

# EEVC NEWSLETTER

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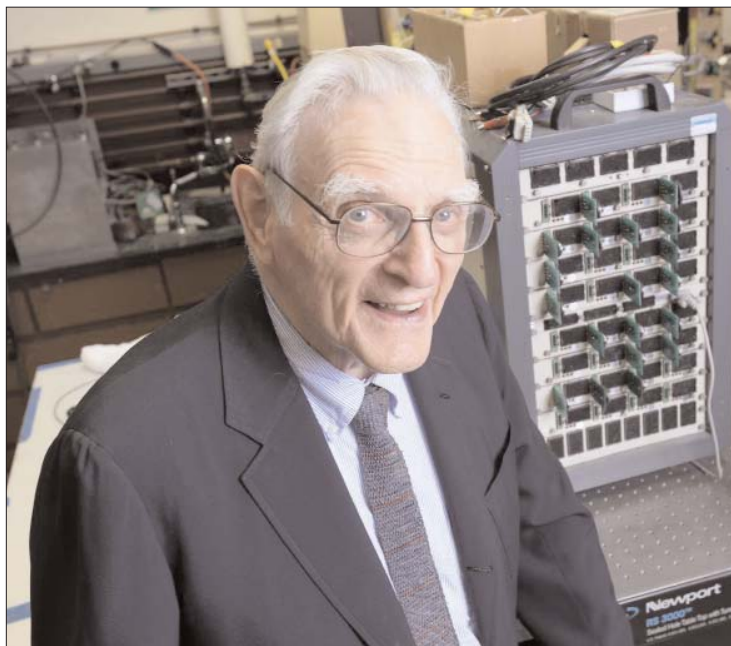


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## LITHIUM-ION BATTERY INVENTOR INTRODUCES NEW TECHNOLOGY FOR FAST-CHARGING, NONCOMBUSTIBLE BATTERIES University of Texas at Austin

A team of engineers led by 94-year-old John Goodenough, professor in the Cockrell School of Engineering at The University of Texas at Austin and co-inventor of the lithium-ion battery, has developed the first all-solid-state battery cells that could lead to safer, faster-charging, longer-lasting rechargeable batteries for handheld mobile devices, electric cars and stationary energy storage.

Goodenough's latest breakthrough, completed with Cockrell School senior research fellow Maria Helena Braga, is a low-cost all-solid-state battery that is noncombustible and has a long cycle life (battery life) with a high volumetric energy density and fast rates of charge and discharge. The engineers describe



Prof. John Goodenough in his lab (Photos: University of Texas at Austin)

their new technology in a recent paper published in the journal *Energy & Environmental Science*.

“Cost, safety, energy density, rates of charge and discharge and cycle life are critical for battery-driven cars to be more widely adopted. We believe our discovery solves many of the problems that are inherent in today’s batteries,” Goodenough said.

The researchers demonstrated that

their new battery cells have at least three times as much energy density as today’s lithium-ion batteries. A battery cell’s energy density gives an electric vehicle its driving range, so a higher energy density means that a car can drive more miles between charges. The UT Austin battery formulation also allows for a greater number of charging and discharging



Maria Helena Braga

cycles, which equates to longer-lasting batteries, as well as a faster rate of recharge (minutes rather than hours).

Today's lithium-ion batteries use liquid electrolytes to transport the lithium ions between the anode (the negative side of the battery) and the cathode (the positive side of the battery). If a battery cell is charged too quickly, it can cause dendrites or "metal whiskers" to form and cross through the liquid electrolytes, causing a short circuit that can lead to explosions and fires. Instead of liquid electrolytes, the researchers rely on glass electrolytes that enable the use of an alkali-metal anode without the formation of dendrites.

The use of an alkali-metal anode (lithium, sodium or potassium) — which isn't possible with conventional batteries — increases the energy density of a cathode and delivers a long cycle life. In experiments, the researchers' cells have demonstrated more than 1200 cycles with low cell resistance.

