

PHOTO CAPTION: Honda FCX fuel cell car is an outgrowth of Honda EV+ electric car program during the 1990s in California. The \$2 million hydrogen-fueled prototype is the first fuel cell vehicle to demonstrate sub-freezing temperature operation and to be leased to a private citizen. It is also the first fuel cell prototype from a major manufacturer to utilize Maxwell Technologies' ultracapacitors to recapture virtually all of the vehicle's regenerative braking (kinetic) energy. Maxwell is a member of the newly created PHEV Consortium.

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## Inside the PHEV Consortium - Part 2

By Bill Moore

**Conclusion of interview with representatives of the new Plug-in Hybrid Electric Vehicle Consortium.**

[To Part 1](#)

Raser Technologies' David West was the original driving force behind the consortium, approaching ultracapacitor-maker Maxwell Technologies with the idea to work cooperatively to develop both individual components and systems that could work together in future hybrid vehicles, thereby making it easier to get the larger OEMs to adapt the resulting products.

Maxwell's Robert Tressler explained that from his company's perspective, the consortium, "enables technology to get into the mainstream and out of laboratories and on the road.. Allowing people the opportunity to benefit from the vision that David (West) is... establishing as he forms the consortium".

As West explained, the catalyst for forming the core group began at the EDTA's summer legislative conference in Washington, D.C., when West, Stokes, and Maxwell's Richard Smith got together and discovered they shared common goals, as well as common problems. They agreed that component suppliers needed to work together more closely, "so that our technologies could be designed correctly to work together, and also to reduce development costs and development time". They also thought that by forming a united effort, they could also reduce some of the frustrations carmakers were experiencing in developing state-of-the-art electric-drive systems that weren't prohibitively expensive.

"I think all of us have been looking for this opportunity for a long time to see how we can solve these problems, and this became the sensible way to do it", West commented.

Pacific Gas & Electric's (PG&E) Brian Stokes explained it's his wish that within a year the consortium will have a prototype system ready to show to carmakers, using it as a means of opening dialog into the needs and concerns of the OEMs. The approach certainly has logic to it. Carmakers, historically, have been highly skeptical of the grid-connected hybrid-electric car concept, questioning everything from its engineering feasibility to marketability. They have often dismissed it as just a ploy by power companies to sell more American-made electricity, as if that

were worse than oil companies selling drivers more imported petroleum.

Assuming in a year's time the consortium is able to begin serious discussions with OEMs, it typically takes at least three years for an idea to find its final expression on the production line. So, a true plug-in hybrid with an initial 20 miles of electric-only driving range, after which the internal combustion engine would start running and burning liquid fuel, wouldn't make it debut until at least 2009.

West added that the consortium's first goal is to increase its membership beyond the original core companies: Raser, Maxwell, Electrovaya, and PG&E. Companies interested in joining the consortium should have compatible technologies that can help the program reach its stated objectives.

The consortium's second goal is to develop a feasible design that has been jointly developed with OEM input.

"The critical thing here is to have a system integrator that looks at this and makes those hard decisions: balance between performance and the costs between components... how much to give to the ultracaps and how much to give to the battery, etc."

West sees the consortium members bringing the project to the point that the member OEM can then do the final system design. As an interim step, Raser's Chief Technology Officer, Tim Fehr -- a former senior vice president with Boeing Engineering -- will serve as the temporary system integrator, while the consortium looks for someone to assume the role, full time.

According to West, that person's task will be to "make sure the proposed design does make sense scientifically and economically. From there, each participating OEM can adapt components designed to their needs. The ultimate goal from there is to get a physical car driving that meets these goals within a year, or what seems reasonable to the participating OEMs.

In addition to each consortium member providing funding and expertise, the group will also seek federal funding as part of an effort to "fast track" the program, which West characterizes as a Boeing "Phantom Works" project, in which Raser's Fehr oversaw the development of the Boeing 777, among other projects.

"We plan to make this a fast track, commercial objective that may present alternatives to FreedomCAR. It may present alternatives to OEMs that they can adapt quickly without disrupting the current FreedomCAR project or funding", West stated. He added that ultimately, he sees this technology being applied to fuel cell vehicles that also offer the ability to use energy from the power grid.

Beyond the 20-mile battery range prototype, the next phase of the project is creation of a 50-mile range demonstrator.

West also clarified what he means by "off-the-shelf" saying that it means the demonstration car is built out of technology that can be immediately put into production.

"If the OEMs decide that they want to run with this design, they don't have to wait five years to solve a price goal. They can take this battery, take this ultracap, take this electric motor and go to work with it. It is a realistic design that can be mass produced immediately".

Stokes interjected that PG&E also sees this as a way to better utilize existing, nighttime, surplus power capacity, because plug-in hybrid owners would be encouraged to recharge their vehicles during cheaper, "off-peak" rate periods. This is surplus energy that is currently being under-utilized and wasted.

Tressler picked up the thread regarding OEM's concerns about the cost of any new technology. He said this is the central issue in any dialog and that they presume the supplier understands that safety, reliability and durability are givens. He is further confident that given discussions with current FreedomCAR sponsors, that OEMs will be open to talks with the consortium.

"It's really a question of education, dialog, discussion and then setting parameters that make sense for them to put their emblem on a vehicle and to distribute that vehicle in mass quantities

to the world", Tressler said.

