EEVC NEWSLETTER

Published by the Eastern Electric Vehicle Club

Peter Cleaveland, Editor **Vol 37 No 11,12**

NOVEMBER-DECEMBER, 2017

email: easternev@aol.com. Web site: www.eevc.info

President: Oliver Perry, 5 Old Stagecoach Turn

Shamong, NJ 08088, (609) 268-0944

Affiliated with EAA

THE ETHANOL LOBBY: UNACKNOWLEDGED ELEPHANT IN OUR MIDST

Oliver Perry

On October 23 the *Wall Street Journal* ran an op-ed piece entitled "Trump Caves on Ethanol." If there is much outrage among the anti fossil fuel advocates for the use of a bio-fuel additive in our fossil fuel based gasoline, it has been placed on the back burner.

We used to think that any bio-fuel was greener and better for the environment than any fossil fuel, that any bio-fuel used in the transportation sector benefited us. Are we aware of the consequences of going green with ethanol?

A quick Google of "The environmental impact of ethanol" will bring readers up to date on the latest.

For example: Studies show that burning ethanol reduces the release of the greenhouse gas CO_2 ; but ethanol has mixed effects on air quality. Increased ethanol use could pose other environmental problems, including decreased fuel economy and a loss of forests and wetlands.

According to the *WSJ*, "The EPA will further consider giving bio-fuels a pass to pollute that NO OTHER INDUSTRY ENJOYS, via what's known as the Reid Vapor Pressure waiver for high-ethanol blends."

EPA regulates the vapor pressure of gasoline sold at retail stations during the summer ozone season (June 1 to September 15) to reduce evaporative emissions from gasoline that contribute to ground-level ozone and diminish the effects of ozone-related health problems.

Wikipedia: Reid vapor pressure (RVP) is a common measure of the volatility of gasoline. It is defined as the absolute vapor pressure exerted by a liquid at 37.8 °C (100 °F) as determined by the test method ASTM-D-323. The test method measures the vapor pressure of gasoline, volatile crude oil, and other volatile petroleum products, except for liquefied petroleum gases. RVP is stated in kilopascals and represents a relative pressure to the atmospheric pressure because ASTM-D-323 measures the gauge pressure of the sample in a non-evacuated chamber. All values are in SI units and are regarded as standards. Imperial units are for information only.

The matter of vapor pressure is important relating to the function and operation of gasoline-powered, especially carbureted, vehicles. High levels of vaporization are desirable for winter starting and operation and lower levels are desirable in avoiding vapor lock during summer heat. Fuel cannot be pumped when there is vapor in the fuel line (summer) and winter starting will be more difficult when liquid gasoline in the combustion chambers has not vaporized. Thus, oil refineries manipulate the Reid Vapor Pressure seasonally specifically to maintain gasoline engine reliability.

WSJ article:The EPA will keep intact a

compliance credit scheme that benefits global and integrated oil companies and ethanol producers at the expense of smaller independent refiners and manufacturers. Renewable identification numbers, or RINs are a credit created overtime a gallon of ethanol is mixed with a fuel. The EPA requires refiners to use RIN's as proof of compliance with biofuel standards, and credits can be bought or sold. Because only major global refiners have the capabilities to blend their own fuel, most small and midsize merchant have no way of producing RINs in-house. Big Oil, the ethanol lobby and speculators have cornered the market for the credits, and RIN prices are soaring.

In 2012 Philadelphia Energy Solutions paid $10 million of RINs. This year it will spend $300 million, twice the price of payroll. Only crude oil, the refinery's main input, costs more annually. The refinery's credit rating has dropped from a BN+ to a CCC- in four years. Bottom line is that independent refiners that provide blue-collar manufacturing jobs will suffer, according to labor leaders, with massive cutbacks in jobs. "We are crushed between Big Oil and Big Ethanol," stated Ryan O'Callahan, the president of the United Steel Workers Local 10-1. Trump's EPA, according to the *WSJ* editorial page, is now capitulating to one of Washington's worst examples of welfare for big business.

I am not sure how many of our readers are interested in investigating details and fact checking. Personally I discovered that there is a lot to learn regarding the nuances of ethanol-gasoline blending, the EPA regulations and the over-all environmental impact. What I gather from surface reading is that we could be sacrificing our goals to better our environment on the altar of Big Ethanol. This altar was initially endorsed by many of us as an improvement in getting free from fossil fuel destruction. We jumped on the bandwagon early on, as we frequently do. Meanwhile, Big Ethanol could be a polluter in the room that we have chosen to ignore.