Additionally, because the solid-glass electrolytes can operate, or have high conductivity, at  $-20\text{ }^{\circ}\text{C}$ , this type of battery in a car could perform well in subzero degree weather. This is the first all-solid-state battery cell that can operate under  $60\text{ }^{\circ}\text{C}$ .

Braga began developing solid-glass electrolytes with colleagues while she was at the University of Porto in Portugal. About two years ago, she began collaborating with Goodenough and researcher Andrew J. Murchison at UT Austin. Braga said that Goodenough brought an understanding of the composition and properties of the solid-glass electrolytes that resulted in a new version of the electrolytes that is now patented through the UT Austin Office of Technology Commercialization.

The engineers' glass electrolytes allow them to plate and strip alkali metals on both the cathode and the anode side without dendrites, which simplifies battery cell fabrica-

tion.

Another advantage is that the battery cells can be made from earth-friendly materials.

"The glass electrolytes allow for the substitution of low-cost sodium for lithium. Sodium is extracted from seawater that is widely available," Braga said.

Goodenough and Braga are continuing to advance their battery-related research and are working on several patents. In the short term, they hope to work with battery makers to develop and test their new materials in electric vehicles and energy storage devices.

### **AWARENESS OF OUR SENSE OF "RIGHTNESS" Oliver Perry**

At our March monthly EEVC meeting, attended by a few of the regulars, and Dennie Sitchter, who traveled half way across Pennsylvania to attend, I brought up the point that because of our human being's sense of rightness we frequently become engaged in heated arguments, which tend to ignore facts. This past presidential election introduced the term of "Fake News" and a re-emphasis on "Fact Checking." A characteristic of human beings is our predisposition to feel that whatever we choose to believe is right and that our opponents with a differing viewpoint are wrong.

I am not sure how many individuals read this EEVC newsletter. The number is few compared to the *New York Times*.... even few compared to *Current Events*. But, to the few who do read the EEVC newsletter, let me clarify why this particular message is appearing in our newsletter, a newsletter with a primary purpose of publishing electric and alternative fueled transportation news.

We had a serious debate back in our September meeting as to what the purpose of the EEVC should be. Some advocated we should be an organization dedicated and committed to electric cars only, and to only serve the interests of those who owned electric vehicles. Some members even advocated that only those who owned an EV should be allowed to be an EEVC member. The meeting turned out to be a heated one. There were members present who argued that the EEVC should remain more of an educational organization exploring all topics related to environ-

mental concerns, including solar, wind, and other forms of alternative energy. And there were those present who felt that economic and political topics that related to the conservation of energy and our environment should remain a part of a continued discussion.

Last evening Denny Sitchter shared with us some of the exciting machine shop work that he and his son are engaged in. All of us in attendance enjoyed what he showed us. Engineering and machine shop work have always been a part of the EV conversion movement. So over the years we have had many presentations related to that topic as well as to other related technical and scientific topics. There has been a strong correlation between those in the EEVC who design and make conversions (and drive EVs) with technical and engineering fields. At this point, although we have more members who have joined us because they have purchased an EV, rather than make a conversion, we remain a diverse bunch sharing many interests. Until the EEVC membership interests consolidate into a narrower field, the EEVC will maintain a forum which provides a wide range of topics related to alternative transportation and sustainable energy, including the economic and political.

(One of the points that can be made regarding our energy and pollution concerns, as well as climate change, involves population control. So discussion of the Pope, sex, and child production came up toward the end of our last meeting. It takes a genius to decide whether or not a topic crosses over our line of acceptance. I guess as long as everybody is engaged and smiling during the discussion it is okay.)

Back to the beginning... The point I made at the beginning of this article was that discussions related to our topics of interest seem to frequently break down into two opposing viewpoints supported by equally opposing political camps. And, those in each camp are convinced that they are right and the others are wrong. No problem, until the sense of rightness within us begins to bend the rules of humane discussion and a lack of tolerance for our opponent's point of view. When we begin to distort the facts, present arguments without fact checking the accuracy of the claims behind them, distorting information in

order to win our argument, I believe we have stepped out of bounds. We are inclined to do this because we are so filled with our sense of rightness that we insist that anything we do or say must be justified in order to stamp out the other side. Our opponent, in our view, is detrimental to mankind. We must save the planet by any means we can or shut up those who are preventing us from making money, with which we can save mankind.

