INL engineers are working to create a smart battery status monitor, which could be as important for hybrid cars as gas gauges are for today's vehicles.

A smart hybrid car monitor puts the brains in battery testing

by Roberta Kwok, *Research Communications Fellow*

In a cavernous lab at Idaho National Laboratory, humming machines are testing batteries of all shapes and sizes. "The Future is Electric," proclaims a sticker shaped like a license plate at one end of the room. The sticker belongs to Jon Christophersen, an INL researcher who wants the next generation of hybrid cars to run smoothly on the road.

Christophersen's team is working on a smart battery monitoring system that will track the health of hybrid and plug-in hybrid electric car batteries, the same way that a gas gauge lets you know when you're about to run out of fuel. The system could offer a quicker, cheaper battery monitor that leads to more accurate lifetime predictions and doesn't drain the battery during testing, as other methods do. If it's successful, the work could apply not only to hybrid cars but also battery-powered military missions and energy storage off the grid.

"Batteries are becoming more and more important as we try to reduce our dependence on oil," says Christophersen, whose team is collaborating with researchers at Montana Tech, an engineering school that is part of University of Montana, and Qualtech Systems, Inc. on the project.

Jon Christophersen is part of the research team aiming to provide faster, more accurate battery life predictions for the next generation of hybrid cars.

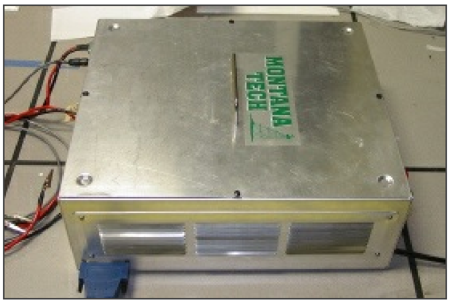
Measuring battery life isn't as simple as checking the gas. Batteries slowly lose their capacity over time, delivering less and less energy with each charge. "It's like a gas tank, but the gas tank is shrinking," Christophersen says.

The most accepted method of diagnosing a battery is pulse testing, which zaps the battery with high current and measures the resulting voltage. But this test drains battery life and can take about 15 hours.

Another system, electrochemical impedance spectroscopy (EIS), tests batteries by measuring a property called impedance, which is essentially resistance to various frequencies of alternating current. While EIS is faster than pulse testing, it requires delicate, bulky equipment and can give inconsistent results depending on the position of the cables.

INL's device puts a new twist on impedance measurements. Instead of applying currents of different frequencies one by one, as EIS does, the system tests all frequencies simultaneously. It does this by starting with white noise -- a hodgepodge of every possible frequency -- and trimming it down to the range needed for testing, leaving what Christophersen calls "pink noise." After pulsing the battery with pink noise, the team runs algorithms to calculate an impedance profile.

The system, called Impedance Noise Identification, can now zip through a typical test in under 30 seconds. So far, the results are very similar to those generated by EIS. And the equipment, built at Montana Tech, is less cumbersome -- about the size of a desktop CPU.



The team's battery diagnosis system is currently the size of a desktop CPU, but the team hopes to miniaturize the

Eventually, the team wants to miniaturize the system to the size of a microchip so that it can be installed in a car. They envision that the impedance test could be just one part of a larger suite of onboard tests, including monitors for temperature, voltage and current. Together, the data could lead to more accurate predictions of battery life. Each car containing the system could also check its information against the entire fleet and alert the owner if the battery isn't behaving normally. "You can really quickly identify bad apples," Christophersen says.

The team also is developing a second onboard test called Compensated Synchronous Detection. This technique is less precise than impedance monitoring but has the advantage of being blazing fast -- about 10 seconds, or near real-time. The two methods could be paired, Christophersen says, giving drivers a combination of instantaneous feedback and high accuracy.

But the team needs to conduct more experiments before the system makes its way into a hybrid car.

equipment so that it can be easily installed in a car.

So far, the researchers have tested batteries at specific stages of life and compared the results to EIS. The next step is to monitor batteries over their entire lifetime, then check the accuracy of the predictions at the end. With the right funding and effort, Christophersen says, the research could come to market in three to four years.

And a smart battery monitoring system would prove useful for more than just hybrid cars. For instance, it could evaluate the health of batteries currently used to store excess energy from the grid. The system could also help military and space mission planners, who tend to discard batteries after a certain number of operations because they don’t want to risk the battery dying unexpectedly.

"Instead of wasting money throwing out perfectly good batteries just in case they might be bad, you can use this system to assess whether these batteries can last another mission," Christophersen says.

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