We seem to focus on a few issues and ignore others while drawing conclusions that might prove to be misleading down the road. I continue to question that MAN MADE (WITH FOSSIL FUEL) CO_2 is our greatest concern on planet earth (as Obama stated in his state of the union address) with the implication that it is the single most important culprit in causing climate change. We still have unaddressed big elephants in the room that deserve our attention.

Lastly, when we cannot agreed on the fundamental causes of our problems, how can we agree as to the most expedient way to achieve solutions?

STUDY HELPS MAKE MICROGRIDS A MORE RELIABLE POWER SOURCE

by Massachusetts Institute of Technology

Today, more than 1.3 billion people are living without regular access to power, including more than 300 million in India and 600 million in sub-Saharan Africa. In these and other developing countries, access to a main power grid, particularly in rural regions, is remote and often unreliable.

Increasingly, many rural and some urban communities are turning to microgrids as an alternative source of electricity. Microgrids are small-scale power systems that supply local energy, typically in the form of solar power, to localized consumers, such as individual households or small villages.

However, the smaller a power system, the more vulnerable it is to outages. Small disturbances, such as plugging in a certain appliance or one too many phone chargers, can cause a microgrid to destabilize and short out.

For this reason, engineers have typically designed microgrids in simple, centralized configurations with thick cables and large capacitors. This limits the amount of power that any appliance can draw from a network — a conservative measure that increases a microgrid's reliability but comes with a significant cost.

Now engineers at MIT have developed a method for guaranteeing the stability of any microgrid that runs on direct current, or DC — an architecture that was originally proposed as part of the MIT Tata Center's uLink project. The researchers found they can ensure a microgrid's stability by installing capacitors, which are devices that even out spikes and dips in voltage, of a particular size, or capacitance.

The team calculated the minimum capacitance on a particular load that is required to maintain a microgrid's stability, given the total load, or power a community consumes. Importantly, this calculation does not rely on a network's particular configuration of transmission lines and power sources. This means that microgrid designers do not have to start from scratch in designing power systems for each new community.

Instead, the researchers say this microgrid design process can be performed once to develop, for instance, power system "kits": sets of modular power sources, loads, and lines that can be produced in bulk. As long as the load units include capacitors of the appropriate size, the system is guaranteed to be stable, no matter how the individual components are connected.

The researchers say such a modular design may be easily reconfigured for changing needs, such as additional households joining a community's existing microgrid.

"What we propose is this concept of ad hoc microgrids: microgrids that can be created without any preplanning and can operate without any oversight. You can take different components, interconnect them in any way that's suitable for you, and it is guaranteed to work," said Konstantin Turitsyn, associate professor of mechanical engineering at MIT. "In the end, it is a step toward lower-cost microgrids that can provide some guaranteed level of reliability and security."

The team's results appear online in the *IEEE journal Control Systems Letters*, with graduate student Kathleen Cavanagh and Julia Belk '17.

Returning to normal operations

Cavanagh says the team's work sought to meet one central challenge in microgrid design: "What if we don't know the network in advance and don't know which village a microgrid will be deployed to? Can we design components in such a way that, no matter how people interconnect them, they will still work?"

The researchers looked for ways to constrain the dimensions of a microgrid's main components -- transmission lines, power sources, and loads, or power-consuming elements -- in a way that guarantees a system's overall stability without depending on the particular layout of the network.

To do so, they looked to Brayton-Moser potential theory — a general mathematical theory developed in the 1960s that characterizes the dynamics of the flow of energy within a system comprising various physical and interconnected components, such as in nonlinear circuits.

"Here we applied this theory to systems whose main goal is transfer of power, rather than to perform any logical operations," Turitsyn said.

The team applied the theory to a simple yet realistic representation of a microgrid. This enabled the researchers to look at the disturbances caused when there was a variation in the loading, such as when a cell phone was plugged into its charger or a fan was turned off. They showed that the worst-case configuration is a simple network comprising a source connected to a load. The identification of this simple configuration allowed them to remove any dependence on a specific network configuration or topology.