It is easy to get caught up in our sense of rightness. After all we do know more than our opponent.. and why can't they see it? Maybe both sides would benefit if we didn't exaggerate or pass on distorted images.

Using an illustration non-related to our topics of discussion, why is it wrong for the media to only post the 12 year old picture of someone shot by the police when the victim was a full grown adult when shot? The 12 year old picture buys sympathy for the victim. It paints a distorted picture of both the victim and the policeman.

Why is it wrong for the news media to only cover the rallies of those with one point of view? Because,,, it causes the uncovered side to feel alienated and unfairly treated. It helps to create war. We are told that all persons what to feel that their concerns matter and that their voice is heard. When it is, they tend to listen more to their opponent.

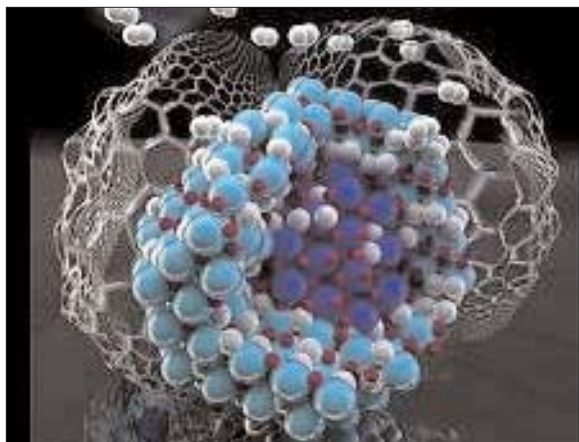
All of us can easily be miss led by half facts and distorted information. Knowing this we sometimes resort to using it to getting something we want or getting out of trouble we deserve.

"Why are you speeding?"..... "Officer I am late for my poor mother's funeral!" ( She died two years ago and we are really late in getting to it.)

So let us continue to share information, fact check, reason, and debate, so that we all can continue to learn from each other.

**CONFINED NANOPARTICLES  
IMPROVE HYDROGEN STORAGE  
MATERIALS PERFORMANCE  
By Staff Writers, Lawrence Livermore  
National Laboratory**

Sometimes, you have to go small to win big. That is the approach a multilab, interdisciplinary team took in using nanoparticles and a



*Hydrogenation forms a mixture of lithium amide and hydride (light blue) as an outer shell around a lithium nitride particle (dark blue) nanoconfined in carbon. Nanoconfinement suppresses all other intermediate phases to prevent interface formation, which has the effect of dramatically improving the hydrogen storage performance. Image courtesy Sandia National Laboratories.*

novel nanoconfinement system to develop a method to change hydrogen storage properties.

This discovery could enable the creation of high-capacity hydrogen storage materials capable of quick refueling, improving the performance of emerging hydrogen fuel cell electric vehicles.

Sandia National Laboratories, Lawrence Livermore National Laboratory (LLNL), the National Institute of Standards and Technology and Mahidol University in Bangkok, Thailand, collaborated on the research, which was published Feb. 8 in the journal *Advanced Materials Interfaces*.

The work was funded by the Department of Energy's (DOE) Fuel Cell Technologies Office and the Boeing Co.

### **Accelerating the uptake and release of hydrogen**

Hydrogen fuel cell vehicles are powered by an electrochemical reaction between hydrogen and oxygen inside a fuel cell. While oxygen is provided by air, the hydrogen must be stored separately on the vehicle. Current fuel cell electric vehicles store hydrogen as a high-pressure gas.

A solid material can act like a sponge for the absorption and release of hydrogen, in chemical terms hydrogenation and dehydrogenation. Thus using such a hydrogen storage

material could increase how much hydrogen can be stored. The material must be able to store enough hydrogen for the vehicle to go at least 300 miles before refueling.

