In the first and largest project of its kind, electric co-ops are testing whether plug-in hybrid electric vehicles can wean our nation off foreign oil, curb greenhouse gas emissions, and increase off-peak electric sales

By **Peter Nye**

HAVE PLUG, WILL

As prices continue to shoot up at gas pumps, Alan Shedd, commercial-industrial marketing engineer at Jackson Electric Membership Corporation in Jefferson, Ga., draws stares and questions from strangers who spot the eye-catching graphics of the Toyota Prius plug-in hybrid electric vehicle (PHEV) he drives for the co-op.

"People stop me in the parking lot of grocery stores, rest stops, and elsewhere and ask if it really gets 100 miles per gallon as painted right above the gas tank," he remarks. "Often, they want to know how to get one."

Of course, PHEVs won't be commercially available for at least a few years. Jackson EMC's model joins only about 100 now cruising about the country, all retrofitted by a handful of shops in what's essentially become a fledgling cottage industry.

But information Shedd collects while driving the PHEV as part of his duties for the 200,000 member distribution co-op, located 50 miles northeast of Atlanta, will be evaluated as part of a two-year study being conducted by NRECA's Cooperative Research Network (CRN). Three other electric co-ops are also participating in the project: Basin Electric Power Cooperative, a multistate generation and transmission (G&T) co-op headquartered in Bismarck, N.D., and two distribution systems, Four County Electric Membership Corporation in Burgaw, N.C., and Salem Electric in Salem, Ore.

Dan Allen, vice president of Four County EMC in North Carolina, gets 70 miles per gallon from the Toyota Prius hybrid he converted to a plug-in. A monitor mounted on the dashboard displays in real time the status of various operating components.

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TRAVEL

"This program has a lot of spunk," asserts Ed Torrero, CRN executive director. "It is the first and largest set of PHEV tests now under way nationally, a distinction for electric co-ops. We offer diversity spread over a large geographic area."

CRN goals include assessing how PHEVs might affect electric co-ops, consumers, and the entire electric utility industry; gaining hands-on experience with vehicle performance on a day-to-day basis; finding out if PHEVs can save co-op consumers money by charging overnight for less than the cost of gasoline or diesel fuel; and looking into the feasibility of PHEVs being turned into a source of distributed generation that co-ops and consumers could tap during a power outage.

PHEV primer

Shedd, who has experience designing and building electric cars and has taught high school classes about the technology, started the PHEV effort rolling last February with a cross-country trek from Monrovia, Calif.—where his 2004 Prius gasoline-electric hybrid with 60,000 miles was turned into a plug-in by the engineering firm EnergyCS—to Jackson EMC headquarters. He has since logged an additional 30,000 miles.

The EnergyCS conversion, which cost roughly $30,000 and took place over four days, included putting in a plug-in charging system accessed above the left rear bumper, disassembling part of the car's interior, mounting extra restraints to hold down the larger battery, and installing software that operates a special data-collection monitor sitting atop the dashboard.

"For a geek like me, the monitor is great—like having a video game in my car," Shedd, a member of the CRN Renewable Energy & Distributed Generation Membership Advisory Group, declares. "I watch in real time what goes on 'under the hood'—miles per gallon and how much electricity and gas get used."

Compared with conventional cars, a factory-built hybrid—such as the Toyota Prius or Ford Escape SUV—achieves better gas mileage around town and when driven at lower speeds because its 1.3-kWh nickel-metal hydride battery/electric motor and gasoline engine both provide power. The battery constantly gets recharged by the engine and regenerative braking system.

In Shedd's PHEV, the nickel-metal hydride battery was replaced with a custom-built 9-kWh lithium-ion model—a much larger version of those used in cell phones and laptops—that delivers more electric power and better fuel economy. When the battery runs down to the point where a one-third charge remains, the PHEV starts acting like a regular hybrid, using the gasoline engine to maintain that level. But the engine and brakes don't recharge the battery much further. Instead, a full charge requires a regular 110-V outlet.

"When plugged in, a PHEV can recharge in four hours," says Torrero. "Doing so consumes around 4 kilowatt-hours, or about 40 cents, of electricity. It's cheaper to fully recharge the battery this way than using the gasoline engine."

The lithium-ion batteries, which cost more than the car itself, also offer greater range. "On my drive to work, around 30 miles, I can get 100 miles per gallon—I'm using electricity most of the time and little gas," Shedd indicates. "When the batteries run down and the gas engine kicks in, the PHEV averages 50 miles per gallon."