"This theory was useful to prove that, for high-enough capacitance, a microgrid's voltage will not go to critically low levels, and the system will bounce back and continue normal operations," Turitsyn said.

Blueprint for power

From their calculations, the team developed a framework that relates a microgrid's overall power requirements, the length of its transmission lines, and its power demands, to the specific capacitor size required to keep the system stable.

"Ensuring that this simple network is stable guarantees that all other networks with the same line length or smaller are also stable," Turitsyn said. "That was the key insight that allowed us to develop statements that don't depend on the network configuration."

"This means you don't have to oversize your capacitors by a factor of 10, because we give explicit conditions where it would remain stable, even in worst-case scenarios," Cavanagh said.

In the end, the team's framework provides a cheaper, flexible blueprint for designing and adapting microgrids, for any community configuration. For instance, microgrid opera-

tors can use the framework to determine the size of a given capacitor that will stabilize a certain load. Inversely, a community that has been delivered hardware to set up a microgrid can use the group's framework to determine the maximum length the transmission lines should be, as well as the type of appliances that the components can safely maintain.

"In some situations, for given voltage levels, we cannot guarantee stability with respect to a given load change, and maybe a consumer can decide it's ok to use this big of a fan, but not a bigger one," Turitsyn said. "So it could not only be about a capacitor, but also could constrain the maximal accepted amount of power that individuals can use."

Going forward, the researchers hope to take a similar approach to AC, or alternating current, microgrids, which are mostly used in developed countries such as the United States.

"In the future we want to extend this work to AC microgrids, so that we don't have situations like after Hurricane Maria, where in Puerto Rico now the expectation is that it will be several more months before power is completely restored," Turitsyn said. "In these situations, the ability to deploy solar-based microgrids without a lot of preplanning, and with flexibility in connections, would be an important step forward."

NEWS UPDATE

Wild idea from Lamborghini (and M.I.T.)

Automobili Lamborghini and the Massachusetts Institute of Technology have been working on a concept supercar for the past year, and on November 7 they unveiled the result of their collaboration, called the "Terzo Millennio" at the recent EmTech MIT Conference. It's an electric supercar to rival anything that Tesla has produced (funny how all the imaginative EVs seemed to be intended as toys for the wealthy), but it has no batteries — or at least that's the plan. Instead of batteries, which are deemed too heavy for a true supercar, the idea is to make the car's body out of carbon nanotubes that will function as supercapacitors. What's more, says the company, "the project aims to combine the technology to monitor continuously the whole carbon fiber structure, both visible and invisible, with the concept of health-monitoring: the goal is to provide for the Terzo Millennio the ability to conduct its own health-monitoring, to detect cracks and damages that might occur after accident, throughout its substructure, while limiting or reducing to zero the risks correlated to the presence and propagation of cracks in the carbon fiber structure.

"The process is limited," says Megan Crouse in a November 13 article in *Product Design and Development*, "— only shallow cracks and dings could be healed this way — but the team is quick to assure that larger dents would also be detected by sensors and brought to the attention of the driver and Lamborghini technicians."

Future of EVs in China: Ford chairman

A December DEC. 5, 2015 *New York Times* article by Keith Bradsheer quotes Ford executive chairman William C. Ford Jr. that "it's clearly the case that China will lead the world in E.V. development." Ford and other car makers are moving to produce their EVs there, driven by a combination of carrots and sticks from the Chinese government.

Ford to build EVs in Mexico after all

Ford Motor Co. has reversed an earlier decision to abandon plans to build an EV plant in Mexico, according to a December 5 *New York Times* article by Neal Boudette, while also announcing the the Flat Rock, MI plant originally planned for EV assembly will instead be used to manufacture self-driving cars, with an investment of $900 million. So Michigan won't lose out. It's also no surprise; *Automotive Industries*" used to print an annual chart showing ownership and alliances

among car companies around the world, and even 30 years ago the connections were numerous. Companies pursue markets, government subsidies and low labor costs, and will always do so.

Italy to Phase Out Coal for Electricity

At the Bonn Climate talks on November 10 "U.N. Secretary-General Antonio Guterres says he will urge leaders at climate talks in Bonn to respond to the latest alarming data by further cutting emissions, helping countries respond to climate shocks, and mobilizing the $100 billion promised to help developing countries," according to the Associated Press. At that event, the article continues, Italian premier Paolo Gentiloni announced that "the country will phase out the use of coal for national electricity needs by 2025 as part of developing a sustainable and competitive energy strategy."

