stability, gives you better permittivity, and gives you the high voltages you're looking for," says Weir. "We've now got the chemicals certified and purified to the point we're looking for." (Better permittivity of the insulator improves the amount of charge that can be stored without letting the current leak across the two plates.)

EEStor announced this week that the first automated production line for its powder has performed as required and that permittivity will meet or exceed expectations. It also said that it achieved 99.9994 percent purity for its barium-nitrate powder, a crucial ingredient in the dialectric. San Antonia-based Southwest Research Institute independently confirmed the results.

In a traditional ultracap, that permittivity is given a rating of 20 to 30, while EEStor's claim is 18,500 or more--a phenomenal number by most accounts. "This is a very big step for us," says Weir. "This puts me well onto the road of meeting high-volume production."

Jim Miller, vice president of advanced transportation technologies at Maxwell Technologies and an ultracap expert who spent 18 years doing engineering work at Ford Motor, isn't so convinced.

"We're skeptical, number one, because of leakage," says Miller, explaining that high-voltage ultracaps have a tendency to self-discharge quickly. "Meaning, if you leave it parked overnight it will discharge, and you'll have to charge it back up in the morning."

He also doesn't believe that the ceramic structure--brittle by nature--will be able to handle thermal stresses that are bound to cause microfractures and, ultimately, failure. Finally, EEStor claims that its system works to specification in temperatures as low as -20 °C, revised from a previous claim of -40 °C.

"Temperature of -20 degrees C is not good enough for automotive," says Miller. "You need -40 degrees." By comparison, Altair and A123Systems claim that their lithium-ion cells can operate at -30 °C.

Burke, meanwhile, says that there's a big difference between making powder in a controlled environment and making defect-free devices in a large quantity that can survive underneath the hood of a car.

"I have no doubt you can develop that kind of [ceramic] material, and the mechanism that gives you the energy storage is clear, but the first question is whether it's truly applicable to vehicle applications," Burke says, pointing out that the technology seems more appropriate for utility-scale storage and military "ray guns," for which high voltage is an advantage.
Weir says the voltage will be stepped down with a bi-directional converter, and the whole system will be secured in a grounded metal box. It won't have a problem getting an Underwriters Laboratories safety certification, he adds. "If you drive a stake through it, we have ways of fusing this thing where all the energy is sitting there but it won't arc … It will be the safest battery the world has ever seen."

Regarding concerns about temperature, leakage, and ceramic brittleness, Weir did not reply to an e-mail asking him how EEStor overcomes such issues.

Nonetheless, the company has some solid backing. Its board has attracted Morton Topfer, former vice chairman of Dell and mentor to Michael Dell.

The company is also backed by Kleiner Perkins Caufield & Byers, a venture-capital powerhouse that has an impressive track record: it made early and highly successful bets on Google, Amazon.com, and Sun Microsystems, among others. Whether EEStor can translate that success to the energy sector remains to be seen.

"I'm surprised that Kleiner has put money into it," says Miller.

Weir maintains that his company will meet all of its claims, and then some. "We're not trying to hype this. This is the first time we've ever talked about it. And we will continue to meet all of the production requirements."