"There are two critical problems with existing sponges for hydrogen storage," said Sandia chemist Vitalie Stavila. "Most can't soak up enough hydrogen for cars. Also, the sponges don't release and absorb hydrogen fast enough, especially compared to the 5 minutes needed for fueling."

In this effort, Stavila explained, the interdisciplinary team of scientists worked closely on the synthesis, characterization and modeling to improve the properties of lithium nitride, a promising hydrogen storage sponge. The team also developed a fundamental understanding of why nanosizing improves the hydrogen storage properties of this material.

### **Confining the space**

The idea came from Mahidol University graduate student Natchapol "Golf" Poonyayant, who approached Sandia with the idea of using nanoconfinement to enhance hydrogen storage reactions in nitrogen-containing compounds. Working with the Sandia researchers, Poonyayant, his adviser, Pasit Pakawatpanurut, and fellow Mahidol student Natee "Game" Angboonpong found that liquid ammonia could be used as a gentle and efficient solvent for introducing metals and nitrogen into the pockets of carbon nanoparticles, producing nanoconfined lithium nitride particles.

The new material that emerged from Poonyayant's idea showed some unusual and unexpected properties. First, the amount of lithium nitride in the carbon nanoparticle host was quite high for a nanoconfined system, about 40 percent. Second, the nanoconfined lithium nitride absorbed and released hydrogen more rapidly than the bulk material. Furthermore, once the lithium nitride had been hydrogenated, it also released hydrogen in only one step and much faster than the bulk system that took two steps.

"In other words, the chemical pathways for both hydrogen absorption and release in this hydrogen storage material were dramatically changed for the better," said Sandia chemist Lennie Klebanoff.

### Understanding the puzzle

To better understand the mechanism responsible for this improvement, the Sandia scientists reached out to computational scientist Brandon Wood of LLNL, a leading expert in the theory of solid-state reactions. Wood and his LLNL colleagues Tae Wook Heo, Jonathan Lee and Keith Ray discovered that the reason for the unusual behavior was the energy associated with two material interfaces.

Since the lithium nitride nanoparticles are only 3 nanometers wide, even the smallest energetically unfavorable process is avoided in the hydrogen storage properties. For lithium nitride nanoparticles undergoing hydrogenation reactions, the avoidance of unfavorable intermediates — extra steps in the chemical process — increases efficiency.

Taking the path of least resistance, the material undergoes a single-step path to full hydrogenation. Similarly, once hydrogenated, the nanoparticles release hydrogen by the lowest energy pathway available, which in this case is direct hydrogen release back to lithium nitride.

“In this way, the nanointerfaces drive the hydrogen storage properties when the materials are made very small, for example with nanoconfinement,” said Wood. “The purposeful control of nanointerfaces offers a new way to optimize hydrogen storage reaction chemistry.”

### The next step

According to the Sandia and LLNL researchers, the next step is to further understand how the dehydrogenated and hydrogenated phases of lithium nitride change at the nanoscale. This is a stiff challenge to the team, as it requires imaging different chemical phases within a particle that is only several nanometers wide.

The team will draw on the capabilities within the DOE’s Hydrogen Storage Materials Advanced Research Consortium (HyMARC), led by Sandia and comprised additionally of scientists from LLNL and Lawrence Berkeley National Laboratory. The team plans to use spatially resolved synchrotron radiation from LBNL’s Advanced Light Source to probe interface chemistry and structure.

In addition, since the nanoporous carbon

host is “dead weight” from a hydrogen storage perspective, the team is examining ways to “lighten the load” and find carbon materials with more nanopockets for a given carbon mass.

“We are thrilled with this technical advance and excited to take on the work ahead,” said Klebanoff. “But it’s bittersweet. Golf, who inspired this work and conducted many of the syntheses, died tragically at the age of 25 during the writing of this paper. The world has lost a talented young man and we have lost a dear friend whom we miss. This work and its published account are dedicated to Golf and his family.”