Get your beer electrically

On December 7 Anheuser-Busch announced that it had placed an order for 40 Tesla semi-trucks from Tesla. "The 40 semi-trucks, which represent one of Tesla's largest reported pre-orders, will be fully electric-powered and equipped with autonomous driving capabilities, as part of the company's commitment to improving road safety and reducing carbon emissions," says A-B.

When they expect delivery was not stated.

The EV tipping point

That is the title of a December article by Ed Richardson in *Automotive Industries*, which says, in part: "Merriam Webster defines tipping point as "the critical point in a situation, process, or system beyond which a significant and often unstoppable effect or change takes place.'

"The next critical tipping point in the history of the automobile is when electric vehicles become cheaper to own than conventional internal combustion models. At present it would seem that the internal combustion engine will be with us for some time to come, but even the die-hard petrolheads are looking at a 50/50 ratio by 2030 or so.

"That could happen a whole lot sooner when the cost of ownership and the total cost per kilometre or mile reaches parity. Owners will reassess their range anxiety, which as we see in this issue is fast becoming less of a problem in the industrialised world due to the rollout of recharging stations. Most owners can live with a range of around 300 kilometres for daily use. The new Nissan Leaf has a claimed range of 378 kilometres or 150 miles. Tesla is claiming 335 miles for its Model S. Drivers of vehicles powered by internal combustion engines are starting to suffer from their own range anxiety.

"Writing in Marginalrevolution.com in 2015 Alex Tabarrok pointed out that gas stations are not massively profitable businesses. 'When 10% of the vehicles on the road are electric many of them will go out of business. This will immediately make driving a gasoline powered car more inconvenient. When that happens even more gasoline car owners will be convinced to switch and so on.'"

BMW hits EV sales target

On December 18 the BMW group announced that it had delivered more than 100,000 electrified vehicles to customers worldwide in 2017, as promised at the beginning of the year.

"This underlines the company's leadership role when it comes to electro-mobility," says the announcement, noting that sales are more than 60 percent greater than 2016, when 62,255 EVs were sold.

Will EVs imperil car dealers?

We all know that much of a car dealer's income is derived from service: money from oil changes, mechanical repairs and the like make up a large part of their profits. But what about EVs, which take much less maintenance than ICE-powered cars? No oil changes, no tuneups — just brakes and the occasional windshield wiper blade.

An article by Robert Truett in *Automotive News Fixed Ops Journal* for December 18 entitled "Electric vehicles and the future of fixed ops" takes a look at the situation and finds it unsettling: "Experts say everything in the back of the store — vehicle repair, parts, body shops, service customer retention — will be disrupted if the coming armada of electric vehicles, which require less maintenance than traditional cars and trucks, sells in high volume." The article quotes Wally

Burchfield, vice president of U.S. aftersales for Nissan North America that "service revenue from regular maintenance of wear items on EVs would amount to 'probably two-thirds to three-quarters of what an internal-combustion engine vehicle would be.'"

What's a dealer to do?

The article quotes Burchfield that dealers do have an advantage over the competition when it comes to EV service: customers are more likely to trust the dealer for service of these vehicles than they would independent operators. Just as it takes a large investment in computerized equipment to diagnose today's gasoline cars, EVs will have the same effect: "'Much like an Apple product, you are going to take it to an Apple store," he says. 'You are not going to go to the local guy who's good with a computer.'"

But, the article goes on, that may change with time; many places now offerer service on a Prius, for example.

On the other hand, sometimes the dealer remains the best place to go. Your editor used to get oil changes on a 2009 Impala at Meineke. One day they recommended a brake fluid flush and replacement. The result: $800 in damage to the brake system from using the wrong fluid. Now the car gets all its service at the dealer.

New hope for battery research

Battery limitations have been a drag on EV development and acceptance for more than a century, and while recent advances in lithium cells show great promise, more must and can be done; that is the premise behind the establishment of the U.K.-based Faraday Institution, which "brings together seven U.K. universities to accelerate fundamental research in the development of battery technologies," according to a December 11 article by Stuart Birch in *Automotive Engineering*. The author interviewed Prof. David Greenwood, Professor of Advanced Propulsion Systems at the University of Warwick's Manufacturing Group. Here are some highlights.