"This is an important difference", West emphasized, picking up on Tressler's remarks, "because organizations like CalCars, and others, which are very valuable and important to this cause have a little bit different goal. CalCars seeks to create a retrofit program, which is important. This organization seeks to create the tools that are necessary to go into mass production by the OEM's themselves, rather than a side project for them".

He explained that Raser's technology offers OEMs the ability to buy low-cost, AC induction motors that don't rely on expensive rare earth materials like those found in permanent magnet motors. He noted that Emerson builds 150,000 low-cost AC induction motors daily, motors which could be made even smaller and more compact, as well as more powerful using Raser's proprietary science and engineering.

"Being able to use these plants to make high volume, low cost motors that don't require rare earth materials is a very important part of this mix. If we can show them that this is a technology that can last them 25 to 30 years, that doesn't cost them more so they can mass produce, these are important things for them to understand".

West stressed that he wants carmakers to understand that it doesn't have to cost them more to build hybrid cars.

"To be realistic, by the time we get the car done and you add batteries to it, the batteries... may make a significant increase in that cost. That's why the consortium is also looking at political arenas to help offset the cost of batteries in the initial or low-volume phases".

West said that Raser, which is located in Utah, is working with Senator Orrin Hatch, a powerful Republican member of Congress on these issues. He's hoping that other consortium members that join will also be able to work with their respective political officials so that the additional cost of the batteries can be offset through tax credits as a bridge to high-volume.

"When we get to high-volume, then the total car cost can be commercial and sustainable at its true cost rather than subsidized cost", West explained.

The consortium isn't just interested in grid-to-vehicle charging, but also in vehicle-to-grid or what Stokes calls "mobile distributed generation" in which the car can provide power back into the grid. He calls it an "interesting concept" from the utilities perspective, in particular its power management and safety aspects.

He could envision, for example a mass transit system with parking lots full of plug-in hybrids that could provide power to keep the system running in event of an outage, the owners being financially compensated by the utility for this service.

"If we can add generation to complement the current infrastructure our ratepayers have invested in, we can find ways to take advantage of cleaning the air while providing a generation resource that reduces the cost of providing electric service to our customers".

Stokes sees this as a way to help mitigate some of the potential higher vehicle cost initially.

Alternative fuels are likely to also be a part of the concept, giving owners the "freedom" to choose which energy source they prefer to use: off-peak electricity, petroleum or biofuels.

"They can choose a liquid fuel at \$3 a gallon or more if they need it. And if alternative fuels are available, and we believe they will be, we want to make sure that we are available to take advantage of that". He is hopefully that OEMs will more widely adapt alternative fuels like E85.

Stokes added that California is currently working on a petroleum dependency reduction plan that he expects to be presented in the legislature in 2006. It would seek to reduce petroleum usage throughout the state by 20-30%.

"I believe that it will be imperative that a menu of fuels will be available to consumers to help meet those goals" he said.

This will obviously require carmakers to make much wider use of flexible fuels technology along the lines of what is being done in [Brazil](#) where virtually all new cars can run on a broad blend of petroleum and alcohol-based fuels.

Both West and Stokes noted that the generating efficiency of central power plants is at least twice that of an internal combustion engine and for a combine cycle gas turbine, its closer to five times more efficient -- 11% at-the-wheel efficiency for a internal combustion engine compared to nearly 60% for combined cycle gas turbines.

Editor's Note: Obviously, there will be some transmission line losses (10%) as well electric drive system losses, but overall, the system is significantly more efficient and generates less CO2 than our predominately petroleum-based system today .

The reason this is important, from their perspective is because today's current crop of hybrids use \$3 a gallon gasoline to keep their batteries recharged -- as well as a small percentage that comes from regenerative braking. Plug-in hybrids offer their owners the opportunity to recharge at a fraction of the cost, depending on local utility rates, as low as the equivalent of 50 cents a gallon. Offered the choice, they believe consumers will choose the plug-in option, especially if it doesn't involve unacceptable compromises in performance.

A key element in accomplishing that objective is the melding of Electrovaya's Superpolymer lithium ion batteries and Maxwell's ultracapacitors into a energy storage package that takes advantage of the strengths of each. West sees this as extremely important to the success of their initiative. Ultracapacitors have extraordinary power density and durability to the tune of hundreds of thousands of cycles. Lithium has high energy density but like any battery, overtime it weakens if cycled too frequently and too deeply. The ideal solution for any electric-drive vehicle, be it pure electric, hybrid or hydrogen fuel cell would be the mating of these two chemistries.

Maxwell's Tressler put it this way, "It's pretty obvious that most of the people that have an appreciation both for batteries, as well as ultracapacitors, see that there's a sweet marriage that can exist. Obviously, batteries provide great energy over continuous demand for that energy, whereas ultracapacitors can provide the power requirements for those short bursts or for the opportunity for regen braking. Because of their efficiency, normally anywhere between 95 and 97 percent of what you put in you're going to get back out again".

He noted that this offers the opportunity to develop entirely new energy storage architectures, especially for advanced energy batteries that can now be optimized for energy density, instead of trying to engineer their chemistry for both energy and power density.

"That presents some interesting combinations that currently don't exist in the marketplace", he stated. "There will be some innovation and some technological advances that I think the consortium will provide, not just in theory, but in practicality in being able to put it on the road and in the street and that' where everyone will get the bang for the buck".