*Editor’s note: While this line of research seems promising, no information is given on how much hydrogen can be stored in a given mass or volume of material. We will attempt to get more, and report in a future issue.*

## NEWS UPDATE

### EV tax credits under attack

Governmental support of EVs and other alternate-energy transportation seems to be fading, although there are pockets of optimism.

On the federal front, the president has proposed easing mpg requirements, which will please Detroit (which is where he made the announcement) and significantly reduce incentives for car companies to sell EVs to bring up their CAFE ratings. “On Feb. 21, a coalition of the 17 largest companies that sell cars in the United States sent two letters to [E.P.A. Administrator Scott] Pruitt, asking him to revisit the tailpipe rules,” according to an article by Coral Davenport in the *New York Times* for March 3. With the current low price of gas sales of SUVs and pickups have soared, which would require car companies to work harder than ever to get mileage up, and to sell more EVs (whose attractiveness is inverse to the price of fuel). One may wonder what will happen to those SUV and pickup drivers when gas prices go back up, but they’ve been down for a long time, the present glut of gasoline is helping to keep a lid on prices, and the recent discovery on Alaska’s North Slope of an oil deposit estimated at 1.2 billion barrels will probably help keep things that way.

A March 11 *New York Times* article by Hiroko Tabuchi reports on efforts by an increasing number of states to reduce or eliminate local subsidies for EVs. Indeed, says Tabuchi, “while the battle in Washington gets much of the attention, the most direct attack against electric vehicles, and in some cases hybrid vehicles, is quietly being waged at the state level.” Tabuchi cites legislation in Georgia, Colorado and elsewhere: “A handful of other states, including Illinois, Pennsylvania and Tennessee, have already let their incentives expire. That has brought down to 16 the number of states that offer financial support for buyers of electric vehicles. That number once approached 25.”

Part of the reason, says Tabuchi, is the fact that EVs pay no gasoline tax, which induces some states to charge them special fees to recoup the money. Others are influenced by lobbying (the article cites the influence on Colorado of “Americans for Prosperity, an advocacy group founded by the conservative billionaire brothers David H. and Charles G. Koch, whose wealth is founded on their petrochemicals empire.”

On the other hand, some states are taking active steps to encourage EV use. California is the best known, but, according to a March 14 article by Joe Ryan in *Bloomberg Technology*, “[d]ozens of U.S. cities are willing to buy \$10 billion of electric cars and trucks to show skeptical automakers there’s demand for low-emission vehicles, just as President Donald Trump seeks to review pollution standards the industry opposes.

“Thirty cities including New York and Chicago jointly asked automakers for the cost and feasibility of providing 114,000 electric vehicles, including police cruisers, street sweepers and trash haulers, said Los Angeles Mayor Eric Garcetti, who is coordinating the effort. That would be comparable to about 72 percent of total U.S. plug-in sales last year.”

### **Toyota and Shell Closer to a Hydrogen Refueling Network in California**

On February 17, The California Energy Commission (CEC) posted a Notice of Proposed Award (NOPA) outlining subsidies to support hydrogen refueling infrastructure in California. Shell, in partnership with Toyota, will be considered for the installation of

hydrogen refueling equipment into seven retail stations in the state of California and an award of \$16,362,500 to develop those stations.

The NOPA marks an important step forward in California’s aspiration for broader deployment of low-carbon fuels and vehicle technologies, via its CEC’s Alternative and Renewable Fuel and Vehicle Technology Program.

“Providing accessible, reliable and convenient refueling is key to mainstream adoption of fuel cell vehicles,” said Craig Scott, advanced technology vehicle senior manager, Toyota Motor North America. “Shell’s partnership will bring the expertise and resources of a major energy company to hydrogen infrastructure efforts in California. The team of Toyota and Shell will bring us one step closer to a hydrogen society.”

“Hydrogen electric vehicles could play an important role in improving air quality while offering convenience to motorists,” stated Oliver Bishop, Hydrogen General Manager, Shell. “This kind of collaboration between government and industry is central to making hydrogen a reality. It’s a great opportunity to encourage a growing number of hydrogen fuel cell vehicles on the roads and support the carbon reduction goals of the State.”

