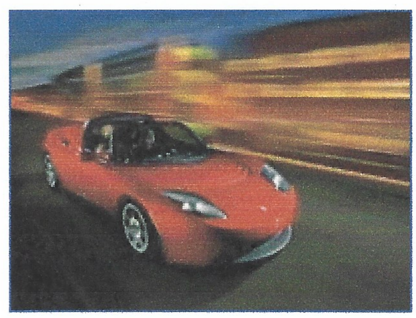
It's the Battery, Stupid!

By Gary Witzenburg

The future of road-going battery electric vehicles, as always, depends on development of a breakthrough battery. It must be safe, reliable and affordable and must store enough energy for practical range in a not-too-big or heavy package. "Practical" range means as much as 300 miles between charges to compete with a tank of gas.

None has ever come remotely close.



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GM's EV1, easily the most energy-efficient semi-practical vehicle ever to roll down the road, could squeeze some 70 miles from its 26 lead-acid (PbA) batteries on a nice warm day. That 1997 battery pack weighed more than 1,100 lb. and stored 312 volts of power and 15 kilowatt hours (kWh) of energy...roughly the equivalent of a half-gallon of gasoline. The Nickel-metal hydride (NiMH) pack optional in '99-model EV1s nearly doubled that, but at a substantial increase in price. NiMH is today's battery of choice in gas/electric hybrids.

Now comes the $100,000 Tesla electric roadster, which its makers claim will surge from zero to 60 mph in four seconds, top 135 mph and run an incredible 250 miles on a charge. While the EV-knowledgeable have scratched their heads and asked how that could be, more than 300 affluent believers have plopped down deposits. Tesla says its Lotus-based EV roadsters will be available this summer. Count us among the skeptical, but maybe so.

The Tesla trick is thousands of Lithium-ion computer batteries connected in both series and parallel to provide 366 volts and 56 kWh -- hardly inexpensive, easy to build or simple to service. "It's going to be interesting to see what happens with this Tesla car," says Robert C. Stempel, chairman of advanced battery maker ECD Ovonics, Inc. "They've got 6,831 Li-ion cells in there, broken up into 11 blocks, each with its own control and each individual cell with a chip. But those guys come out of Silicon Valley with years of experience with those batteries, so they know what they're doing, and they think they've got it bullet-proof."

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Li-ion batteries have become fairly common in such low-power applications as cameras and computers and at somewhat higher levels in power tools. But can battery makers successfully scale up Li-ion technology to 300- plus-volt automotive power levels while maintaining acceptable safety, size, weight and cost? More than a dozen in the U.S. and elsewhere are working feverishly to get it done.

"The manufacturing challenge is that you have to be absolutely perfect," Stempel points out, "and some cells coming out of China haven't had the quality control they need. A Lithium battery is wound up with plates and a separator between them. If a little fleck of metal gets through that separator, you have an instant short that can lead to a fire. That last computer battery incident happened because they had a manufacturing problem with tiny pieces of metal that got through the separator.

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"On the other hand, Lithium-Ion has the power and the energy, and three to four volts in a small package is pretty attractive. The chemistry's proven, it's lightweight and -- like NiMH - it doesn't need any maintenance. A lightweight, powerful battery is the obvious solution, and it's been used for airplane starter motors because when you're in the air, mass is everything."

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ECD Ovonics has been in the NiMH battery business since developing those extended-range packs for GM's '99 EV1. Now, through its Cobasys subsidiary, it has teamed with Chevron and A123Systems to develop Li-ion batteries under one of two GM contracts announced in early January. Even the best Li-ion packs are unlikely to propel a safe, practical, multi-passenger vehicle close to that 300-mile bogey, but Li-ion is seen as the enabler for practical, affordable plug-in hybrids, which will be expected to carry enough on-board energy for acceptable performance and range on their electric motors alone.

GM's production-intent Chevrolet Volt plug-in hybrid concept, based on a new "E-Flex" EV architecture that the company says will eventually carry its fuel cell power pack, has a 1.0-liter turbocharged gas engine solely to recharge its batteries to extend its range when needed. Since this engine will work in series with the electric motor to drive the car (as in a diesel-electric locomotive) but will never power the wheels, the Volt is a "series" hybrid. By contrast, today's Toyota Prius and other "parallel" hybrids team an electric motor with an engine to power their wheels through a complex transmission.

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One key battery comparator is energy density, how much energy it can store per unit of weight. According to battery expert Isidor Buchmann, founder and CEO of Cadex Electronics in Vancouver, BC, Canada, lead-acid (PbA) batteries can pack 30 to 50 watt-hours per kilogram (Wh/kg), while Nickel Metal Hydride (NiMH) can double that. Li-ion) is capable of as much as 190 Wh/kg...a lot more energy in a smaller, lighter package.

Another is volts (power) per battery cell. Since each charged cell exhibits a specific voltage, most batteries combine multiple cells to provide meaningful power. For example, the common 12-volt car battery links six two-volt PbA cells. Buchmann says NiMH offers 1.25 volts per cell, while Li-ion ranges between 3.3 and 3.8 volts. That means a 320-volt automotive battery pack might need 256 NiMH cells compared to 90 or so for lighter, higher-energy Li-ion. Joe LoGrasso, manager of energy storage system development for GM's hybrid EV programs, says a practical Li-ion automotive battery pack will likely link 90 to 100 cells of three to four volts each, depending on the energy and power the vehicle needs to meet its range and performance targets. Obviously, the fewer the better for both cost and complexity reasons.

"A battery system is not just a battery," he says. "It contains batteries and monitoring electronics. In the case of Li-ion, those electronics are very important because they monitor not only mission-critical but safety-critical aspects of the system. The challenge is a battery with the right balance of power and energy to meet the mission performance while operating within constraints that allow it to last the life of the vehicle, or at least 10 years. We're putting that challenge out to the supply base, and we're seeing promising 'elopments."

No one knows when automotive-size Li-ion battery packs will be developed and ready for mass production, but best guesses range from three to five years. That should be plenty of time for GM's Chevy Volt and other practical plug-ins to be ready and waiting.

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