"'The Faraday Institution will work on research programs developed from grand challenges set by industry, so a focus will be on the biggest research issues that are inhibiting progress. The first tranche of research areas covered will be battery degradation, multi-scale modeling, solid state batteries and recycling/circular economy.'

Later research will investigate — always with the end application in mind — such things as lithium-sulfur, solid-state batteries, as well is necessary changes in infrastructure going forward.

The original article is available at http://articles.sae.org/15780.

IT'S PROBABLY TOO LATE TO STOP CLIMATE CHANGE
By California Pete

Readers of a certain age will remember a class of literature that has been popular since the late 19th century: post-apocalyptic fiction. It started in 1826, with Mary Shelley's *The Last Man*, and includes H.G. Wells's *The Time Machine*, Arthur C. Clarke's *Childhood's End*, Walter M. Miller's 1959 classic *A Canticle for Leibowitz*, and many more. All posit the collapse of civilization due to causes that range from alien invasion to nuclear war to climate change.

It looks like the latter may make that fiction come true. The California fire season, which once ran from June to September, is now year-round, driven by incessant warming and shifts in precipitation patterns. Much of the state now looks like a war zone.

There have been articles recently suggesting that, if everyone acts together quickly, global warming can be brought to a halt before it brings civilization to a halt. Other articles (and a little thought) suggest the opposite is true: it's probably too late to stop, and we're heading into unknown territory.

There is every reason to believe that humanity will be unable or unwilling to reduce its carbon emissions enough to prevent climate catastrophe, and even if it were possible, it's too late. The concentration of atmospheric CO_2 passed 400 parts per million a few months ago, and it's not going back.

As the climate warms the polar sea ice melts, replacing white ice that reflects sunlight back into space with dark seawater

(remember that Homer referred to it as the wine-dark sea). That will further increase the heat input to the planet.

As the climate warms the permafrost begins to melt, and the carbon stored there as peat or other organic material begins to decay, releasing CO_2 and methane (which is 25 times as effective a greenhouse gas as CO_2).

Another worry is methane clathrate (aka methane hydrate), which resembles ice and forms when methane from decaying organic material combines with water at low temperatures and high pressure. It's found on the sea bed all around the world, at the bottoms of deep lakes in cold climates (Siberia's Lake Baikal, for example), and in deep sediments on land in Siberia and and Alaska. The amount of methane locked up as hydrate on the seabed alone is estimated at several times the world's known terrestrial natural gas reserves. The problem is that the stuff breaks down at higher temperatures. As stated in the *Wikipedia* article on the subject, "Research carried out in 2008 in the Siberian Arctic found millions of tonnes of methane being released with concentrations in some regions reaching up to 100 times above normal."

"In their Correspondence in the September 2013 *Nature Geoscience* journal, Vonk and Gustafsson cautioned that the most probable mechanism to strengthen global warming is large-scale thawing of Arctic permafrost which will release methane clathrate into the atmosphere. While performing research in July in plumes in the East Siberian Arctic Ocean, Gustafsson and Vonk were surprised by the high concentration of methane.

"In 2014 based on their research on the northern United States Atlantic marine continental margins from Cape Hatteras to Georges Bank, a group of scientists from the US Geological Survey, the Department of Geosciences, Mississippi State University, Department of Geological Sciences, Brown University and Earth Resources Technology, claimed there was widespread leakage of methane.

"Scientists from the Center for Arctic Gas Hydrate (CAGE), Environment and Climate at the Arctic University of Norway, published a study in June 2017, describing over a hundred ocean sediment craters, some 3,000 meters wide and up to 300 meters deep, formed due to explosive eruptions, attributed to destabilizing methane hydrates, following ice-sheet retreat during the last glacial period, around 12,000 years ago, a few centuries after the Bølling-Allerød warming. These areas around the Barents Sea, still seep methane today, and still existing bulges with methane reservoirs could eventually have the same fate."

Warming temperatures cause CO_2 releases in another way: wildfires. Forests all over the West are burning more and more each year, and recent estimates are that the amount of CO_2 released in California wildfires dwarfs the amount saved though all the state's environmental efforts.