### **New competitor for Tesla?**

A March 16 article by Scott Collie in *New Atlas* (the publication formerly known as *Gizmag*) reports that EV startup Lucid Motors has priced its first offering, the Air EV, to “start at \$60,000 but that figure doesn’t include the \$7,500 Federal tax credit applied to electric cars sold in the US.” This, the article says, puts it in direct competition with the Tesla Model S. Will it actually happen? “If we’re being brutally honest,” says the article, “there isn’t any guarantee the car will be built at all, but Lucid certainly looks more solid than the likes of Faraday Future and LeEco at the moment.”

Similarly voicing questions about competition for Tesla is a Feb 7 article by Brian Deagon in *Investor’s Business Daily*. Deagon looks at GM, Ford and the Chinese: “Tesla has had an early lead, but the risks are increasing that its dominance in all-electric vehicles will wane over time, says a report by S&P Capital IQ.” The article continues:

“CFRA Research analyst Efraim Levy, in a research note Tuesday, said Tesla’s early lead in electric vehicles has given it a good head start.

‘However, as more competitors are joining the electric-vehicle space, we see risks increasing that Tesla’s dominance in all-electric vehicles will wane by the time the market reaches critical size,’ he wrote.”

### **NOT BY A DAM SITE By California Pete**



Too little rain, or too much? California can’t seem to get it right. We suffered a drought for five years, with rivers low, farmers going without irrigation water, and restrictions on household water use, including public shaming — and even fines —

for people who watered their lawns too much.

That was then.

This winter has been one for the books, with many reservoirs filled to overflowing even before the end of the rainy season. And at least one overflowing reservoir has turned out to be a real problem. Held back by Oroville Dam, the tallest in the U.S., Lake Oroville, in the Sierra Nevada foothills, has a maximum capacity of 3.5 million acre-feet of water (an acre foot, 325,851 gallons, is enough water to supply one or two average households for a year). During the drought the lake fell to 32 percent of capacity. This year it rained more than usual — 39 inches in the vicinity of the lake — and snowed in the mountains. At one point water was pouring in at 150,000 cubic feet per second. The lake filled up and water began to go over the main spillway, which began to crumble under the load (lots of water; who knew?). Debris from the spillway threatened to get into the hydroelectric plant’s turbines, so they were shut off, and could no longer drain off their 16,000 cubic feet per second.

The water continued to rise, and began to go over the nearby emergency spillway, which was just a dirt hillside next to the dam and had never been used. Surprise, the hill-

side began to wash away, threatening to cause the hill itself to go, and causing the evacuation of 200,000 people along the Feather River downstream.

Engineers eventually got the reservoir level low enough that they could stop the flow over the spillway and do emergency repairs, but it will cost \$200 million to repair, according to estimates. How much it will actually cost is anybody’s guess.

### **Southern California Gas Co. tries to do the right thing**

In the last issue we reported that Southern California Gas Co., which was responsible for the blowout of an underground natural gas storage facility that was the worst release of methane (21 times as potent a greenhouse gas as carbon dioxide) in U.S. history.

It is now reported that the company will be paying \$8.5 million for the incident: “\$1 million for [a] health study; \$5.65 million to pay for emission fees related to the leak, with \$1 million of that earmarked to fund a renewable natural gas production project; \$1.6 million to reimburse the regulatory agency for air monitoring costs and \$250,000 for the [Air Quality Monitoring District’s] legal fees,” according to the Associated Press. Nothing is mentioned about compensating the 8000 families who were forced out of their homes by the leak.

### **PG&E and Tesla, perfect together**

In the same story last month we mentioned that Southern California Electric has begun installing batteries for load levelling, partly to eliminate the need to store so much gas for peaking plants. Now PG&E, in the northern part of the state, has made a deal with Tesla to install a bank of lithium batteries from Tesla’s Gigafactory “at a Pacific Gas and Electric Co. substation in Browns Valley (Yuba County),” according to a Feb 16 story by the *San Francisco Chronicle’s* David Baker. This is in addition to a number of existing sodium-sulfur battery installations, one in San Jose and the other in the North Bay, near Vacaville. (If you ever want a good name for a western town, that’s it — it seems to mean “Cowtown” in Spanish, although it was actually named for its founder, Manuel Cabeza Vaca).