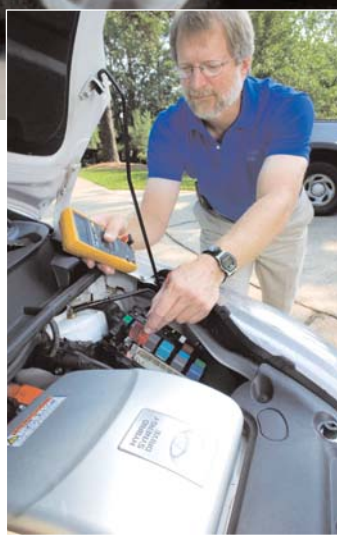
As Shedd prepared to get behind the wheel in California for his cross-country drive to the Peach State, EnergyCS engineers suggested he first stop by a local Home Depot store and buy an extension cord.

"I bought two cords—one 25 feet long, the other 50 feet," he recalls. "Usually I can find an outlet within that length."

Driving 2,800 miles in three days, Shedd discovered that inexpensive motels allowed him to park directly in front of the room so he could stretch the cord from inside.

"I put a little duct tape down on the sidewalk so nobody would trip over it," he recounts. "At one motel, I discovered the only available outside plug was blocked by another guest's car. So I drove around and found a different motel with an outlet where I could park."

Last October, Shedd cruised to Washington, D.C., to show lawmakers—and the media—how PHEVs work. At an upscale Capitol Hill hotel, he was treated to parking his vehicle at the valet stand.



Eye-catching graphics allow Alan Shedd, commercial-industrial marketing engineer at Jackson EMC, to quickly communicate the advantages of the Georgia co-op's plug-in hybrid electric vehicle. Information he collects while driving the car will be evaluated as part of a two-year study being conducted by NRECA's Cooperative Research Network.

"The attendants were very interested in how it worked," he marvels. "I stressed that on longer trips, or at speeds faster than 35 miles per hour, the gasoline engine runs more of the time to deliver additional energy. But since it's cheaper to 'burn' electricity, you can run the car overall for the equivalent of buying gasoline at 80 cents per gallon. And battery power doesn't produce any tailpipe emissions."

Enhancing load balance

A joint 18-month study by the Electric Power Research Institute (EPRI), a non-profit utility-sponsored consortium based in Palo Alto, Calif., whose members include electric co-ops, and the Natural Resources Defense Council (NRDC), an environmental advocacy group headquartered in New York City, released last July finds that greater use of PHEVs promises huge environmental benefits.

"Widespread adoption can reduce greenhouse gas emissions [blamed for contributing to global climate change] from vehicles by more than 450 million metric tons annually by 2050—equivalent to removing 82.5 million passenger cars from the road," points out Mark Duvall, EPRI director of electric transportation. "Combined, the country's electric and transportation sectors account for nearly three-quarters of all U.S. greenhouse gas emissions from human activity. Electricity generation alone represents the biggest chunk, about 40 percent—mostly from carbon dioxide being released when fossil fuels like coal and natural gas are burned."

In the 2007 report *Electricity Technology in a Carbon-Constrained Future*, EPRI spelled out how electric utilities can help the United States slash carbon dioxide emissions below 1990 levels within 22 years—even as they take on about 40 percent more load, half of which will be generated by coal—if aggressive steps are taken in seven principal areas, including making PHEVs commercially available. The study assumes that PHEVs will hit the market around 2010 and comprise 10 percent of new vehicle sales by 2017 and 30 percent by 2027—a schedule that would require significant market transformation.

In addition to lowering gasoline consumption—and U.S. dependence on imported oil—by about 3 million to 4 million barrels per day (20 percent of current consumption), PHEVs further cut carbon dioxide emissions when batteries are recharged by electricity generated from renewable resources. EPRI estimates 50,000 MW of addi-

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tional green power will be developed by 2020, with the total then rising by about 2,000 MW a year through 2030.

According to a study by the U.S. Department of Energy Pacific Northwest National Laboratory in Richland, Wash., the nation's existing power grid could fuel as many as 180 million PHEVs. Duvall calculates that PHEV batteries would be charged three-quarters of the time during off-peak periods, raising electric demand between 3 percent and 4 percent and better balancing utility loads. The end result: greater system efficiencies that could help hold down costs.

"Plug-ins have the potential to create the greatest end-use product, and greatest challenge, for electric utilities since air conditioning was introduced in the 1950s," Torrero relates. "Air conditioning load grew much faster than expected and caught a lot of utilities unprepared, including electric co-ops. We need an early understanding to get ahead of any unintended consequences."