An article by David Baker in the *San Francisco Chronicle* for November 21 says it best: "To get a sense of the problem, look at 2015.

"Greenhouse gas emissions across the California economy inched downward by 1.5 million metric tons that year, the most recent for which emissions data are available. And just one fire in 2015 — the Rough Fire, in the foothills of Fresno County — produced 6.8 million metric tons of greenhouse gases, according to an estimate from the U.S. Forest Service.

"Other fires that year on federally managed land within California emitted 16 million metric tons."

An article by Elizabeth Kolbert in *The New Yorker* for November 20 explores various technologies being developed to remove CO_2 from the atmosphere. Two problems, however, suggest that these are probably futile:

- Many capture the CO_2 in solid or other form, but then convert it back to a gas. What do you do with the gas? Pumping it underground has not worked well.
- The scale of the problem dwarfs anything we could do. It's like making sure the rest rooms on the Titanic are flushing properly, while water is flooding in through the huge hole in the hull.

So what will happen? Large parts of the world will become desert, while those regions that are already semi-arid will resemble the part of the Arabian Peninsula called An Nafud, which was referred to in the film *Lawrence of Arabia* as The Sun's Anvil. San Francisco will become Phoenix.

Sea levels are rising inexorably, with predictions from NOAA of 0.3 to 2.5 meters (1

to 8.2 feet) this century. The coasts of most nations will change dramatically, and many cities (New York, London, etc.) will be under water. Meanwhile much of the world's farmland will be unsuitable for agriculture. There will be massive population displacements, possibly leading to wars over arable land and other resources.

The end result (in a century or two) will be a significant decrease in world population; if humanity is lucky it will not join the many species driven to extinction, but life will be more difficult for those who remain. Most of us, of course, will be unaffected, being long dead by that time.

Responses from readers with differing opinions are welcome, provided they are well thought out and free of invective.

COMING EVENTS

Motor and Drive Systems 2018
Feb 8-9, Orlando, FL. https://motoranddriveconference.com

SAE 2018 Hybrid & Electric Vehicle Technologies Symposium
Feb 20-22, San Diego-Mission Valley, CA. www.sae.org/events/hybridev/

ACI's Hydrogen & Fuel Cells Energy Summit
Jan. 24-25, Brussels. www.wplgroup.com/aci/event/hydrogen-and-fuel-cells-energy-summit/

WCX: SAE World Congress Experience
April 10-12, Detroit, MI. http://wcx18.org/

Electric Vehicles 2018
April 11-12, Berlin. www.idtechex.com/electric-vehicles-europe/show/en/

Green Transportation Summit & Expo
April 17-19, Tacoma, WA. https://www.eventbrite.com/e/green-transportation-summit-expo-tickets-36660048191?discount=EMC30

Montreal Electric Vehicle Show
April 24-27, Ottawa. https://emc-mec.ca/ev2018ve/

EEVCongress
March 14, Geneva, in the framework of the Geneva International Motor Show, March 8-18. https://www.gims.swiss/en/

Movin'On, the international summit on sustainable mobility (successor to the Michelin Challenge Bibendum)
May 30-June 1, Montréal. https://movinon.michelin.com/en/

American Solar Challenge 2018
Across North America, starting in Hastings, NB. americansolarchallenge.org/the-competition/american-solar-challenge-2018

Intersolar North America 2018
July 9-12, San Francisco. www.intersolar.us/en/home.html

The MAGLEV 2018 Conference, together with MTST 2018 Conference
Sept 5 - 8, St. Petersburg, Russia. http://rus-maglev.com/en/

National Drive Electric Week
Sept 8-16, nationwide. https://driveelectricweek.org/

Electric & Hybrid Vehicle Technology Expo & Conference
Sept 11-13, Novi, MI. https://evtechexpo.com/

Electric Vehicle & Plug-in Hybrid Vehicle Exhibition
Sept 26-28, Tokyo. https://10times.com/evex

SAE Range Extenders for Electric Vehicles Symposium
Nov 14-15, Dearborn, MI. www.sae.org/events/rex/

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.

MEETING SCHEDULE

Meetings are held in Room 49, Plymouth-Whitemarsh High School, 201 East Germantown Pike in Plymouth Meeting, PA, and begin at 7:00 p.m.

January 10

February 14

March 14

April 11

May 9