### Speech is free if we like what you say

From a story by John Wildermuth in the *San Francisco Chronicle* for Feb. 23: "A Republican legislator and Vietnamese refugee was dragged from the state Senate floor Thursday morning when a Democratic leader ordered her removed after she tried to criticize the late Tom Hayden, a former state senator and vocal opponent of the war in Vietnam.

"State Sen. Janet Nguyen, R-Garden Grove (Orange County), who was born in what was then Saigon, spoke briefly in Vietnamese, but her microphone was shut off less than 30 seconds after she began to repeat her remarks in English."

It seems she was annoyed at how Mr. Hayden (who went on to become a California state senator) had given aid and comfort to the North Vietnamese during the war, and spoke out during a memorial to him.

### Wild ride on I-80

Interstate 80, which runs from San Francisco through the East Bay, then to Sacramento and across the country to the East Coast, has been the scene of a great many shootings in recent years. It seems that local gangs have discovered that there are few traffic cameras and no license plate readers along the stretch in the East Bay, so they use it as a free-fire zone. Gang members spot a car with enemies in it, follow it onto the freeway, pull alongside and open fire. So far there have been about 80 incidents, most of them unsolved, since late 2015. There are calls for cameras and license plate readers, but the road belongs to the state, which has been slow to act (doesn't want to spend the money). Apparently no state official has been targeted on the highway, so it's a low priority.

## COMING EVENTS

### J1

#### 17: SAE World Congress Experience

April 4-6, Detroit. [www.wcx17.org/](http://www.wcx17.org/)

#### 21st CAC

April 7-9, Penn State. More info to come.

#### Earth Day 2017

April 22. [www.earthday.org](http://www.earthday.org)

#### 3rd International Conference on Vehicle Technology and Intelligent Transport

### Systems (VEHITS)

April 22-24, Porto, Portugal. [www.vehits.org/](http://www.vehits.org/)

#### 6th International Conference on Smart Cities and Green ICT Systems (SMART-GREENS)

April 22-24, Porto, Portugal, colocated with the above. Go to [www.smartgreens.org](http://www.smartgreens.org).

#### 7th China International New Energy Vehicle Forum 2017

April 24-25, Shanghai. [www.ecvinternational.com/2017ChinaVehicle/](http://www.ecvinternational.com/2017ChinaVehicle/)

#### ACT Expo 2017 - Alternative Clean Transportation

May 1-5, Long Beach, CA. For info go to [www.actexpo.com/](http://www.actexpo.com/)

#### Electric Vehicles: Everything is Changing

May 10-11, Berlin. [www.idtechex.com/electric-vehicles-europe/show/en/](http://www.idtechex.com/electric-vehicles-europe/show/en/)

#### National Drive Electric Week

Sept 9-17, nationwide. At press time no events were listed for the eastern PA-NJ area; for more information go to <https://driveelectricweek.org/>

#### 2017 Bridgestone World Solar Challenge

Oct 8-15, Darwin to Adelaide, Australia. Go to [www.worldsolarchallenge.org](http://www.worldsolarchallenge.org)

## NOTICE ON DUES

Annual dues are \$20 with electronic delivery of the Newsletter, or \$25 for a printed copy. Make checks payable to EEVC and mail to James Natale, 3307 Concord Dr, Cinnaminson NJ, 08077, or pay via PayPal to [www.paypal.me/EEVC](http://www.paypal.me/EEVC).

## MEETING SCHEDULE

Meetings are held in Room 49, Plymouth-Whitmarsh High School, 201 East Germantown Pike in Plymouth Meeting, PA, and begin at 7:00 p.m. Since the school is closed in the summer there will be no July or August meetings there. Possible alternate locations will be discussed at a future time.

April 12

May 10

June 14