Torrero contends that if PHEVs become popular, they will put extra demands on all aspects of electric co-op operations, from residential transformer sizing to distribution system and generation capacity. "But PHEVs also represent an opportunity for new off-peak load growth, increased kilowatt-hour sales, and lower transportation costs for co-ops and their consumers."

Conversion fly-in

Even though the Achilles heel of PHEVs remains energy storage, Torrero feels confident that entrepreneurs in the market will soon achieve the long-awaited "battery physics breakthrough." One of these firms, A123 Systems, founded in 2001 in suburban Boston, Mass., produces a 225-lb. lithium-ion battery pack that features conductive material made from thin layers of nanophosphate, licensed from the Massachusetts Institute of Technology.

"The batteries are made up of more than thousands of individual cells, each the size of a roll of quarters," Torrero explains.

Basin Electric Power, serving 125 member co-ops in nine states, created a media event late last October when one of its two Ford Escapes was converted to a PHEV during the Great Plains Energy Expo & Trade Show in the Bismarck Civic Center Exhibit Hall. Experts flown in from A123 Systems and its subsidiary, Hymotion out of Toronto, Canada—which makes custom-engineered Battery Range Extender Modules that can be installed in the spare-tire well—modified the SUV in about six hours. Watching the process take place were North Dakota Governor John Hoeven (R), U.S. Sen. Byron Dorgan (D-N.D.), U.S. Energy Secretary Samuel Bodman, Basin Electric Power CEO/General Manager Ron Harper, and students from a local automotive vocational-tech school.

"The retrofit added an 8 kilowatt-hour lithium-ion battery to supplement the Escape's 330-volt nickel-metal hydride battery," comments Chris VandeVenter, Basin Electric Power legislative representative. "Working together, the gasoline engine and electric motor produce a combined 155 horsepower. We initiated the process in response to a 2006 membership resolution that endorsed the national grassroots campaign of Plug-In Partners. [CRN has also joined more than 500 cities, businesses, utilities, auto manufacturers, and battery developers in support of Plug-In Partners, a coalition seeking to build a market for flex-fuel, plug-in hybrid vehicles.] The resolution tied in nicely with discussions we already had under way to improve the efficiency of our vehicle fleet."

In fall 2006, Ron Rebenitsch, Basin Electric Power manager of alternative technologies and chairman of the CRN Renewable Energy & Distributed Generation Membership Advisory Group, asked VandeVenter to take charge of the Basin Electric Power conversion. CRN had just approved the PHEV research project, and VandeVenter then contacted Hymotion, the only company at the time performing conversions on Ford Escapes. However, the G&T needed to get in line behind Internet giant Google, which had previously hired Hymotion to adapt its growing fleet of hybrids into PHEVs.

"Hymotion engineers perfected the conversion process with Google, and we were next," VandeVenter reports. "We've assigned the PHEV to our government relations department and make it available to others as needed to enhance its exposure."

No golf cart

When Dan Allen, vice president of Four County EMC in Burgaw, N.C., first started driving his Toyota Prius PHEV last fall, he expected it to handle as sluggish as a golf cart. "That's not the case," he admits. "It has a lot of pickup. I'm impressed."

He's also satisfied with fuel savings from commutes around the co-op's service territory, which includes more than 5,400 miles of lines in the southeastern corner of the Tar Heel State.

"Our fleet vehicles [pickups and cars] average about 20 miles per gallon," Allen suggests. "Last April, we bought a Prius hybrid which gets 46 to 48 miles per gallon. Now, with the Prius converted to a PHEV [by A123 Systems and Hymotion], I can get 70 miles per gallon. If I used it just for local trips no longer than 30 miles or so, I'd never have to fill up at a gas station."

Four County EMC volunteered for CRN's PHEV endeavor. "We wanted to be part of the solution about global warming," Allen maintains. "This car demonstrates our commitment, and we let our members know of its success. We drive it in parades. It's the subject of two middle school projects. We visit local high schools and talk with the students about green power, plug-ins, and the conversion. That gives us the opportunity to talk about cooperatives, Touchstone Energy®, and to tell our youngsters what we do."

The latest co-op to join the PHEV family, Salem Electric in northwestern Oregon, did so "to find ways to use electricity for transporta-

tion, and we wanted to test the new hybrids," notes Roger Kuhlman, the co-op's manager of engineering & operations and a member of the CRN Renewable Energy & Distributed Generation Membership Advisory Group. Salem Electric's service territory spans 17 square miles and embraces 18,000 consumers.

"A lot of our trips are under 30 miles," Kuhlman discloses. "At the same time, we have hills, so we need a boost from the gas engine. The PHEV will give us the optimum of gas and electric power."

In 2006, the co-op bought a Ford Escape hybrid that more than doubled the miles per gallon as compared to a Ford Explorer SUV. Kuhlman had the vehicle converted last month by Hybrids Plus of Boulder, Colo., and then drove it to the CRN Renewable Energy & Distributed Generation Membership Advisory Group meeting in Phoenix, Ariz.

Chris VandeVenter, Basin Electric Power Cooperative legislative representative, uses the wholesale power supplier's Ford Escape SUV plug-in as a co-op "innovation ambassador."

PHOTOGRPAPHS BY MARK LUINENBURG

"We're a bit skeptical but plan to put the plug-in through its paces reading meters, meeting with members, and maintaining our electric system," he insists. "If it does work, hopefully car manufacturers will get on board and make them in bigger numbers and lower costs."

Back to the future

From Shedd's years of talks before classrooms, civic clubs, and lawmakers about hybrids and plug-ins, he observes that people often confuse them with electric vehicles (EVs), typically perceived as slow.

"The reality is that electric motors generate a lot of torque at lower speeds, better than gasoline combustion engines that produce maximum torque at high speeds," he says. "An electric vehicle, such as the all-electric $98,000 Tesla Roadster, puts out a huge amount of power right off the line—from zero to 60 in four seconds."

The world land speed record for an EV, incidentally, tops 300 mph, and EV dragsters are allowed on most tracks that hold National Hot Rod Association events. The Portland, Ore., International Raceway provides 240-V outlets that charge 10 EV dragsters at a time. EV dragsters, though, don't usually race heats against gas-combustion rivals because spectators accustomed to the roar of engines find the quiet EV dragsters underwhelming.

Ferdinand Porsche, renowned for designing the Volkswagen (and whose son made the sports car company famous), built an electric car and drove it 38 miles at the Paris Exhibition of 1900. Porsche and Vienna coach builder Jacob Lohner added an internal-combustion gas engine to charge the batteries. The Lohner-Porsche prototype hybrid reached a top speed of 35 mph.

In the United States, electric cars were more popular than their gasoline-powered cousins at the start of the 20th century because gas engines required drivers to turn a dirty hand crank on the front of the vehicle to get the engine started.

"Electric cars appealed to women because they didn't have to get out of the car or risk breaking an arm from a cantankerous crank," Shedd mentions.

By 1920, thanks to the arrival of the starter motor, more roads being paved (allowing for excursions beyond the range of batteries), and relatively cheap gasoline prices, electric cars were pushed aside. Now, with crude oil prices crowding $100 per barrel and anxieties over global warming climbing, EVs, hybrids, and PHEVs are finding new life.

"Going electric" may also be a key to economic survival. Authors Ian Carson and Vijay V. Vaitheeswaran of *Zoom: The Global Race to Fuel the Car of the Future* (Twelve Press) warn of potential geopolitical calamity if rates of car ownership rise in developing nations like China (from nine personal vehicles per thousand eligible drivers today) and India (11 for every 1,000) to even half of the U.S. total (1,148 for every thousand) and gasoline remains the fuel of choice—100 million more barrels of oil per day, greater than the 86 million barrels now used daily worldwide, will be required.

Bob Gibson, CRN manager of the PHEV demonstration project, believes PHEV conversions could pick up this year when Hymotion offers Battery Range Extender Modules for second-generation Priuses and Escapes that could be installed for about $10,000 at a local garage.

"Conversions represent an intermediate step toward getting PHEVs mass produced," Gibson concludes. "The future becomes reality when automobile manufacturers mass produce PHEVs in volume, like any other car or light truck." ■

This article represents the seventh and final installment in a series on how electric co-ops are looking out for their consumers and working to control power costs in an environmentally responsible fashion. Aimed at "closing the reality gap" on public understanding about climate change, the series examines ways electric co-ops are addressing seven Electric Power Research Institute recommendations that will allow the electric utility industry to slow, halt, and eventually decrease carbon dioxide emissions to 1990 levels by 2030 while still meeting demand for affordable, reliable electricity. The seven recommendations (some of which are still on the drawing table) are: boosting energy efficiency, improving the operating efficiency of coal-fired power plants, investing in renewable energy, expanding nuclear power capacity, capturing and storing carbon produced by coal-fired power plants, adding distributed generation resources, and putting plug-in hybrid electric vehicles on the road.